Effects of the Elimination of Grade 12 Provincial Exams in Chemistry, Biology, and Physics on Teachers in a British Columbia School District

by

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B.PE., University of British Columbia, 1993

B.Ed., University of British Columbia, 1994

M.A., San Diego State University, 1999

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University of Victoria

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Abstract

From 1983 until 2011 Grade 12 students in the Canadian province of British Columbia were required to write provincial exams in a wide variety of academic subjects, including Biology 12, Chemistry 12, and Physics 12. These government-administered exams may be considered "high stakes" in that they counted for 40% of a student's mark, were used in part to determine post-secondary admissions and scholarships, and the publicly-available exam results were used in highly publicized school "ranking" systems. A large volume of research literature suggests high stakes exams of this nature dictate the manner in which courses are delivered as teachers feel obliged to "teach to the test" in order to maximize the grades students receive on these exams.

A major gap in the literature appears to be an examination of the effects on teacher behaviours and practices when a long-standing high-stakes testing program is eliminated. The decision made by the British Columbia Ministry of Education to remove provincial exams in

secondary science at the Grade 12 level in August of 2011 created a unique and original opportunity to examine teacher pedagogical practices following the removal of subject-specific exams. Specifically, the question considered in this investigation centred upon the effect(s) the elimination of provincial exams in Biology 12, Chemistry 12, and Physics 12 had on the pedagogy and work environment of teachers in one British Columbia school district.

This investigation followed case study methodology. The primary source of data was interviews with teachers who had experience teaching the three aforementioned courses in both the time of mandatory exams and following exam elimination. Interviews were semi-structured and focussed on the effects of the removal of Grade 12 exams on teacher pedagogy and general practices, classroom resource and time allocation, relations with colleagues, perceived student responses to courses, and exam data usage.

The findings from this research suggest that, contrary to popular discourse, exam-generated data is not a valuable pedagogical resource for teachers and a high-stakes exam is not required to ensure full curricular coverage by teachers. In fact, the results suggest the opposite: curricular coverage is enhanced in the absence of a high-stakes exam. Further, not having to spend classroom and external time preparing students for exams has allowed teachers to implement and explore a greater diversity of pedagogical avenues not utilized during the time of exams. Teachers also spoke of reduced pressures in the absence of an exam. Finally, findings of this investigation suggest the presence of an exam greatly affected the way teachers both assessed and motivated students, effects that continue to have repercussions following elimination of provincial exams.

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Chapter 1 – Background to the Problem

In the 1970s and early 1980's, a political ideology commonly referred to as neoliberalism gained significant traction in terms of shaping government policy in many western democracies. Many analysts trace occurrences from the 1970's such as declining corporate profits, deficit spending by governments, the formation of OPEC, inflation, and oil shortages as major contributors to the increase in public and government favour towards neoliberal policies (Bowles and Gintis, 1986; Faux, 2006; Parenti, 1999; Tabb, 1980). From a neo-liberal perspective, the perceived superiority of free-market forces and the private sector over publicly-provided services should be the central tenets of government policy both socially and economically. Even public institutions held sacred to the functioning of society under Keynesian economic policy, such as schools and hospitals, are not exempt from the neoliberal mantra of the supremacy of private enterprise and markets over publicly supplied services. For example, as education professor Michael Peters (1999) stated "there is nothing distinctive or special about education or health; they are services and products like any other, to be traded in the marketplace" (p. 2).

In terms of education, neoliberal viewpoints envision an education system driven by corporate economic market principles and run via a business management model. With the gaining popularity of neoliberalism, educator David Hursh (2005) stated, "over the last several decades, neo-liberal and neoconservative politicians have reshaped educational policy around the ideology that schools need to incorporate markets, competition, and choice in order to prepare students for the global economy" (Hursh, 2005). Poole (2007) described the neoliberal doctrine as it applies to education in the following way:

> Neo-liberals conceptualize education as a commodity to be bought by customers (students and parents) and sold by suppliers (schools and others). From a market

> perspective, schools are training grounds for future workers and consumers, as well a multi-billion dollar industry offering opportunities for profit. Efficiency, accountability for student outcomes (usually measured by standardized test scores and other measures like graduation rates), choice for parents (e.g., charter schools, vouchers, within-district school choice), privatization (e.g., public funding for private schools, user-pay fees, contracting with private firms to operate public schools, private-public partnerships for school construction, school-business partnerships), and attacks on teachers unions are hallmarks of neo-liberalism in education. (para. 1)

An examination of literature on the relation of neoliberalism to the delivery of education services reveals many recurrent themes in the neoliberal vision for an education system represented in the above quotes from Poole (2007) and Hursh (2005). Phrases and themes that continually arise are: markets, consumer choice, privatization, accountability, future workers, economic prosperity, attacks on teacher unions, school-business relationships, decreased public funding, and lower costs to the taxpayer (Ball, 1999; Fallon & Paquette, 2008; Gutmann & Thompson, 2004; Hursh, 2007; Levin, 1998; Martino & Rezai-Rashti, 2012; Poole, 2007; Young, 2000). While each of these themes offers a plethora of potential research opportunities, this study will focus on the neoliberal theme of accountability, and in particular the role of standardized tests as a tool of this agenda.

Accountability and Testing

No matter what the sphere, whether industry or service, public or private, accountability is a complex and multi-layered concept. To be accountable implies the defining of a formal relationship between parties where one party is held to a standard established by itself or the

other in the stewardship of a service, business, etc.. While no single definition of accountability is without flaw, Dunsire (1978) described the concept in the following manner:

> Being accountable may mean . . . no more than having to answer questions about what has happened or is happening within one's jurisdiction . . . But most usages require an additional implication: the answer when given, or the account when rendered, is to be evaluated by the superior or superior body measured against some standard or some expectation, and the differences noted: and then praise or blame are to be meted out and sanctions applied. It is the coupling of information with its evaluation and application of sanctions that gives 'accountability' or 'answerability' or 'responsibility' their full sense in ordinary usage. (p. 41)

With this definition in mind, a series of questions may be raised about accountability in education. Firstly, who is accountable to whom? Is it the government who is accountable to the taxpayers, or is it teachers whom are responsible to government, taxpayers, parents, students, or some combination of these? Further, what standards are the accountable party responsible for achieving and are these standards determined by the public, parents, government, or educators? Additionally, what instrument(s) and assessment tools are used to judge the accountable parties? Is it student test scores, administrative observations, a combination of these, or other methods entirely? Finally, what are the rewards and sanctions for any accountable party in relation to their achieving, or not achieving, these standards? These and many more possible questions create a very murky picture when the issue of accountability in education is raised.

Not surprisingly, accountability as a concept is rarely clearly articulated in educational policy documents (Earl, 2001; Kuchapski, 1998; Ouston, Fidler, & Earley, 1998) and there appears to be no set agreement on a definition of accountability by educational researchers and

practitioners. However Ranson (2003), in regards to the neoliberal view on accountability, stated, "public services… would flourish more effectively if they modelled their management practice on the private sector" (p. 465). In terms of education, a focus on business management practices comes with an almost inherent need to provide quantitative information in order to provide taxpayers, teachers, and educational "consumers" with information that, supposedly, can be used to indicate the quality of service being provided. This leads to what is perhaps the most publicized and controversial part of the neoliberal governance model in education: accountability through standardized testing.

Under neoliberal influences, assessment-led reform has become one of the most widely favoured strategies to promote more credible forms of public accountability (Black, 1995). Earl and Torrance (2000) note that:

> Unlike the assessment agenda of the 1960's and l970's, assessment programs in the 1990's and beyond are part of a broader scheme for changing education. Large scale assessment has become the vehicle of choice for accountability purposes around the world, and testing has become the lever for holding schools accountable for results. (p. 114)

Nichols, Glass, & Berliner (2006) and Volante (2004) reach similar conclusions.

With few exceptions, this model of accountability through standardized testing is now pervasive across Canada (Jaafar & Anderson, 2007). Jaafar and Anderson (2007) stated that "this represents another shift in the locus of responsibility in education. It signifies that provincial governments no longer rely simply on their trust in the expertise and professionalism of education civil servants to satisfy provincial and public education expectations" (p. 220).

To achieve accountability measures through large-scale assessments, educational jurisdictions generally align standardized exams to their curriculum which, since education in Canada is a provincial responsibility, is established by the individual provincial governing bodies. While the organization of these curricula will differ from jurisdiction to jurisdiction, essentially in this model the governing body establishes the form of accountability (in this case, a large scale exam) and it is the "challenge" of the schools, teachers, and students to meet curricular "standards". The exams are supposedly aligned to this curriculum and are then administered with the intention of enabling students to show their mastery of said curriculum. In a neoliberal framework of accountability, the results of these tests are used to quantify, among other things, the performance of the student, their teachers, and their school. Such regimes of public accountability have been strengthened and become so commonplace that they are no longer merely an important component of the system, but in many instances have become the system itself (Ranson, 2003). Ranson's assertion is bolstered by research implying the presence of large scale assessments leads to reallocation of classroom temporal and financial resources to test preparation, aligning classroom assessment formats with those of the exam, focussing only on aspects of the curriculum likely to be tested, emphasis on memorization of examinable facts over high order thinking, increased teacher-centred pedagogies, and a decrease in exposure to laboratory activities for science students (Abrams, Madaus, Russell, Ramos, & Miao, 2003; Afflerbach, 2005; Anderson, Muir, Bateson, Blackmore, & Rogers, 1990; Collins, Reiss, & Stobart, 2010; Crocco & Costigan 2007; Diamond, 2007; Galton, 2007; Gayler, 2005; Hamilton, Stecher, Marsh, McCombs, Robyn, Russell, & Barney, 2007; Higgins, Miller, & Wegmann, 2006; Jones, Jones, Hardin, Chapman, Yarborough, & Davis, 1999; McCarthey, 2008; McClaskey, 2001; Moon, Brighton, & Callahan, 2003; Nathan, 2002; Pedulla,; Pringle & Martin,

2005; Reback, Rockoff, & Schwartz, 2013; Samiroden, 1990; Sturman, 2003; Traub, 2002; Valli & Buese, 2007; van Hover & Heinecke, 2005; Vogler, 2005; Wideen, O'Shea, Pye, & Ivany, 1997).

Exams and Accountability in British Columbia

By the early 1980's the province of British Columbia had fallen on tough economic times. Record high interest rates, unemployment of 13.9% in 1983, and a deep recession crippled the finances of many British Columbians (Statistics Canada, 2013). Also at this time school board budgets were escalating and, with them, local taxation (allowed at this time in British Columbia). In 1981 alone, board budgets across British Columbia rose an average of 19% and school taxes 25% compared to the previous year (Fleming, 2002). Further, from 1976-1981, the costs to fund the public school system increased nearly 80% despite a decrease of 32, 000 students province-wide (Fleming, 2002). These factors, combined with the growing popularity of the previously discussed neoliberal ideologies that began in the 1970's, prepared an environment for the neoliberal agenda to gain a strong foothold both inside and outside the education system in British Columbia.

In addition, fairly or not, tough economic times such as these tend to put education systems under the microscope as politicians and a large segment of the public lean towards blaming "failing schools" for not preparing workers for the economy (Ungerleider, 2006). In this vein, at around this same time British Columbia's economy was faltering and neoliberal policies were gaining public favor, the National Commission on Excellence in Education (1983) in the United States produced *A Nation at Risk*. This seminal report, while American based, greatly influenced Canadian education policy makers. Ungerleider (2006) stated "like the Cold War,

Hollywood, McDonald's, and countless other things American, the rhetoric of a nation at risk because of school failure overflowed into Canada" (p. 87).

Aside from blaming the American economic slowdown of the times on a "rising tide of mediocrity" (p. 8) in the American public school system, *A Nation at Risk* also called "for standardized tests of achievement at major transition points from one level of schooling to another and particularly from high school to college or work" (p. 22). Raptis and Fleming (2006) observed that this report "set policymakers across North America on a quest to reform education through greater accountability and to focus attention on the 'outputs' as much as the 'inputs' of schooling" (p. 78).

The influences discussed in the preceding paragraphs left British Columbians ripe for drastic changes in governmental policy and led to sweeping transformations in 1983. Among other policy changes, the socio-political climate emerging in the late 1970's and early 1980's led the government, via the Ministry of Education, to re-establish large-scale quantitative assessment practices that were becoming the norm in both business and government of the day (Fleming, 2002). This movement saw large scale testing in British Columbia move from being an instrument used to evaluate individual students and programs to being used as a tool of accountability to hold schools and districts to task for test results and the meeting of educational standards (Firestone, Mayrowetz, & Fairman, 1998; Mussio, 2012; Torrance & Pryor, 1998). For British Columbia, these factors culminated in the re-introduction of provincial exams at the Grade 12 level in the fall of 1983 (Mussio, 2012). These exams tested a wide variety of subjects, including Biology, Chemistry, and Physics, and each exam counted for 50% (to be lowered to 40% several years later) of a student's course mark (Mussio, 2012). The re-introduction of these exams was the beginning of a program of assessment that lasted until August of 2011, when a

restructuring of the provincial exam program led to the elimination of exams in all Grade 12 courses except English 12 and Communications 12.

The Problem

The British Columbia Grade 12 exams in the subjects of Biology, Chemistry, and Physics may be considered to be "high stakes" in that these exams counted for a large percentage of a student's mark – originally 50% in 1983 and 40% at the time of their elimination in 2011. Consequently the exams had large-scale implications for the students' Grade 12 course grades, grades that were used to at least in part determine post-secondary admissions and the rewarding of scholarships. In addition, the results of these exams were available to the public, allowing organizations such as the Fraser Institute, a Canadian right-wing public policy "think tank", to use exam scores as part of a formula used to "rank" schools (Fraser Institute, 2010; Raptis, 2012). Rightly or wrongly this publicizing meant teachers, administrators, and schools were judged, at least in part, based on the exam results of their students. As a result, it has been alleged that these exams dictated the manner in which courses were delivered as teachers felt, consciously or subconsciously, obliged to "teach to the test" in order to maximize the grades students would receive on these exams.

"Teaching to the test" is a term generally used in literature to refer to a circumstance where pedagogy, time, and effort focussed on test preparation comes at the expense of other curricular areas and instructional practices (e.g. Anderson, Muir, Bateson, Blackmore, and Rogers, 1990). This alleged focus on the test is backed up by a large volume of research findings that focus on the effects on teachers of high-stakes standardized testing in Canadian and American K-12 schools. Well publicized concerns in this area include compromises to instructional practice and pedagogy (Pedulla, Abrams, Madaus, Russell, Ramos, & Miao, 2003),

less teacher attention to non-test related needs of students (Noddings, 2001, 2002), intensification of teacher workload (Apple, as cited in Flinders and Thornton, 2009), constricting the curriculum through the reduction or elimination of untested subjects and spending curricular time teaching students how to write tests (Elmore & Fuhrman 2001; Gunzenhauser 2003; Hoffman, Assaf, & Paris 2001; Jacob 2001; Jorgenson & Vanosdall 2002; Mathison & Freeman 2003; McGehee & Griffith 2001; McNeil & Valenzuela, 2001; Nichols, Glass, & Berliner, 2005; Noddings, 2001, 2002; Pedulla, Abrams, Madaus, Russell, Ramos, & Miao, 2003; Ricci 2004; Thompson 2001). Further research noted teacher attempts to integrate pedagogical reforms, such as arts assimilation and inquiry learning, are greatly hindered in high-stakes testing environments (Gunzenhauser & Gerstl-Pepin 2002; Jorgenson & Vanosdall 2002).

Essentially this research tells us that, for many teachers, what is tested becomes what is taught. Gunzenhauser (2003) observed that schools and teachers under intense standardized testing accountability pressure fall into a "default" practice where external constraints (exams) determine the purpose and value in education, little reflection or dialogue occurs between colleagues, and the examination determines pedagogical practice. The result appears to be a decline in morale and sense of disempowerment among teachers (Jeffrey, 2002; Kelley, Heneman, & Milanowski, 2002; Mintrop, 2003).

Significance of the Study and a Gap in the Research

A review of the literature reveals that essentially all research centred on teacher behaviours in high stakes testing environments examines situations where testing has recently been implemented or been in place for a long period of time. A major gap in the literature appears to be an examination of the effects on teacher behaviours and practices when a long-standing high-stakes testing program is eliminated. The decision made by the British Columbia

Ministry of Education to eliminate provincial exams at the Grade 12 level in August of 2011 created a unique and original opportunity to examine teacher pedagogical practices following the removal of subject-specific Grade 12 science exams.

There is a debate in educational circles surrounding the merits and drawbacks of standardized testing, which will be illuminated in the literature review of Chapter 2. However, at this point it bears mention that a large volume of research on standardized testing suggests detrimental effects for these programs in a variety of areas surrounding teaching. The question then becomes, has removal of these programs ameliorated or even reversed such perceived negative effects and has the removal fostered change in teacher practices? Are there any negative consequences related to the removal of tests?

Overview of the Dissertation

This dissertation focuses on three science courses, Biology 12, Chemistry 12, and Physics 12, whose provincial exams were eliminated by the British Columbia Ministry of Education in August of 2011. There were four major factors in the decision to focus on these three courses. First, when provincial exams were eliminated, exams in twenty-one Grade 12 courses were abolished. These courses covered a broad range of subject matter, from Punjabi to Math to British Columbia First Nations Studies. A study focussing on all 21 subjects would be a daunting undertaking for a single researcher, not only in terms of volume of work but from a logistical perspective. In addition most, if not all, districts in the province did not offer all 21 of these courses, making the examination of a district that faced the elimination of all 21 exams impossible. As an example, schools in the district that is the focus of this investigation only consistently offered ten of the twenty-one Grade 12 courses that concluded with a provincial exam.

Second, teaching methodology has the potential to be vastly different within this wide variety of subjects. For example, a language-based course such as French 12 would potentially employ dissimilar teaching strategies than a course such as Math 12. Therefore, if all 21 subjects were studied it would likely be very difficult to come to a consensus on how elimination of exams affected teacher practices across the board in all subjects. Therefore, the decision was made to focus on the three previously mentioned science courses.

Third, and specific to science education, developments over the last several decades have given science a place of prominence in Canada's school curriculum and our progress in this subject is viewed as an indicator of our world standing and advantage economically (Amgen Canada Inc. & Let's Talk Science, 2012). This has served to deeply entrench the status of provincial, national, and even international science assessments such as the highly scrutinized Organization for Economic Cooperation and Development (2013) PISA exams. Today academic journals, popular media outlets, and even government websites (Statistics Canada, 2010) often devote large amounts of copy and airtime to the scores of Canadian students in comparison to other nations and provinces in the field of science. These results are reported in the media and scores are used as indicators of the strengths and weaknesses in our science and technology education both in British Columbia and Canada (LaRose, 2013; OECD, 2013).

Finally, the background of the researcher played a role in the selection of these three science courses as a target of this investigation. The researcher has spent 19 years as a high school science teacher in British Columbia and taught Grade 12 science courses both in the exam and non-exam eras. Following the elimination of mandatory exams at the Grade 12 level an increase in enrolment in at least some Grade 12 science courses was noticed by the researcher in

his school. This observation, and subsequent informal examination of this phenomenon, was the genesis for sparking interest in this investigation.

Research Location and Data Collection

This study was conducted in a British Columbia School District and employed case study methodology. The primary source of data was obtained through interviewing Biology 12, Chemistry 12 and Physics 12 teachers regarding how removal of Grade 12 exams impacted their roles as educators. Specifically, interview questions focussed on the effects of exam removal upon pedagogy and general teaching practices, classroom resource and time allocation, teacher relations with colleagues, student responses to courses, and data usage. A full list of interview questions used can be found in *Appendix A*.

Further, to help in data triangulation, secondary sources of data were examined. These data sources contained several publications from the British Columbia Ministry of Education including curriculum guides for the three subjects under investigation, Teacher Regulation Branch standards, provincial exam data reports, graduation requirements, examples of past provincial exams, statements regarding the purposes of provincial exams, and reports surrounding provincial scholarship programs. In addition, school and district-level data were collected including school calendars and district achievement contracts. Finally, documentation gathered from teachers was comprised of course outlines, teacher-generated final examinations, and in-class assessment instruments. Chapter 3 will elaborate on these data sources and their purposes.

Chapter 2 – Education and High-Stakes Science Exams: A Review of the Relevant Literature

Definition of Terms

The following terms and definitions will be used throughout this study:

Biology 12. This is the highest-level official biology course offered at the high school level in British Columbia. It is a non-required (elective) course taken, with some exceptions, by Grade 12 students who have completed the Grade 11 level biology course. The province of British Columbia provides specific learning outcomes that students taking this course are expected to achieve. The now defunct course-ending provincial exam was based on these objectives.

Chemistry 12. This is the highest-level official chemistry course offered at the high school level in British Columbia. It is a non-required (elective) course taken by Grade 12 students who have completed the Grade 11 level chemistry course. The province of British Columbia provides specific learning outcomes that students taking this course are expected to achieve. The now defunct course-ending provincial exam was based on these objectives.

Physics 12. This is the highest-level official physics course offered at the high school level in British Columbia. It is a non-required (elective) course taken by Grade 12 students who have completed the Grade 11 level physics course. The province of British Columbia provides specific learning outcomes that students taking this course are expected to achieve. The now defunct course-ending provincial exam was based on these objectives.

Biology 12 provincial exam. This term refers to the examination formerly administered to students by the Ministry of Education in the Province of British Columbia at the conclusion of the Biology 12 course. Until June 2006, all students in the province were required to write this

exam at the conclusion of the course, with the exam counting for 40% of the student's overall grade. In the 2006-2007 school year this exam was made optional, with students given the choice of whether they wanted to write the exam or not. In August of 2011 the Ministry of Education announced the termination of the exam program for Biology 12. Thus, the Biology 12 exam no longer exists in any form.

Chemistry 12 provincial exam. This term refers to the examination formerly administered to students by the Ministry of Education in the Province of British Columbia at the conclusion of the Chemistry 12 course. Until June 2006, all students in the province were required to write this exam at the conclusion of the course, with the exam counting for 40% of the student's overall grade. In the 2006-2007 school year this exam was made optional, with students given the choice of whether they wanted to write the exam or not. In August of 2011 the Ministry of Education announced the termination of the exam program for Chemistry 12. Thus, the Chemistry 12 exam no longer exists in any form.

Physics 12 provincial exam. This term refers to the examination formerly administered to students by the Ministry of Education in the Province of British Columbia at the conclusion of the Physics 12 course. Until June 2006, all students in the province were required to write this exam at the conclusion of the course, with the exam counting for 40% of the student's overall grade. In the 2006-2007 school year this exam was made optional, with students given the choice of whether they wanted to write the exam or not. In August of 2011 the Ministry of Education announced the termination of the exam program for Physics 12. Thus, the Physics 12 exam no longer exists in any form.

High-stakes test. A test is said to be high stakes if the results of the test has some form of a major consequence. In terms of this study, high-stakes tests may have major consequences not

only for students, but their teachers, administrators, schools, and educational jurisdiction. In many cases, standardized tests are high-stakes tests.

Low-stakes test. A test is said to be low stakes if the results of the test do not have some form of a major consequence. In terms of this study, low-stakes tests may not have major consequences not only for students, but their teachers, administrators, schools, and educational jurisdiction. In some cases, standardized tests are low-stakes tests.

Standardized test. A standardized test refers to an exam that is managed in such a way that questions, writing conditions, and grading procedures are consistent for all students. Standardized tests are usually administered to large groups of students.

To help lay a foundation for understanding why Grade 12 exams were written in science in British Columbia, this literature review will begin with an analysis of why science as a subject enjoys a place of prestige in our high schools. The discussion will then shift to socio-political forces at the international, national, and provincial levels that have shaped what defines, determines, and regulates the role of large scale assessments (with a focus on science courses) at the senior secondary level. The literature review will conclude with a discussion on how these exams affect teachers and their classroom practices.

The Priority of Science Education in the Secondary School Curriculum

While science and science assessments have been part of the British Columbia school system since the early 1900's (Raptis & Fleming, 2006), we can trace the modern-day emphasis on science as a school subject back to fears regarding national security that began to gain a foothold in North America in and around the ending of the second world war (WW II) (Blades, 1997). While the most high-profile events of this time tended to centre on the United States, they had a major impact on Canadian curriculum reform. As Ungerleider (2006) noted:

> A problem affecting Canada with which all Canadian politicians must cope is Canada's proximity to the United States and the influence that information from US media exerts on Canadians. In the education domain, the most pernicious problem is the rhetorical spill-over of the dominant media messages about US education in the post WWII period: 'America's schools are failing'. (p. 86)

Due to post WW II tensions with the Soviet Union, the federal government in the United States established the President's Scientific Research Board to assess the state of science and science education in the United States. The report produced by this board began by declaring:

> The security and prosperity of the United States depend today, as never before, upon the rapid extension of scientific knowledge. So important, in fact, has this extension become to our country that it may reasonably be said to be a major factor in national survival. (President's Scientific Research Board, 1947, p. 1)

This report eventually culminated with the National Defense Education Act (1958). This act of congress linked education to the budget of national defence and allotted, in today's inflationary adjusted dollars, billions to both high school and university science education and marked the first time, aside from the GI Bill, that the American federal government subsidized higher education (Kaplan, 2012).

Interest in science, with perhaps a hint of hysteria, increased exponentially in 1957 when the Soviet Union launched Sputnik, the world's first earth-orbiting satellite. This event, rightly or not, was widely interpreted as a crisis showing that the science, technology, and innovation of the Soviet Union was superior to that in the western world. The Sputnik launch, and the aftermath of reforms and spending that followed, is viewed in a great deal of literature as perhaps

the watershed moment in elevating the importance of science education (Blades, 1997; DeBoer, 1997; Hassard, 2010; Kaplan, 2012).

With the end of the Cold War and the dissolution of the Soviet Union, national security fears in Canada and the United States, while not completely disappearing, have dwindled somewhat. So why, in 2015, is science still perceived as such an important subject in our high schools? Turner (2008) discussed four major arguments for why we teach science in contemporary times and categorized these arguments as democratic, cultural, skills, and economic.

The democratic argument centres around the desire to have science emphasize the preparation of students "to be informed citizens and enlightened consumers who can intelligently negotiate the technoscientific challenges of modern life, politics, and society" (Turner, 2008, para. 14). Curriculum in a classroom following the democratic argument would focus on equipping students with the knowledge to understand debate and make informed decisions on scientific issues such as the environment, biotechnology, and energy sources, only to name a few.

The cultural argument reasons that school science should focus on the enterprise and stories behind past and current science and expose students to the history, philosophy, and tribulations of those who have toiled in this field (Hassard, 2010; Turner 2008). The skills argument focuses on a belief that science teaches students abilities that are transferrable to other areas of academics and life. Turner (2008) stated these skills "include the ability to formulate and conduct experiments, evaluate empirical evidence, appreciate quantitative arguments, carry out inductive generalization, and engage in critical thinking" (para. 18).

The economic argument "is the dominant reason why we teach science, especially in the more advanced and prosperous countries" (Hassard, 2010, para. 4) and "has probably been responsible for the remarkable expansion of science as a compulsory subject in the school curriculum that has occurred around the world over the last twenty years" (Turner, 2008, para. 7). This argument focusses on the need to produce a sufficient number of scientists and engineers, a "scientific pipeline" so to speak, so that a nation can be productive, innovative, and have a prosperous economy. This argument has powerful implications for why we have large-scale assessments in science, which will be discussed in a later section of this paper.

In a Canadian context, this economic imperative was underlined in an extensive report by Amgen Canada Inc. (2012). This report spoke at great lengths about the need for highly trained and skilled workers to fill current and future jobs in the Science, Technology, Engineering, and Mathematics (STEM) fields in order to keep Canada's economy prosperous. To underline the importance of school science in this undertaking the report stated "science and technology are increasingly important to Canada's economic well-being and quality of life. A critical element for our long-term success – as individuals and as a country – is science learning" (p. 5).

Further, the literature surrounding the importance of STEM education often makes references to our progress in relation to other nations as a barometer of how well we are performing. For example, the Amgen Canada Inc. (2012) report noted:

> Around the world, countries are placing a greater focus on STEM learning for the sake of their national well-being. Canada, too, must put science and technology at the forefront; if we do, we can help ensure a thriving 21st-century economy, and better prospects for our citizens and quality of life. (p. 8)

Our federal government seems to be on the same page as the Amgen Canada Inc. report. In a speech in February of 2012, minister of state for science and technology Gary Goodyear declared that, “science and technology means jobs and economic growth” (Government of Canada, 2012, para. 2). In addition, public opinion seems to agree; nearly 90% of respondents to a Canadian survey agreed that the interest of young people in science is key to Canada’s future economic prosperity (Amgen Canada Inc., 2010). Further, the already large and ever-increasing amount of media and government attention paid to international rankings of countries’ high school science performance on tests such as the Programme for International Student Assessment (PISA) allows countries to compare how their science education system stacks up to others around the world (Amgen Canada Inc., 2012; Hassard, 2010; Organization for Economic Co-operation and Development, 2013; Turner, 2008).

With the rationale behind the importance of high school science established, the question then becomes why have large-scale assessments played such a prominent role in these courses? What has defined, regulated, and determined the role of these exams? While the value placed upon science education is part of the answer, a full understanding of the dynamics at play is found in an analysis of the social and political trends that have emerged in our world, Canada, and British Columbia over the last several decades and the effects these trends have had on education. Generally, these trends have centred on a political ideology called neoliberalism.

Neoliberal Politics

Like any public service, how education is administered by government is largely determined by the social and political climate of the day. Since roughly the mid 1970’s a political movement commonly referred to as neoliberalism has gained significant traction in western democracies as a preferred form of governance (Bowles & Gintis, 1986; Faux, 2006;

Harvey, 2005; Parenti, 1999; Tabb, 1980; Ungerleider & Levin, 2007). At this point a detailed discussion of the neoliberal political movement, its foundations, and its implications for education will set the framework for discussion of the role of senior secondary science exams in British Columbia in a neoliberal climate.

A background to the rise of neoliberal politics. Neoliberal policies have arisen and been implemented in varying degrees and rates across nations and regional jurisdictions. This led Davies and Bansel (2007) to state that, "one of the difficulties of providing a history of neoliberalism is that it has emerged at different times and in different guises over the last 30 years" (p. 250). Despite these inconsistencies, most authors describe the mid to late 1970's as the time neoliberal policies began to gain public and political footholds in western democracies (Bowles & Gintis, 1986; Faux, 2006; Harvey, 2005; Parenti, 1999; Tabb, 1980; Ungerleider & Levin, 2007).

In the roughly 25-30 years following WW II in Europe and North America, social and economic strategies generally followed Keynesian welfare-state policies. Under such programs, social justice was a priority, with inequalities decreased through social programs and a re-distribution of wealth and influence (Levitas, 1998). Killian (2011) summed up this time period by saying "for a quarter-century after the war, resources had moved toward working-class and middle-class families, sparking a golden age when a family could live on one wage-earner's income, buy a house, and send the kids to college" (para. 4).

Essentially, at this time the political and social climate favoured the introduction of social and economic rights for citizens. In terms of business-employee relations, "an unusual level of agreement between corporations and workers marked the first two decades after the war" (Hursh, 2005, p. 4) and workers of this era made significant inroads in terms of wages, employment

protection, and workplace safety. Further, women and people of colour made substantial gains in personal rights and freedoms, particularly in the areas of education, the workplace, welfare and voting rights, and access to housing and health care (Bowles & Gintis, 1986). Also at this time, young people on college campuses were engaging in protest and political action at never before seen levels, demanding the free speech rights to criticize government policies (Hursh, 2004).

By the mid-1970's, social and political changes in western democracies began to work counter to these trends. As workers' rights increased under Keynesian policies and unionization post WW II, so did their wages. From 1965-1974 the net rate of profit for businesses fell by more than 50% (Parenti, 1999, p. 118). Bowles and Gintis (1986) stated that, "profits fell primarily because cost pressures from labour could not be passed on to consumers in the increasingly competitive and open world economy" (p. 60). In addition, deficit spending by governments, the formation of OPEC, inflation, and oil shortages contributed to the increase in public and government favour towards neoliberal policies (Faux, 2006; Tabb, 1980).

From an international perspective, perhaps the two best-known examples of the emergence of neoliberal politics were the elections of Prime Minister Margaret Thatcher in Britain in 1979 and President Ronald Reagan in the United States in 1980. Both of these leaders of prominent world nations subscribed to neoliberal philosophies of growing corporate profits through increased trade, economic deregulation, and dismantling or reorganizing of Keynesian-era public sector institutions such as social welfare, education, and health. In America, Reagan decreased public spending, deregulated high profile industries (including communications and airlines), and famously attacked unions such as the air traffic controllers. In Britain, Thatcher made tax cuts, attacked unions, implemented massive cuts to government social programs, privatized government enterprises, and reduced regulations on business (Harvey, 2005).

Specific to a Canadian context, movement in the direction of neoliberal market-based policies was in part triggered in the late 1970's and early 1980's by rising unemployment and increasing public debt loads (Ungerleider & Levin, 2007). Perhaps the best-known example of the arrival of neoliberal politics in Canada was the 1983 budget of the Social Credit government in British Columbia, an event which will be discussed in significant detail in later sections of this paper.

Tenets of neoliberal politics. As mentioned earlier, the rollout of neoliberal policies has taken many forms and been implemented under various timelines over a wide variety of jurisdictions. However, the basic tenets and underpinning of neoliberal ideologies and policy implementations have many similarities from jurisdiction to jurisdiction. Harvey (2005), in his book *A Brief History of Neoliberalism*, described neoliberalism as:

> A theory of political economic practices that proposes that human well-being can best be advanced by liberating individual entrepreneurial freedoms and skills within an institutional framework characterized by strong private property rights, free markets, and free trade. The role of the state is to create and preserve an institutional framework appropriate to such practices, using force, if need be, to guarantee the proper functioning of markets. If markets don't exist (in areas such as land, water, education, health care, social security, or environmental pollution) then they must be created, by state action if necessary. (p. 2)

Critics of neoliberal policies feel this doctrine puts corporate profits, markets, and the economy at the top of its agenda at the expense of personal rights, public services, and the power of working people (Hursh, 2004). Instead of a concern for the social welfare policies of the decades following WW II, neoliberal policies emphasize "the deregulation of the economy, trade

liberalization, the dismantling of the public sector (such as education, health, and social welfare), and (especially in the U.S.) the predominance of the financial sector of the economy over production and commerce" (Vilas, 1996, p. 16).

With these factors in mind, a shift towards neoliberal economic policies reconstructs the relationship government has with society and private enterprise. In this form of governance, the power of markets and the private sector are the central influences on government policy both socially and economically. Even public institutions held sacred to the functioning of society under Keynesian economic policy, such as schools and hospitals, are not exempt from the neoliberal mantra of the supremacy of private enterprise and markets over publicly supplied services. As Peters (1999) stated “there is nothing distinctive or special about education or health; they are services and products like any other, to be traded in the marketplace” (p. 2).

Predictably, the public education system has been reshaped by the neoliberal ideology in many western democracies over the past 30-plus years (Davies & Bansel, 2007; Gutstein, 2010; Hursh, 2004; Hursh, 2005; Hursh, 2007; Killian, 2011; Sattler, 2012). Since a major intent of this literature review is to focus on the role of secondary science exams in schools, a background into the specifics of neoliberal policies and how they do/may affect education is needed at this point. Therefore the following sections will address neoliberal policies, and the effects they have when implemented into an educational system such as that in British Columbia.

Neoliberalism in Education

An introduction. In terms of education, neoliberal viewpoints envision an education system that is driven by corporate economic market principles and run via a business management model. Hursh (2005) stated, “over the last several decades, neo-liberal and neoconservative politicians have reshaped educational policy around the ideology that schools

need to incorporate markets, competition, and choice in order to prepare students for the global economy" (p. 13). Poole (2007) described the neoliberal doctrine as it applies to education in the following way:

> Neo-liberals conceptualize education as a commodity to be bought by customers (students and parents) and sold by suppliers (schools and others). From a market perspective, schools are training grounds for future workers and consumers, as well a multi-billion dollar industry offering opportunities for profit. Efficiency, accountability for student outcomes (usually measured by standardized test scores and other measures like graduation rates), choice for parents (e.g., charter schools, vouchers, within-district school choice), privatization (e.g., public funding for private schools, user-pay fees, contracting with private firms to operate public schools, private-public partnerships for school construction, school-business partnerships), and attacks on teachers unions are hallmarks of neo-liberalism in education. (para. 1)

An examination of literature on the relation of neoliberalism to the delivery of education services reveals many recurrent themes in the neoliberal vision for an education system characterized in the above quote from Poole. Phrases and themes that continually arise are markets, consumer choice, privatization, accountability, future workers, economic prosperity, attacks on teacher unions, school-business relationships, decreased public funding, and lower costs to the taxpayer (Ball, 1999; Fallon & Paquette, 2008; Gutmann & Thompson, 2004; Hursh, 2007; Levin, 1998; Martino & Rezai-Rashti, 2012; Poole, 2007; Young, 2000). Since these themes relate to topics that will be discussed in later portions of this paper, each will be discussed below for the purposes of background information.

Markets, choice, and privatization. A foundation of neoliberalism is the minimizing of any restrictions imposed by government onto free markets. As Poole observes (2007):

> Neo-liberalism is a political ideology grounded in an unshakeable belief in unbridled markets as the source of all benefits for a society and its citizens. Neo-liberals believe the application of market principles to the public sector will result in greater efficiency and contribute to overall economic prosperity. (para. 2)

In relation to education, traditionally in North America students have been assigned to schools based on geography. These schools are known by terms such as neighbourhood or "catchment" schools; the boundaries for these schools have been determined by educational officials who, in varying degrees from jurisdiction to jurisdiction, have been responsible for their enforcement.

In a neoliberal context, this is viewed as inefficient and can only be overcome "if individuals are able to make choices within a market system in which schools compete rather than the current system in which individuals are captive to educational decisions made by educators and government officials" (Hursh, 2007, p. 498). Within the "education as a market commodity" mindset, parents and students are viewed as consumers while schools are viewed as suppliers of a service, which is to be marketed to these consumers (Poole, 2007). Essentially, neoliberal doctrine subscribes to the theory that this arrangement will lead to a greater degree and improved quality of competition, specialization, and customer service between schools.

In this approach, parents and students should be able to exercise their rights as customers in choosing the school that best suits their needs, wants, and interests (Gordon & Whitty, 1997). Since schools are generally funded based on the number of students they have, schools offering the "best" programs will have the highest enrolments and will thrive. Schools offering what may,

fairly or unfairly, be viewed as inferior programs will have less customers (students) and will perhaps go "out of business". The belief is this increase in consumer choice, combined with the funding implications for schools, induces a competitive market approach to how financial resources are allocated to schools, leading to a more efficient use of tax dollars and an increase in the quality of school programs.

As stated earlier in a quote from Harvey (2005) regarding neoliberalism and markets, "if markets don't exist… they must be created by state action if necessary" (p. 2). Within a neoliberal framework of creating more market competitiveness and choice in the education system, three major and highly visible mechanisms are widely proposed and/or undertaken.

The first is to create open boundaries within the public school system, which can take various forms. In British Columbia, for example, open boundaries were introduced in 2002 by the Premier of British Columbia, Gordon Campbell, through Bill 34 (British Columbia Ministry of Education, 2002a). This legislation allowed students to attend any public school outside their "neighbourhood catchment" school as long as there was space available following the registration of "in-catchment" students. This type of boundary-less school system has the potential to force schools to enter into market-type competition to keep their catchment students and also attract those from outside their boundaries (Poole, 2007).

In addition to open boundaries, many educational governing bodies at least partially fund private (sometimes known as independent) schools. In British Columbia, a policy of partial funding for private schools began in 1977 with the passage of the *Independent School Support Act* by the then-ruling Social Credit Party government (British Columbia Ministry of Education, 2011a). Canada and British Columbia's still highly developed welfare state and long tradition of "free at the point of delivery" schooling culture would make complete privatization of the

education system a very difficult undertaking at this time (Elliott & MacLennan, 1994). Therefore, a type of compromise has been reached in many jurisdictions where the governing body at least partially funds private schools. This somewhat achieves the neoliberal goal of increasing choice and fuelling competition (public vs. private) within the educational marketplace, with the ultimate end goal being benefit to the consumer who would be free to choose from a variety of options what program best suits the needs of their child.

Another proposed mechanism for creating markets and choice, though not currently in practice in British Columbia, is a "scholarship" or "voucher" system. In such a system the current bureaucratic structure of public education is viewed as an impediment to school flexibility and innovation. Chubb and Moe (1990) asserted that, "the most important prerequisite for the emergence of effective school characteristics is school autonomy, especially from external bureaucratic influence" (p. 23). To alleviate this perceived problem, Chubb and Moe in part proposed parents be given a voucher equalling the funding a district would receive for each pupil and allowing parents the freedom to spend this money at the school of their choice. It is the belief of Chubb and Moe that this would create a consumer-driven system where schools compete for these educational dollars. This competition would trigger market mechanisms where schools providing what is desirable to consumers will attract and retain students, while schools providing services deemed less attractive would lose out in the marketplace.

Accountability and testing. Gutstein (2010) spoke of how accountability in education, and who is accountable for what, is a hotly contested concept between two frames of thought. Borrowing on the work of cognitive scientist George Lakoff, Gutstein labelled these frames as "progressives" and "conservatives" (a term often used in the literature interchangeably with

neoliberal). Gutstein noted that while both camps believe that some party is responsible and accountable for the education of our children:

> The progressive view of accountability focuses on the government and the individual. The government must be held accountable if it does not provide the teachers, books, computers and lab equipment for students to have an effective and rigorous learning experience. After that, it is the student's responsibility. (p. 26)

By contrast, Gutstein (2010) detailed how the conservative perspective on accountability absolves the government of responsibility for the individual. Gutstein summarized this view by stating that "the conservative view of accountability focuses on the individual and the school. Regardless of circumstances, if a student or school does not succeed, it is their own fault for not working hard enough to produce the necessary learning" (p. 26). Under such a framework, any inequalities are the result of inadequacies of the individual, individuals who need to take it upon themselves, without reliance on social welfare, to strive to achieve better.

How accountability in education is, or should be, measured is rarely clearly outlined in government documents (Earl, 2001; Kuchapski, 1998; Ouston, Fidler, & Earley, 1998). However, in the last several decades the neoliberal perspective on accountability has grown in favour among both politicians and the general public (Ranson, 2003). This perspective comes with an almost built-in need to produce quantitative information that consumers can use as they navigate the educational marketplace. In recent decades the preferred vehicle for providing this quantitative information to consumers has been the large-scale standardized test (Black, 1995; Earl & Torrance; 2000; Nichols, Glass, & Berliner, 2006; Volante, 2004).

Ranson (2003) stated in regards to the use of large scale exams as the primary means of accountability that:

> Any framework of accountability reveals the polity it expresses. An instrumental, regulatory model of accountability has developed with increasing intensity over time because it has served to express and reinforce the neo-liberal polity of market exchange, and the incentives of relative advantage: competition, contract, corporate ownership have been constituted as the most effective means of formalizing accountability and evaluating performance. (p. 476)

The system of accountability through exams allows the state/province to follow another neoliberal philosophy, which is to not directly intervene in the day-to-day operation of schools. Neoliberal promoters decry "state intervention because it is held that administrative and bureaucratic structures are inherently inferior to markets as a means of allocating resources" (Thrupp & Willmott, p. 18). To this end, governments often legislate that schools and districts must publicly articulate goals and targets, performance plans, monitoring procedures and consistent progress reports on how students and schools are performing in relation to scores on standardized exams (Jaafar & Anderson, 2007). If a school or district fails to reach projected targets, they are held responsible for these shortcomings. Thus in such a system responsibility for outputs are shifted away from the state and onto the individual units within the hierarchy. This allocation gives the appearance that government is not responsible for the day to day operations of the individual units, who in turn become answerable for their own success or failures; talk of government "inputs" (or lack thereof), thus become overshadowed by the responsibility of the individual units for their own "outputs".

Consequently, in this model education governing bodies have devised a system in which they can govern and regulate schools from afar via rigorous testing, what Ball (1994) described as "steering at a distance" (p. 54). Barry, Osborne, and Rose (1996) stated:

> Public authorities seek to employ forms of expertise in order to govern society at a distance, without recourse to any direct forms of repression or intervention. Neo-liberalism, in these terms, involves less a retreat from governmental 'intervention' than a re-inscription of the techniques and forms of expertise required for the exercise of government. (p. 14)

Future workers and economic prosperity. In his critique of a neoliberal view of the purpose of education, Hursh (2004) observes that, "education is no longer valued for its role in developing political, ethical, and aesthetic citizens. Instead, the goal has become promoting knowledge that contributes to economic productivity and producing students who are compliant and productive" (para. 21). To this end, neoliberal policies have been redefining education to be viewed primarily as a vehicle for promoting continued economic prosperity. In this type of education, there is a heavy emphasis on basic educational skill (primarily literacy and numeracy) and considerable effort is focussed on career planning and preparation.

Thus the neoliberal view of education does not emphasize a well-rounded, liberal education but instead focuses on employability skills that will enable the student to become a productive member of the economy. Robertson (2000) stated "educational systems, through creating appropriately skilled and entrepreneurial citizens and workers able to generate new and added economic values, will enable nations to be responsive to changing conditions within the international marketplace" (p. 187).

Two highly influential examples from the United States are worth noting at this point. In 1983, under President Ronald Reagan, the National Commission on Excellence in Education (1983) produced a report, titled *A Nation at Risk*, blaming the recession of the early 1980's on

American schools. This report, seen by many as a watershed moment in the education history of the United States and in the neoliberal movement in US education, stated:

> Our Nation is at risk. Our once unchallenged pre-eminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world. This report is concerned with only one of the many causes and dimensions of the problem, but it is the one that undergirds American prosperity, security, and civility. We report to the American people that while we can take justified pride in what our schools and colleges have historically accomplished and contributed to the United States and the well-being of its people, the educational foundations of our society are presently being eroded by a rising tide of mediocrity that threatens our very future as a Nation and a people. What was unimaginable a generation ago has begun to occur—others are matching and surpassing our educational attainments. . . . We have, in effect, been committing an act of unthinking, unilateral educational disarmament. (p. 5)

This practice of blaming schools instead of governments for economic woes has been examined and critiqued by, among others, Elliott and MacLennan (1994), Hursh (2004), and Ungerleider (2006). While a thorough analysis of these critiques is beyond the scope of this paper, it is interesting to note that just one year after *A Nation at Risk* (1983) forecast gloom and doom for the American economy based on a faltering school system, in 1984 the United States economy posted its second highest GDP annual growth rate in history and the United States embarked on a nearly uninterrupted two decades of economic growth that can arguably be labelled as the most prosperous in human history (Manuel, 2010).

More than two decades later, President George W. Bush re-iterated the neoliberal theme of linking educational systems with economic prosperity by stating, in regards to the No Child Left Behind (NCLB, 2002) policy of his administration:

> NCLB is an important way to make sure America remains competitive in the 21st century. We're living in a global world. See, the education system must compete with education systems in China and India. If we fail to give our students the skills necessary to compete in the world in the 21st century, the jobs will go elsewhere. (U.S. Department of Education, 2006, p. 2)

Attacks on teacher unions and decreased professional autonomy for teachers. From a neoliberal perspective, trade unions are viewed as a third party that acts as an impediment to the forces of the free market, including supply and demand between employers and employees, and are thus viewed as a roadblock to the achievement of economic prosperity (Poole, 2007). Unions in the teaching profession are not exempt from this viewpoint. Neoliberals view teacher unions as an outside influence obstructing the relationship educators have with their employers; further to this point, educators are often cast by neoliberals as victims who are being used as pawns by their own self-serving unions (Moe, 2006). For example, during the 2014 British Columbia teachers strike, former Minister of Education Patrick McGeer wrote:

> The requirement that membership in the B.C. Teachers' Federation as a condition for teaching in a British Columbia public school should be eliminated. That way teachers can follow their conscience and will no longer be obliged to obey their union leaders. (McGeer, 2014, para. 2)

Describing the general feelings of the public towards teachers in the time prior to roughly the early 1970's, Ranson (2003) stated:

> Public trust was afforded to the specialist knowledge of professionals and the necessary requirements of answerability could be fulfilled by delegating authority to heads, teachers, and advisors – only the trained eye could judge the quality of teaching and the pupil progress. (p. 464)

Since this time, Ranson (2003) observed that, "a regime of neo-liberal corporate accountability has dominated the governance of education" (p. 459). Under neoliberal education policies, attempts to gain public trust in the teaching profession are achieved through specifying performance standards and regulating compliance to these standards through the use of externally-imposed large scale standardized tests.

Teachers in externally (government) imposed accountability environments driven by high-stakes standardized tests tend to have their professional autonomy greatly impacted by these tests. These impacts include constricting curriculum to only teach tested areas, allotting already limited resources to test preparation materials, and spending curricular time teaching students how to write tests (Elmore & Fuhrman, 2001; Gunzenhauser, 2003; Hoffman, Assaf, & Paris, 2001; Jacob, 2001; Jorgenson & Vanosdall, 2002; Mathison & Freeman, 2003; McGehee & Griffith, 2001; McNeil & Valenzuela, 2001; Nichols, Glass, & Berliner, 2005; Noddings, 2001; Pedulla, Abrams, Madaus, Russell, Ramos, & Miao, 2003; Ricci, 2004; Thompson, 2001). Effectively this research reveals that for a large number of teachers working in high-stakes testing conditions, what is tested is what is taught.

Essentially externally imposed exams lead many teachers to base their curricular and pedagogical decisions around exam preparation. As Mathison and Freeman (2003) said "teachers sacrifice their professional integrity in order to help every child be as successful as s/he can be on the tests" (para. 11). The result appears to be a decline in morale and sense of

disempowerment among teachers (Jeffrey, 2002; Kelley, Heneman, & Milanowski, 2002; Mintrop, 2003) as teachers "become subjected to a process that denies their agency" (Ranson, 2003, p. 460).

Financial efficiency and decreased public expenditure on education. Within the neoliberal framework of fiscal governance, public institutions such as education are viewed as remnants "of earlier mistaken governmental interventions" (Burchell, 1996, p. 27) that are unaffordable, unsustainable, and cause uncontrolled growth of the state (Davies & Bansel, 2007). While it would likely be political suicide for western governments with neoliberal leanings to abolish public education in one fell swoop, legislative and political incremental steps have been taken in recent decades to reduce the financial impact of public education on government coffers.

These steps have resulted in many restructurings surrounding public education designed, at least in part, to reduce the financial impact of this service upon taxpayers. These restructurings have included outright monetary cuts, alternative funding models, encouraging schools and boards to create revenue via fees and entrepreneurial activities, encouragement of the establishment of private schools, amalgamation of school boards, and establishment of school-community partnerships (Dale, 1998; Jafaar & Anderson, 2007; Lessard & Brassard, 2009; Lindblad, Johannesson, & Simola, 2002; Poole, 2007; Ungerleider & Levin, 2007). All of these actions can serve/have served to reduce government financial inputs into educational services, all while government and taxpayers maintain expectations of high outputs as measured through exam score focussed accountability.

Neoliberalism in BC Education

In Canada the British North America Act of 1867, in which the British parliament enacted Canada as a sovereign nation, gave jurisdiction over education to the individual

provinces as a condition of entering confederation. An examination of the experience of every province and territory with the implementation of neoliberal policies in their education system is beyond the scope of this paper. Therefore, I will concentrate on the province this study is based in - British Columbia.

Historical backdrop of the 1960's and 1970's. Up until the late 1960's, the school system in British Columbia was modelled around a structure of highly centralized control, with a focus centred as much or more on government inputs as outputs. Fleming (2002) stated:

> To schoolmen and schoolwomen of the post-World-War-II era as well as the public at large it was axiomatic that increased levels of educational support led directly to newer schools, more extensive and richer educational programs, a more complete range of school services, more modern athletic and other facilities, and smaller class sizes. Such investments, it was generally assumed, were ultimately associated with better schools and higher pupil performance. (para. 32)

Fleming (2002) noted that this began to change by the late 1960's, stating this shift in attitudes towards school funding was caused "in part by a malaise inside educational government and by new forces in and outside schools" (para. 1). Specific factors Fleming attributed to causing this transformation included a large growth in the under 30 population, large and diverse groups demanding increased rights and provision of education and governmental services, and public demands for both fiscal and academic accountability from the education system.

For his part, Mussio (2012) attributed much of the changes seen at this time to a "backlash" against the centralized control of education. Up until the late 1960's, education in British Columbia was highly government-centred. Fleming (2002) noted that:

> Control of provincial schooling was highly centralized and virtually all major decisions about schools were made within the province's educational bureau on Victoria's Government Street…. After 1972, however, this completely centralized and generally sedate world of school administration disintegrated, corroded from within by the passing of old traditions and harassed from without by powerful new forces that radically challenged how schools were governed and administered. (para. 3-4)

These influences, combined with rapidly increasing education budgets and growing public concern over educational quality, forced government action. Fleming (2002) stated this "meant that provincial authorities had to devise new ways to govern the system without a tangible administrative presence" (para. 26). The eventual actions taken by government can be seen as the planting of the seeds of what defines, regulates, and determines the role of large-scale assessments in modern day British Columbia education.

This "seed planting" had its beginnings in 1974 when the province passed legislation allowing the largest districts in British Columbia to hire their own superintendents. By 1980, all boards were afforded this freedom (Fleming, 2002). This marked a significant turning point as the provincial government, while still ultimately responsible for the results of the education system, had now essentially ceded a large portion of control to local administrative bodies. The relationship between this move and large -examinations in British Columbia will be discussed in an upcoming section.

The early 1980's. In addition to this decentralization initiative, by the early 1980's the province of British Columbia was experiencing financial difficulties. An economic recession, combined with historically high interest rates and 13.9% unemployment in 1983, hampered the financial well-being of many British Columbians (Statistics Canada, 2013). Further, school board

budgets, along with the local taxations that funded them, were drastically escalating at this time (Fleming, 2002).

At around the same time the British Columbia economy was stumbling, the National Commission on Excellence in Education (1983) in the United States published *A Nation at Risk*, a document that attributed the slumping American economy to problems within the public education system and advocated strongly for the implementation of standardized tests at the high school level. While American in origin, this report held great sway over Canadian educational policy makers (Raptis & Fleming, 2006; Ungerleider, 2006)

These factors created an environment that led to sweeping transformations in British Columbia in 1983, a time that marks the first of two watershed moments in what would come to define, regulate, and determine the role of large scale assessments at the senior secondary level in British Columbia.

1983 in British Columbia. In 1983, neoliberalism arrived in earnest in British Columbia with the budget and throne speech of then-premier Bill Bennett's Social Credit party. Richmond and Shields (2011) stated this budget "was unprecedented in its scope and in its shifting of policy agendas and discourse to the political right" (p. 218) and that the budget was a move in a direction "that would help liberate market forces, and create a climate very favourable to capital accumulation and business investment. These included deregulation, lower corporate taxes and constraining the power of trade unions" (pp. 218-219). In the accompanying throne speech, the government reiterated their major philosophical positions, which Ungerleider (1996) stated included "the inefficiency of the public sector brought about by excessive size and regulation; and the belief that growth and development can be achieved through private sector activities" (para. 23).

Since a thorough analysis of the many social and economic implications of this budget and the neoliberal leanings of the Social Credit government are beyond the realm of this paper, specific consideration will focus on one of the main tenets of this paper, that being standardized exams in senior secondary science in British Columbia. Among other policy changes, the socio-political climate emerging in the late 1970's and early 1980's led governments to begin using large scale test results as an accountability tool to ensure schools and districts were meeting educational standards (Firestone, Mayrowetz, & Fairman, 1998; Mussio, 2012; Torrance & Pryor, 1998). In British Columbia, this led to the re-introduction of Grade 12 provincial exams in the fall of 1983 (Mussio, 2012), exams that would continue until August of 2011.

Accountability 1.0 - Defining, Regulating, and Determining the Role of Grade 12 Exams

As discussed, the general catch-phrase "accountability" is most commonly used as the reason for implementation and functioning of arrangements such as the Grade 12 exam program. However, digging a little deeper and looking within the political rhetoric of the early 1980's, five major reasons, all under the general umbrella of accountability, can be seen as driving the implementation, and continued use, of these exams for so many years.

Focus on outputs. Firstly, the social and political changes of the early 1980's outlined on previous pages led to a public, and hence a government, that was hungry for hard data on the performance of the public school system. Passing were the Keynesian days where the focus was on government provisions, or "inputs", for public institutions such as education. The emerging neoliberal views advocated moving away from a "progressive" focus on government inputs into public services and towards a focus on the "outputs" of public services like education.

The implementation of high stakes science exams at the Grade 12 level in 1983 was a great example of this. These exams provided data that gave education stakeholders and the

taxpaying public concrete and easy to understand information on how students were allegedly performing (outputs) in the schools of British Columbia. Mussio (2012) noted that education was no different from any other public domain like highways or hospitals; the public wanted to know what kind of return they are getting for their financial investment; the simple to understand numbers provided by large scale exam scores supposedly provided this information.

Adherence to ministry objectives. Secondly, Mussio (2012) stated that during the 1970's and into the 1980's people became concerned about what he termed the "loose control" government had in curriculum and education in general. Mussio said this led to a call for strongly defined province-wide curricular objectives and an overhaul of the graduation program. Part of this overhaul was the 1983 introduction of Grade 12 provincial exams. Mussio said these exams, and the fact they counted for 50% of a student's mark, ensured strict adherence to the ministry established provincial curriculum by teachers. Whether intrinsically or extrinsically, these high-stakes exams lead many teachers to take ownership of producing the outputs (suitable test scores) relative to curricular objectives desired by government.

Decentralization. Thirdly, as mentioned earlier, by 1980 all school districts in British Columbia were able to hire their own superintendents to oversee operations (Fleming, 2002). This signaled a shift in control from a centralized (ministry centred) model to a decentralized one where the Ministry of Education, on the surface at least, was ceding control to districts while still being ultimately responsible for education in the province.

The Grade 12 provincial exams, along with various testing programs at lower grade levels, provided for the central ministry a surveillance tool to ensure each district and its schools were teaching the mandated curriculum. Since the Grade 12 exams counted for 50% of a student's mark, and were based on curriculum prescribed by the ministry, tight adherence to

government desires by teachers and students were largely ensured. This model, with exams serving as a form of surveillance, allows government to run the education system by "steering at a distance" (Ball, 1994, p. 54) and, at least partially, deflects blame for poor results (outputs) onto districts and schools.

Economic ties. On the preceding pages it was noted that neoliberal doctrine places a strong emphasis on education as a means of training workers to maintain a vibrant economy. In addition to this link, two further connections between education and the economy were noted, connections that also influenced the re-introduction of Grade 12 science exams in 1983.

Firstly, the beginning portion of this paper discussed how the dominant argument for why we teach science centres on economics (Amgen Canada Inc., 2012; Hassard, 2010; Turner, 2008). In this section, I outlined the importance researchers, government officials, and the public place upon science as a vehicle to produce the technologies and innovations that will keep Canada competitive in the global marketplace. In addition, while it may be argued the link between science education and the economy is stronger today than in 1983, it is worth remembering that in 1983 the Cold War was still in effect, strengthening the argument for science being a key tool for national defence purposes. Since it is an old adage in education that what is important gets tested, the privileged place science enjoyed as a "core academic" subject and a driver of our national security and economy made it a prime candidate for the scrutiny of a government-administered high-stakes exam.

Secondly, as also discussed earlier, 1983 marked the release of *A Nation at Risk* (National Commission on Excellence in Education, 1983). The authors of this report drew strong links between the economic strength of a nation and that nation's education system. In addition, the report called "for standardized tests of achievement at major transition points from one level of

schooling to another and particularly from high school to college or work" (p. 22). This report, as previously mentioned, had a large effect on Canadian education policy makers and is credited by some for having an influence on exam programs in our country (Ungerleider, 2006).

With these forces strongly at work in 1983, it is not surprising that the re-introduction of Grade 12 provincial exams in British Columbia included tests in Physics 12, Biology 12, and Chemistry 12. The data derived from student results of these tests were assumed to provide a potentially useful indicator of our strengths, weaknesses, and areas needing improvement in science education.

University pressure. Finally Mussio (2012), who at this time was a high ranking official in the assessment program at the Ministry of Education, remarked that since the cancelling of Grade 12 provincial exams in the early 1970's, universities were frequently expressing concerns to his office. These concerns, justified or not, centred on high school marks inflation, the quality of British Columbia graduates and how, without provincial exams, it was difficult to gauge entrance applications. Mussio noted that universities "pushed very, very hard" for exams to be put back in at the Grade 12 level and that this pressure played a role in the revision of graduation requirements and the re-implementation of Grade 12 provincial exams for those entering senior year in the fall of 1983.

Since the implementation of exams would require all students in Physics 12, Chemistry 12, and Biology 12 to write the exact same course-ending assessments, it was felt these exams would give universities a "fair" method of comparing high school graduates applying to post-secondary education. This university entrance component would add another layer to the exam accountability picture and loomed large in the lives of Grade 12 teachers and students for nearly 30 years.

These new forces indicated a shift from the 1960's and 1970's, a time when Mussio (2012) said large scale provincial assessments were used only partly for accountability, but mostly for program evaluation and improvement. The factors discussed in the preceding sections - focus on outputs, adherence to ministry objectives, decentralization of administrative powers, education-economic ties, and university pressure – indicate a shift in ideology from decades past and all played a role in the re-introduction of Grade 12 exams in 1983. They are what defined, regulated, and determined the role of senior secondary exams in their early years and would continue to be a driving force behind these examinations for nearly three decades. However, before the cancellation of senior secondary exams in August of 2011, these forces would be fortified and joined by new influences. These developments will be discussed in the ensuing sections.

The Late 1980's and the 1990's

The remainder of the 1980's and the 1990's were significantly quieter than 1983. However, implementation of, and support for, neoliberal education policies continued in British Columbia, albeit at a much slower yet consistent pace which Richmond and Shields (2011) labelled "relentless incrementalism" (p. 231). For example, Fleming and Raptis (2005) noted how a British Columbia Provincial School Review Committee (1985) report showed almost 70% of public respondents to a survey indicated they felt standardized evaluations were "very important" (p. 17).

Further examples of the gaining popularity of neoliberal educational ideals both in public policy and mindset were underlined in a 1988 government sanctioned report by the Royal Commission on Education (1988). This document advocated for the rights of citizen consumers to choose private schools over public. The following year, the Social Credit government stated in

the School Act (British Columbia Ministry of Education, 1989) that, “the purpose of the British Columbia school system is to enable learners to develop their individual potential and to acquire the knowledge, skills, and attitudes needed to contribute to a healthy society and a prosperous and sustainable economy” (p. D-100). No other goals or purposes for education were given in this document, which strongly underlined government belief in the education-economic prosperity link.

During the 1990’s even the traditionally left of centre New Democratic Party in British Columbia adopted neoliberal-style education policies. Responding to public demands and opinion polls calling for increased accountability, in 1998 the NDP government implemented the Foundation Skills Assessment program, essentially tests of numeracy and literacy skills, for students in Grades 4, 7, and 10 (Ungerleider, 2006). Around this same time, through the Freedom of Information Act, the NDP made results of provincial assessments available to the public (Ungerleider, 2015). This allowed third party organizations such as the Fraser Institute to access this data and create influential school “report cards” that are generally unflattering to British Columbia’s public education system (Fraser Institute, 2010, 2011; Raptis, 2012).

The BC Liberals and the 2000’s

The relative calm of the 1990’s was shattered in 2001 with the election of Premier Gordon Campbell and the BC Liberal party. At the time, the electorate of British Columbia were ready for a change with a weak economy and scandals that dogged the New Democratic Party government of Premier Glenn Clark. A strong signal of this appetite for change was shown at the ballot box as the Liberals won a landslide 77 of the 79 seats in the provincial election (Elections B.C., 2013).

The Liberal party was elected on a platform of decreased taxation, deregulation, creation of a business-friendly climate, and deficit reduction (Poole, 2007). This platform attached education to economic competitiveness and spoke of the creation of an education system that would ensure "young people have the skills and knowledge to compete with the world's best and win" (BC Liberals, 2001, p. 7). Further, the program called for more decentralization in the education system, increased accountability, more flexibility and choice, and maintenance of funding arrangements with private schools.

Accountability 2.0 – Further Defining, Regulating, and Determining the Role of Grade 12 Exams

Following their resounding election win, the Liberal government began to implement their election promises with the implementation of Bill 34, also called *The School Amendment Act* (British Columbia Ministry of Education, 2002a). This bill, in terms of controversy and movement to the political right, rivalled the 1983 legislation of Premier Bill Bennett. Bill 34 had, in the words of Fallon and Paquette (2008):

> The central themes of accountability, parental empowerment, decentralization, choice, and the establishment of a quasi-free market in education, school-district *providers*, student *consumers*, and an increasing role for entrepreneurship became entrenched as organizing principles for the provision of public education in British Columbia. (p. 2)

Coupled with the events surrounding 1983, the socio-political climate of the early 2000's and the implementation of Bill 34 was the second watershed moment in defining the role of large-scale senior science assessments in British Columbia. The factors contributing to the implementation of exams in 1983, such as the focus on outputs, adherence to ministry objectives, decentralization, education-economy ties, and university pressure, were still a part of what

defined the role of these assessments in 2002. However, Bill 34 served to further fortify these old factors, while at the same time introducing new influences to the accountability landscape that would further entrench these exams into the fabric of the British Columbia education system. These themes centred around choice and markets, further tying of the economy to education, increased school autonomy and parental input, and increased accountability from government and outside agencies.

Choice, markets, and privatization. As mentioned earlier in the paper, a tenet of the neoliberal view of education is that education is a service, a commodity that is made available to consumers (parents and students) who have the free will to choose which service best suits their own personal interests. It is believed the introduction of choice into the educational "marketplace" will naturally induce competition where schools will strive to provide more and better services to attract the most customers. Schools not providing adequate programs and services will lose their market share of consumers and run the risk of "going out of business". Issues of equity are ignored in this framework, individual choice and responsibility is favoured, and education becomes a "private good to be pursued and provided in terms of individual self-interest" (Lubienski, 2001, p. 656).

In the areas of choice and markets, Bill 34 reaffirmed the government's commitment to increasing parental options through continued governmental funding of private schools. In addition, it introduced a new "open boundaries" policy within the public system, allowing students, space permitting, to attend any public school they wished. The logic behind this policy was that if a local neighbourhood "catchment" school did not suit the needs of a student and their parents, they were free, space permitting, to attend any school of their choice. The rationale was this system would naturally induce schools to improve and become more responsive to student

needs in order to not only keep their catchment students, but to also attract out of catchment learners and the funding dollars that come with them.

In keeping with the theme of education as a market commodity, Bill 34 allowed for, and encouraged, school districts to form business companies and engage in entrepreneurial activities. Fallon and Paquette (2008) stated "this policy change reconceptualised school districts as a new breed of public institutions acting like private enterprise in an open market for consumers" (p. 22). This policy has allowed schools and boards to undertake activities such as fee-charging specialty academies in areas such as sport and performing arts, recruitment of foreign exchange students to boost revenues, and the sale of educational services both within Canada and to foreign markets (Poole, 2007). All of these moves are attempts to create a quasi-marketplace within the public education system (Whitty, Power, & Halpin, 1998; Woods, 2000) and dovetails with the Harvey (2005) description of neoliberalism which, in part, states that "if markets don't exist (in areas such as land, water, education, health care, social security, or environmental pollution) then they must be created, by state action if necessary" (p. 2).

Within this marketplace, to allow consumers to make choices they feel are best for them, information is required. The markets and choice mantra of Bill 34 has been buttressed by the public provision by government of school and district exam scores. These scores are freely available on the British Columbia Ministry of Education website and are updated following the completion of each round of government exams. This easily accessible data can serve to provide education consumers with a source of information on which to base their decisions as they navigate the educational marketplace.

Since 1998 the right-wing "think-tank" the Fraser Institute has accessed these school exam marks and used them exclusively to formulate a report ranking public and private schools

in British Columbia. Despite glaring flaws and private-school biases in how these rankings are determined, they have "won the hearts of parents and the press" (Raptis, 2012, p. 187). To this end, there is evidence these rankings may play a role in the choices some parents make regarding the schools they select for their children (Gutstein, 2010).

While exam scores, used as an accountability tool, was not new to the province of British Columbia, the use of these scores for the purposes of marketing schools to potential consumers added another layer to the role large scale provincial assessments play in the accountability landscape of our province.

Education for economic benefits. The link between exams, the economy, and science education was discussed in the section detailing the events surrounding 1983. Leading up to Bill 34, the rhetoric in this area was amplified by statements made by the BC Liberal party. Around this time, the Liberals commissioned a study to make recommendations on how to improve public education in British Columbia (British Columbia Ministry of Education, 2002b). This report stated, in regards to the purpose of public education, that:

> Public education is the key to a healthy and a prosperous economy. Its value is framed by the need for a highly educated workforce in order to stay competitive in the knowledge-based global economy. The report reflects societal belief that an educated population has social and economic value for the individual and for society. (p. 7)

The report urged schools to develop highly skilled and entrepreneurial graduates that would contribute economically to enhance the competitiveness of British Columbia both within Canada and on the international stage. The recommendations of this report formed the basis of Bill 34 and led Fallon and Paquette (2008) to state "educational policy changes embodied in Bill

34 (2002a) occurred …in relation to a perceived need to prepare a flexible workforce required to enhance the competitiveness of the province within the global market" (p. 29).

Specific to science education, additional developments since 1983 have served to further entrench the status of science exams. Due to the importance placed on science in terms of our world standing and advantage economically, our results on the Organization for Economic Cooperation and Development (OECD) (2013) PISA exams have become highly scrutinized. These exams were not conducted in 1983 but today academic journals, popular media outlets, and even government websites (Statistics Canada, 2010) will often devote large amounts of copy and airtime to the comparison of the scores of Canadian students in comparison to other nations in the field of science. Rightly or wrongly, these results are reported in the media and scores are used as indicators by organizations such as the OECD (2013) of the strengths and weaknesses in our science and technology education both in British Columbia and Canada.

Parental empowerment and school autonomy. Bill 34 also facilitated increased participation of parents in schools. The bill mandated every school in the province was to have a School Planning Council, made up largely of parents. These groups were charged with formulating school improvement plans and goals, to be submitted to local boards, that centred around student achievement. While an examination of the improvement plans of each school in British Columbia would be an immense undertaking not feasible at this time, my personal experience with these councils in multiple schools suggests that these councils choose, as their indicators of progress, student performance on provincial exams administered by the Ministry of Education.

This element of Bill 34 serves two purposes. First, it makes teachers, through exam scores, more accountable to goals set by parents. Second, it allows the Ministry of Education to

give parents a feeling of input, despite the fact that ministry-administered exams remain the driver in planning council goals. This further cemented the dominant role these exams play in the lives of students and teachers. It also expands their function as a surveillance tool for the Ministry of Education in its "steering at a distance" (Ball, 1994, p. 54) management style, allowing for control of outputs while, superficially at least, empowering others to design how outputs will be arrived at.

Continued decentralization. Bill 34 also continued the decentralization movement that began in the 1970's. With this bill many administrative powers and functions from the central ministry were shifted to local boards, including increased autonomy in the areas of administrative structures and financial matters. These moves further served to distance government from day to day responsibility for public education, devolving this to local boards. With this increased responsibility comes greater accountability for producing suitable outputs. Fallon and Paquette (2008) stated:

> What matters is not process but output. Concern with provision for and equity of access and opportunity gives way to measures of output quality. In essence, what seems to be presented as an accountability approach to assessing quality of learning is gravitating to an evaluation of efficiency instead. (p. 19)

To maintain control of the education system while devolving responsibility, Bill 34 required each school district to prepare an accountability contract. Later renamed "achievement contracts", these documents focussed on improving student achievement in individual districts. "Improvement" and "achievement" in the contracts overwhelmingly were framed in relation to student scores on province-wide standardized exams such as Grade 12 provincial exams. In fact, accountability became such a large priority with the Liberal government that in 2007 Bill 20, the

School Amendment Act (Legislative Assembly of British Columbia, 2007), created a position of superintendent of achievement, who was given the authority to not only inspect but to revoke school board decisions.

This form of exam score based accountability allows the Ministry of Education to continue to decentralize controls, at least optically so, to boards. However, the focus on exam scores, with exams being made at the provincial level and based on ministry-established curriculum, allows government to conduct surveillance over districts in a very subtle way. In addition, these high profile accountability contracts serve to put the focus on outputs (test scores) of schools as opposed to resource (financial) inputs from the government end, shifting accountability for education away from a progressive model and to a neoliberal model where responsibility for results rests squarely on the shoulders of individual districts, schools, teachers, and students. Fallon and Paquette (2008) characterize this more as: "government has maintained control of the overall framing and output functions (policy, curriculum, assessment, audit) while decentralizing responsibility for implementation and management functions to school-districts" (p. 29).

As the preceding pages have shown, a multitude of forces have been at play in defining, regulating, and determining the role of senior secondary science assessments in British Columbia over the past three decades. Socio-political and education trends in the 1970's and early 1980's, such as focus on outputs, adherence to ministry objectives, decentralization of administrative controls, education-economic ties, and university pressure, all contributed to the re-implementation of Grade 12 science exams in 1983. Many of these forces strengthened with time and were joined in the early 2000's by focuses on choice, markets, and parental empowerment to make Grade 12 exams in British Columbia a high profile, high-stakes program.

Arguments Used By Proponents of Large-Scale Testing

There is an abundance of literature advocating for standardized testing. An examination of this literature reveals a myriad of arguments in favour of this practice. However, very few of these writings use peer-reviewed research to substantiate their claims. Therefore the ensuing discussion on this topic will focus upon research-based arguments that directly affect teachers and their practice.

Assessment of student and program strengths and weaknesses. Proponents of standardized testing argue these exams allow for the collection of data for the purposes of evaluating individual students, school programs, and various segments of school populations. Taylor and Tubianosa (2001) investigated student assessment in Canada and called for broad levels of testing in each province for the purposes of measuring and improving school and student performance. In this vein, following each session of provincial exams the British Columbia Ministry of Education provides schools and districts with reports detailing performance of students in the various subjects evaluated. The Ministry advises schools and districts that this data can be used to monitor trends over time for the purposes of implementing interventions to improve programs and student achievement (e.g. British Columbia Ministry of Education, 2005). Proponents of standardized testing argue when assessment data is used in this manner teachers may better assess student strengths and weaknesses and plan instruction accordingly for students to receive any required assistance (Borko & Stecher, 2001; Dee & Jacob, 2006; Massell, 2001; McMillan, 2000).

In this regard, following their study of the Grade 12 provincial exam program in British Columbia, Anderson, Muir, Bateson, Blackmore, and Rogers (1990) reported there was “some” use of examination data in this manner by teachers. Specifically, these authors suggested data

surrounding exam results was used to a "moderate" degree by teachers to compare exam results with teacher-assigned grades and to outcomes of other schools within their own district and across the province. However, it is worth noting these authors did not speak about teachers using data in any way to improve student learning or classroom instruction.

In an American-based study, Murnane and Papay (2010) stated many teachers surveyed regarding *No Child Left Behind* (2002) related the testing element of this program helped identify skill deficiencies in low achieving students and assisted in developing strategies to remediate these issues. Similarly, Buck, Ritter, Jensen, and Rose (2010) indicated "almost all" teachers they interviewed noted testing provided useful data in regards to student progress. Likewise, the Center on Education Policy (2006) reported an increase in the use of exam data in guiding teacher planning and instruction while Yeh (2005) reported teachers establishing after-school programs focussing on the needs of their low-achieving students.

Testing advocates also argue exam data can be used to compare students by sub-groups. For example, comparisons can be made between males and females, native English speakers and English as a second-language learners, ethnic minority groups and the majority, and high and low socioeconomic status groups (Canadian School Boards Association, 2010; Giambo, 2010; Lee & Wong, 2004). The rationale for these comparisons lies in a belief that if discrepancies are revealed between groups, causal factors may be determined and action taken to remediate potential issues.

Teacher motivation and focus. Supporters of high-stakes standardized testing believe education quality increases with the rewards and consequences that come with this form of evaluation (Raymond & Hanushek, 2003). Standardized tests are seen as a means of motivating both teachers and students to work harder, with the end result believed to be increased student

achievement. Research in this area is surprisingly limited in volume and somewhat inconclusive in its findings.

In terms of motivation, research suggests while standardized testing can serve to motivate and increase efforts in teachers, it also leads to a decline in morale (Kelley, Heneman, & Milanowski, 2002; Mintrop, 2003). Gayler (2005) indicated while teachers working in exit-exam situations generally had mostly negative comments regarding these circumstances, some revealed the exams served to induce less motivated teachers to stay focussed on the curriculum. Further, Yeh (2005) reported teachers in standardized testing settings were more focussed on what they had to teach, more goal-oriented, and reflective about their practice; similar findings to this were reported by Buck, Ritter, Jensen, and Rose (2010).

While some studies have reported standardized testing producing negative effects on staffs and teachers morale (Byrd-Blake, Afolayan, Hunt, Fabunmi, Pryor, & Leander, 2010; Finnigan & Gross, 2007), others have reported positive findings in this area. Both Gayler (2005) and Yeh (2005) reported more dialogue, communication, and collaboration centred on teaching and student learning among staff members working in high stakes testing situations.

Limitations of the Remainder of This Literature Review

The remainder of this review will focus upon what literature reports regarding how testing situations influence teachers and their practices. An extensive search revealed only two research papers specifically examining the British Columbia Grade 12 provincial exam program (Anderson, Muir, Bateson, Blackmore, & Rogers,1990; Wideen, O'Shea, Pye, & Ivany, 1997). Of these two, only Wideen, O'Shea, Pye, and Ivany had science courses as a primary focus. In order to expand the quantity of research examined for this review, a large volume of articles not focussing on British Columbia, the subject of science, and Grade 12 courses had to be surveyed.

The findings of this review will be discussed on the subsequent pages. However, it bears noting that one may need to exercise caution when drawing parallels from one exam program to another. Various factors surrounding the setting studied in an investigation may make it difficult to transfer findings from one program and super-impose them upon another. These factors will be briefly discussed below.

The "stakes" of the testing program investigated. The "stakes" of an exam program may influence the conclusions researchers arrive at regarding impacts of assessments upon teachers. For example, in some testing programs (although not in British Columbia) student test scores have a large bearing on teachers' job security (Murnane & Papay, 2010; Yeh, 2005) and/or financial compensation (Jones, Jones, Hardin, Chapman, Yarborough, & Davis, 1999; Yeh, 2005). In addition, tests may be used to determine if students graduate from high school and various sanctions may be imposed by government upon schools whose student body does not meet expectations on tests (Abrams & Madaus, 2003; Jones, Jones, Hardin, Chapman, Yarborough, & Davis, 1999; Murnane & Papay, 2010). Further, in some jurisdictions the results of large-scale standardized tests may be used to "rank" schools in a public forum (Fraser Institute, 2011) and exam scores may be utilized to determine student course grades and scholarship awards (British Columbia Ministry of Education, 2012a). As defined at the conclusion of this chapter, testing environments where some or all of these pressures exist may be labelled as "high stakes". Testing circumstances where these influences are absent may be labelled as "low stakes".

A substantial body of research strongly suggests the higher the "stakes" of a test, the greater the influence on teachers and their practices (e.g., Jones et al., 1999; McMillan, Myran, & Workman, 1999; Pedulla, Abrams, Madaus, Russell, Ramos, & Miao, 2003; Stecher, Barron,

Chun, & Ross, 2000; Yeh, 2005). Therefore, research cited in this review may have had its conclusions influenced by the stakes of the exam program it was investigating.

Curricular subject(s) and grade level(s) examined. In addition to the stakes surrounding a large-scale standardized testing program, research findings may differ depending upon what curricular subject(s) is/are the focus of the investigation. Following an exhaustive search for this review, only a small portion of literature found focused exclusively on how testing impacts educators teaching *science* courses (e.g. Collins, Reiss, & Stobart, 2010; Sturman, 2003; Wideen, O'Shea, Pye, & Ivany, 1997). Therefore, a large volume of the literature quoted on the ensuing pages may come from curricular areas outside the realm of science.

Similar to the issue discussed in the previous paragraph, the majority of literature uncovered surrounding the effects of standardized testing on teachers does not specifically target teachers at the Grade 12 level. While a handful of studies found did deal with this grade level (e.g. Anderson, Muir, Bateson, Blackmore, & Rogers, 1990; Puhlmann, 1991; Wideen, O'Shea, Pye, & Ivany, 1997), many investigations examine teachers at lower grade levels. Further, of all literature found for this review, only Wideen, O'Shea, Pye, and Ivany focussed exclusively on Grade 12 science courses in British Columbia.

Socio-economics. Finally, some researchers have suggested the socio-economics of a school population may have a significant effect on how a testing program influences teachers and their work. Research indicates teachers serving students from disadvantaged backgrounds feel greater pressure to narrow the curriculum, teach to the test, and allocate resources into test-prep materials and programs (Herman, 1992; McNeil, 2000a; Pace, 2011). Therefore, some research cited may have had its findings influenced by the socioeconomics of the location(s) investigated.

The Effects of Large-Scale Standardized Exams on Teachers and Their Practice

There is a large volume of literature speaking to the issue of how the presence of exams influences teachers and their practice. This literature includes a multitude of effects, each of which will be discussed on the subsequent pages.

Increased teacher stress and pressure. Research suggests teachers working in large-scale testing environments incur greater degrees of stress and pressure than teachers not working under such conditions. Both research documents focussing on the British Columbia Grade 12 provincial exam program concurred with this statement. Anderson, Muir, Bateson, Blackmore, and Rogers (1990) reported an increase in stress levels experienced by teachers following the implementation of provincial exams in 1983. Wideen, O'Shea, Pye, and Ivany (1997) surveyed British Columbia science teachers at the Grades 8, 10, and 12 levels and found the Grade 12 teachers felt a greater deal of "psychological pressures" than those teaching Grades 8 and 10, pressures they attributed to the presence of the year-end exam in Grade 12 courses.

Outside the British Columbia context, a large quantity of research parallels these findings. Jones, Jones, Hardin, Chapman, Yarborough, and Davis (1999) conducted an investigation of teachers in North Carolina shortly after a high stakes testing program was put into place and reported 76% of respondents felt their jobs were more stressful than before the program began. Further, 88% of teachers surveyed in Maryland (Koretz, Mitchell, Barron, and Keith, 1996), 98% in Kentucky (Koretz, Barron, Mitchell, & Stecher, 1996), and 90% in Minnesota (Fitzgerald, 2008) believed they were under "undue" and "unfair" pressure to improve student performance on state-wide tests. Abrams, Pedulla, and Madaus (2003) reported similar findings and noted the higher the "stakes" of the test, the greater the pressure teachers felt to produce high student test scores. The need to produce positive outcomes on large-scale

standardized tests has also been shown to cause increases in teacher stress and pressure by a large volume of additional investigators (e.g. Ballet, Kelchtermans, & Loughran, 2006; Berry, 2009; Jones & Egley, 2004; Maisuria, 2005; McCarthey, 2008; Moon, Brighton, Jarvis, & Hall, 2007; Scherff & Hahs-Vaughn, 2008; Valli & Buese, 2007).

In addition to the pressures to produce high test scores, research suggests many teachers worry about the consequences of not producing these scores. These concerns centre on job security, loss of professional freedoms, and potential changes to schools if acceptable test scores are not produced (Gayler, 2005; Murnane & Papay, 2010; Reback, Rockoff, & Schwartz, 2013).

The implications of this exam-related stress may be disconcerting to school administrators and the general public based on the findings of Hoffman, Assaf, and Paris (2001) who found 85% of Texas teachers surveyed agreed with the statement "some of the best teachers are leaving the field because of the TAAS", a test the authors noted Texas students had to pass at the Grade 9 level in order to graduate high school. Further, Crocco and Costigan (2007) found pressures associated with high stakes testing play a role in creating feelings of disenchantment that can lead to teachers leaving the profession. Similar findings regarding test-related stress exacerbating the problem of teachers departing the profession were reported by Scherff and Hahs-Vaughn (2008), Calderhead (2001), Haney (2000), Reardon (1996), and Smith (1991).

Changes in staff morale. In addition to the stress levels associated with teaching in a standardized test-driven environment, research indicates such environments may also influence both individual teacher and overall staff morale. Anderson, Muir, Bateson, Blackmore, and Rogers (1990) reported that, following the re-introduction of Grade 12 provincial exams in British Columbia in 1983, teachers, principals, and counsellors all reported the presence of these exams led to a decrease in morale on teaching staffs. Another study focussing on the British

Columbia Grade 12 exam program conducted by Wideen, O'Shea, Pye, and Ivany (1997) revealed teachers expressed a general unhappiness surrounding the psychological pressures associated with the exams. In addition these researchers found the comparison of test scores from one teacher to another or one school to another created feelings of resentment among teachers who expressed concerns their competence as teachers was judged on the basis of student exam performance.

Similar findings were noted in studies conducted outside British Columbia. Jones, Jones, Hardin, Chapman, Yarborough, and Davis (1999) found 77% of teacher respondents in their study said teacher morale decreased following implementation of an exam program. Similar results were found in Kentucky and Maryland where more than 50% of Maryland teachers and roughly 75% of Kentucky educators indicated teacher morale deteriorated following the implementation of state tests (Koretz, Barron, Mitchell, and Stecher, 1996; Koretz, Mitchell, Barron, and Keith, 1996). The constant need for teachers to show growth in student test scores has also been reported as a cause of low teacher morale by Byrd-Blake, Afolayan, Hunt, Fabunmi, Pryor, and Leander (2010), Finnigan and Gross (2007), Mintrop (2003), and Kelley, Heneman, and Milanowski (2002).

Further, McNeil (2000b) and Charlesworth, Fleege, and Weitman (1994) reported teachers felt shame and embarrassment when students scored poorly on tests, which eroded the teachers' sense of efficacy and feelings of competence. Potentially exacerbating this problem are findings by Finnigan and Gross (2007) that teachers' motivation to increase their efforts on behalf of students decreased in schools that continued to produce poor exam results.

In addition, Abrams, Pedulla, and Madaus (2003) surveyed teachers and found those who felt the greatest degrees of pressure from either superintendents or principals regarding exam

results were most likely to work in schools with lower teacher morale. They further found a large proportion (38%) of teachers in testing programs with high stakes indicated they wished to transfer out of the grade in which tests were administered. Calderhead (2001) reported similar findings that teachers working under such tightly regulated conditions expressed feelings of job dissatisfaction, lowered commitment levels, burnout, and damaged self-esteem. Not surprisingly, teachers working in environments highly focussed on standardized tests have been found to express doubts about their suitability for the profession and their ability to craft a satisfying teaching practice (Crocco & Costigan, 2007; Wright, 2002).

Staff relationships. Literature surrounding the effects of large-scale testing programs on teaching staff relationships is somewhat contradictory and inconclusive. In a survey of teachers following the re-implementation of Grade 12 provincial exams in British Columbia in 1983, Anderson, Muir, Bateson, Blackmore, and Rogers (1990) reported 70% of teachers they surveyed revealed their relationships with colleagues are essentially the same as they were prior to exam implementation.

In contrast, a portion of research in this area suggests such exams leads teachers to become more co-operative and collaborative in areas such as planning, increases dialogue about student performance, forces "resistant" teachers to more closely follow the curriculum, and leads to greater communication between classroom and special education teachers (Buck, Ritter, Jensen, and Rose, 2010; Gayler, 2005; Valli & Buese, 2007; Yeh, 2005).

Negatives surrounding staff relations and large scale testing programs noted in the literature include teachers of non-tested subjects feeling their classes were less valued and had decreased "status" in the school (Anderson, Muir, Bateson, Blackmore, & Rogers, 1990; Gayler,

2005). In addition, some research indicates the presence of exams creates unhealthy struggles between colleagues (Gayler, 2005; Jones & Egley, 2004).

An increase in teacher workload. Valli and Buese (2007) reported teachers have increased workloads due to testing, with additions being directly proportional to the pressure and stakes of the exam program. In particular, these researchers cited issues such as collection and analysis of student exam data, meetings surrounding such data, implementing district exam initiatives, and devising and implementing instructional responses to this data, as adding to teacher workload. Similarly, Gayler (2005) reported teachers in a high-stakes environment felt pressured by districts to focus on planning lessons and collecting evidence that curricular objectives had been "covered" rather than teaching. One teacher in Gayler's study professed "every day we have to write down what… objectives we covered to cover ourselves if the tests come back bad" (p. 17).

Other researchers have reached similar conclusions surrounding the correlation between exams and increased teacher workload (Ballet, Kelchtermans, & Loughran, 2006; Elmore & Furhman, 2001; O'Day, 2002). Interestingly, both Elmore and Furhman and Valli and Buese contended that despite workload increase and the appearance teachers were working harder, there was little evidence to suggest the teachers in their investigations actually improved their instructional practice.

Allocation of school and classroom resources. While not a large research focus, findings surrounding allocation of school resources vis-à-vis testing was discussed in a portion of the literature examined. Specifically, studies speak about the purchasing of supplemental test preparation materials by teachers and school administrators as a means of complimenting classroom teaching (McClaskey, 2001; McNeil, 2000a & 2000b; Mitchell, 1997; Nathan, 2002;

Pedulla, Abrams, Madaus, Russell, Ramos, & Miao, 2003; Pringle & Martin, 2005; Traub, 2002; Valli & Buese, 2007). For example, a national study in the United States by Pedulla, Abrams, Madaus, Russell, Ramos, and Miao (2003) found teachers in high-stakes testing situations were four times more likely than those in low stakes environments to purchase and use commercial test-preparation materials; similar findings focussing on the purchase of test preparation materials in high stakes environments was reported by Pringle and Martin (2005), Traub (2002), McClaskey (2001), and Mitchell (1997). Further to this, McNeil (2000a) reported on a school that used almost an entire year's instructional budget to purchase test preparation materials, while an English teacher in an investigation conducted by Gayler (2005) revealed "in English, we buy SOL coaching books instead of literature now" (p. 15). Gayler also reported that in some instances, resources were reallocated from other budgetary areas to cover the demands of exams.

Classroom assessment aligning with exams. In the large volume of literature examined for this review, no authors spoke of a situation where a standardized test constituted 100% of a student's report card mark. Therefore, it is the assumption of this writer that all teachers examined in the reviewed literature are required to evaluate students throughout the school year and report these assessments to administrators, students, and parents. With this in mind, a large volume of literature indicated teachers working in standardized testing situations direct their assessment to match the standardized test in terms of assessment formats, frequency of assessments, and assessment weighting.

Assessment format. In terms of assessment format, a study examining re-implementation of Grade 12 provincial exams in British Columbia reported teacher-made tests showed a "striking increase" in the use of multiple-choice questions and a reduction in the use of open-ended problems following exam re-implementation, changes that mimicked the format of the

course-ending provincial assessments (Anderson, Muir, Bateson, Blackmore, and Rogers, 1990). Similarly, Abrams, Pedulla, and Madaus (2003) revealed teachers tailored in-class test formats to that of the standardized exam students would write. Specifically, they found 51% of teachers in high-stakes situations (compared to 29% in low-stakes situations) reported classroom tests were of the same format as state tests. Valli and Buese (2007), Gayler (2005), Jones and Egley (2004), and, Darling-Hammond and Wise (1985) all reached similar conclusions that teachers aligned test questions and formats with those students would encounter on standardized tests.

In some cases it would appear this emphasis on exam format has become so pervasive that teachers are incorporating items from previous exams into their own classroom assessment. Anderson, Muir, Bateson, Blackmore, and Rogers (1990) found teachers of Grade 12 provincial examinable courses in British Columbia used exam questions from previous years to define what they taught and compose student assessments such as tests and quizzes. Wideen, O'Shea, Pye, and Ivany (1997) reported similar findings in the British Columbia Grade 12 exam program where they found Grade 12 science teachers placed a high value on building a "pool" of test questions from previous exams to be used as part of their in-class tests, quizzes, and assignments. Collins, Reiss, and Stobart (2010) studied Year 6, which is the sixth year of compulsory education and incorporates students between the ages of 10 and 12, science teachers in the United Kingdom and discovered these teachers also relied on items from previous science exams to be part of their assessment of pupils' attainment in science. Gayler (2005) reported similar findings, revealing teachers in his Virginia-based study frequently incorporated questions from old exams into class discussions and tests. These results suggest that in high-stakes exam environments teachers, to at least some extent, willingly relinquish their individual professional

autonomy over student assessment in order to prepare students for exams. McLaren (1989) stated:

> The increasing adoption of management-type pedagogies has resulted in… the deskilling of teachers and the creation of a technocratic rationality in which planning and conception are removed from implementation, and the dominant model of the teacher becomes that of the technician or white-collar clerk. (p. 5)

Assessment frequency. In the area of assessment frequency, Anderson, Muir, Bateson, Blackmore, and Rogers (1990) found an increase in the number of in-class tests administered by teachers through the year in British Columbia Grade 12 courses following re-implementation provincial exams in 1983. Jones, Jones, Hardin, Chapman, Yarborough, and Davis (1999) also revealed nearly 40% of teachers surveyed shortly after implementation of a high stakes testing program reported using tests more frequently as a means of assessment in their classroom. Further, Abrams, Pedulla, and Madaus (2003) reported 31% of teachers in high stakes situations (as opposed to 17% in low stakes situations) stated they gave weekly multiple-choice quizzes that mimicked the state test in format and content; similar findings on test frequency and format have been reported by McMillan, Myran, and Workman (1999), Mehrens (1998), Stecher, Barron, Kaganoff, and Goodwin (1998), Corbett and Wilson (1991), and Madaus (1988).

Assessment weighting. In addition to potential changes to assessment format and frequency, a single finding from the study conducted in British Columbia by Anderson, Muir, Bateson, Blackmore, and Rogers (1990) bears mentioning. These researchers found that following implementation of British Columbia Grade 12 provincial exams, in the area of student report card grading, teachers increased the weighting assigned to class-based tests while decreasing the portion assigned to projects, assignments, and labs.

Impact on relationships with students. A small portion of the research reviewed spoke to how large-scale testing environments impact teacher-student relationships. A large portion of educators in studies conducted by Abrams, Pedulla, and Madaus (2003), Jones, Jones, Hardin, Chapman, Yarborough, and Davis (1999), and Koretz, Barron, Mitchell, and Stecher, (1996) reported they felt their students experienced higher degrees of anxiety and pressure as a result of being in a class/grade that featured a large scale test.

This pressure and anxiety may play a role in altering relationships between teachers and students. Anderson, Muir, Bateson, Blackmore, and Rogers (1990) reported after Grade 12 exams were re-introduced in British Columbia in 1983 nearly 30% of teachers reported at least some change in relationships with their students. Although the article did not elaborate on the specifics of these changed relationships, Crocco and Costigan (2007) hypothesized the drive to teach to the test pushed teachers away from opportunities to use student-centred pedagogies and lessons tailored to student needs, which potentially led to a de-personalization of the student-teacher relationship.

Valli and Buese (2007) conducted a similar investigation and reported findings that echo those from the above paragraph. They found teachers reported pedagogical and personal relationships with students were compromised in a standardized testing environment. They stated this environment created a situation where "the focus was 'not on the child' but on the information due date" (p. 548) and teacher-student interaction was reduced to remediating student deficiencies in relation to the exam. Valli and Buese described the end result being diminished relationships between teacher and students.

Time spent on test-specific preparation activities. The literature examining the impacts of standardized testing on teachers contains a great deal of information regarding strategies

educators use to prepare students for these tests. Two such areas focus on time devoted to test preparation and specific test-taking strategies students are taught.

Time. In terms of time spent on exam preparation, Anderson, Muir, Bateson, Blackmore, and Rogers (1990) concluded Grade 12 teachers in British Columbia spent a large portion of class time on test-related activities. They also reported teachers provided students a substantial amount of outside of class tutorials to prepare for exams. Similarly, Wideen, O'Shea, Pye, and Ivany (1997) stated the British Columbia Grade 12 science teachers they surveyed indicated that "too much" class time was spent preparing students for exams and that students had become so ingrained in exam prep that they "tuned out" when teachers introduced activities or material not relevant to the exam.

While the above two studies are relevant as they focussed on Grade 12 exams in British Columbia, they did not place specific numbers on the amount of class time devoted to exam preparation. Pedulla, Abrams, Madaus, Russell, Ramos, and Miao (2003) conducted a national survey in the United States and found 44% of teachers in high stakes environments spent more than 30 hours of class time in a year on test preparation activities, as opposed to just 10% of teachers in low stakes settings. In addition, 70% of teachers in high stakes settings reported spending time through the entire school year on exam preparation (rather than just in the weeks prior to the exam) as opposed to 43% in low-stakes environments.

Further, Jones, Jones, Hardin, Chapman, Yarborough, and Davis (1999) investigated a high stakes testing environment and chronicled of 470 teachers they surveyed, 80% indicated their students spent 20% of their instructional time during the school year practicing and preparing for their end of year tests. Further, more than 28% of these teachers indicated they spent more than 60% of instructional time practicing for tests. Similarly, Gayler (2005) reported

teachers in his study spoke of "cramming" for the exam in the last two or three weeks of school before the exam, a time in which these teachers reported covering no new curricular material with their students.

In other studies focussing specifically on time spent preparing students for tests, Hoffman, Assaf, & Paris (2001) reported teachers in Texas revealed they spent on average 8-10 hours per week through the entire school year preparing students for the Texas Assessment of Academic Skills (TAAS). In a study performed in Britain, Harlen (2007) assessed several surveys of classroom time usage and concluded students in Year 6 (age 11 years) spent a combined total of 13 school days preparing for testing and performing these assessments.

While not specifying hours or percentage of class time spent on test preparation, a large volume of studies has reported findings similar to those noted in the preceding paragraphs. For example, both Collins, Reiss, and Stobart (2010) and Sturman (2003) conducted investigations focussing on Year 6 (11 year-olds) classes in the United Kingdom preparing for a large-scale science test and found an overwhelming percentage of teachers they surveyed stated they went away from the regular curriculum leading up to the test in order to create time to prepare students for the exam. Similarly, a large number of researchers across various jurisdictions, subjects, and grades have found schools devoting class time away from content instruction and towards test-taking strategies and preparation (Diamond, 2007; Hamilton, Stecher, Marsh, McCombs, Robyn, Russell, & Barney, 2007; Hillocks, 2002; Jones & Egley, 2004; Jones, Jones, & Hargrove, 2003; Mansell, 2007; McCarthey, 2008; McNeil, 2000a; Moon, Brighton, Jarvis, & Hall, 2007; Patterson, 2002; Reback, Rockoff, & Schwartz, 2013). Additionally, McClaskey (2001) reported that to make time for a test preparation "period", teachers skimmed minutes off of other periods during the school day, taking time away from untested topics.

***Test preparation activities*.** Research in this area also detailed specific test preparation activities teachers engaged in, what Anderson, Muir, Bateson, Blackmore, and Rogers (1990) spoke of as coaching students on how to write tests. Aside from the major activity of covering exclusively the material that would be on tests (a strategy discussed in another section of this paper), strategies reported included how to fill in answer sheets correctly and budget time while writing a test, preparing students in the type of questions they would encounter (e.g. multiple choice), how to read test questions correctly, and using questions or entire tests from previous years as practice. In addition, researchers have reported teachers providing extra tutoring sessions for students both inside and outside of class time, using commercial test-preparation materials, and working through teacher-made study guides as additional test-preparation activities (Abrams, Pedulla, & Maduas, 2003; Anderson, Muir, Bateson, Blackmore, & Rogers, 1990; Center on Education Policy, 2007; Collins, Reiss & Stobart, 2010; Diamond, 2007; Gayler, 2005; Hillocks, 2002; Hoffman, Assaf, & Paris, 2001; Jones, Jones, Hardin, Chapman, Yarborough, & Davis, 1999; Klenowski & Wyatt-Smith, 2010; Luna & Turner, 2001; McNeil, 2000a; McNeil & Valenzuela, 2000; Pedulla, Abrams, Madaus, Russell, Ramos, & Miao, 2003; Sturman, 2003). Jones and Egley (2004) reported that teachers in their study said many of these skills and knowledge otherwise would not have been taught were it not for the presence of the exam. Further, Abrams, Pedulla, and Maduas (2003) conveyed that the higher the "stakes" of the test, the more likely teachers were to focus on such strategies.

Alignment of curriculum and exam/teaching to the test. Perhaps the largest portion of literature examining the impact of testing environments on teachers focuses on how such settings impact curriculum delivery. Research suggests a by-product of the time and effort focussed on test preparation detailed in the previous section is this time comes at the expense of other

curricular areas, a phenomenon commonly referred to as “curriculum narrowing” (e.g. Jones & Egley, 2004) or “teaching to the test” (e.g. Anderson, Muir, Bateson, Blackmore, and Rogers, 1990). Au (2007) looked at 49 qualitative studies focussing on high stakes testing and its effect on teaching and curriculum delivery and found:

> In an overwhelming number of the qualitative studies, participants reported instances of the narrowing of curriculum, or curricular contraction to tested subjects. This phenomenon was the most prominent way in which ‘teaching to the test’ manifested in curricula, as non-tested subjects were increasingly excluded from curricular content. (p. 262)

Grade 12, British Columbia, and science-specific examples. In their study of the Grade 12 provincial exam program in British Columbia, Anderson, Muir, Bateson, Blackmore, and Rogers (1990) found the problem most noted by teachers was that curriculum narrowed to the point where they taught only what would appear on the exam. Essentially, Anderson et al. revealed if curricular items were not tested, they were either not emphasized by teachers or dropped altogether, while items consistently appearing on provincial exams became the focus of instruction. In a similar study of Grade 12 exams in British Columbia focussing specifically on Grade 12 science courses, Wideen, O’Shea, Pye, and Ivany (1997) reported parallel findings. These authors conveyed that 16 of 18 teachers surveyed stated the scope of what they taught was narrowed due to the presence of the provincial exams. Specifically, these teachers said certain topics were no longer taught in great depth and other topics had been eliminated entirely to accommodate the preparation of students for the provincial exam. The authors stated the general tone from survey participants was teachers felt they were teaching students how to write tests rather than teaching science. The study currently being undertaken by myself examines how

these and other issues were affected when these Grade 12 science exams were eliminated in British Columbia.

In the province of Alberta, a jurisdiction that had a Grade 12 exam program similar to that of British Columbia, Puhlmann (1991) examined the effect of Grade 12 exams on the teaching practices of teachers of Trigonometry. He concluded the content of this course was:

> Condensed to its most manageable and measurable fragments, splitting the learning process into means and ends, and emphasizing the province-wide exam as the most important event for teachers and students... The result is that students acquiesce to the pattern of classroom knowledge thereby participating in their own de-skilling of mathematical knowledge. (p. 261)

In terms of science, Collins, Reiss, and Stobart (2010) examined teachers working within the Year 6 (11 year-olds) large-scale standardized science exam in the United Kingdom and reported a perception among teachers that test preparation narrows the science curriculum. Since the test these teachers were preparing students for only focussed on a limited sampling of the curriculum, only the portions of the curriculum likely to appear on the test became the focus of classroom instruction. A consequence of this, the researchers concluded, was that many of the investigatory and laboratory aspects of science were omitted from the classroom experience by teachers. In addition, Collins, Reiss, and Stobart concluded, like Hopkins (2003) had in an investigation conducted under similar circumstances, the presence of an exam meant many students in science were unlikely to engage in out-of-classroom activities, such as field trips, that may serve to divert attention away from the curricular components that would be tested. Sturman (2003) and Jurd (2000) also investigated science teachers working in the Year 6 program in Britain and reached similar conclusions to the preceding authors, finding exam preparation came

at the expense of other science activities and forced teachers to narrow the curriculum delivered to students.

Subject-specific examples. While the narrowing spoken of in the above paragraphs addressed science teachers eliminating or de-emphasizing curricular topics, research suggests this phenomenon also occurs in subjects outside of science. In a large, nation-wide U.S. based study, the Center on Education Policy (2007) revealed that, in districts with English and Mathematics state tests, overwhelming numbers of districts reported English and math curriculum delivered to students was adjusted to place greater emphasis on the content and skills included on state tests.

Similarly but on a smaller scale, Gayler (2005) investigated two districts in Virginia following the implementation of subject-specific high stakes tests and found teachers revised their instruction to emphasize only topics and skills likely to be tested, while also increasing class time devoted to reviewing testable information and developing test-taking skills. In addition, Gayler reported teachers expressed topics were covered in a more superficial manner that did not involve any exploration or depth. As one teacher in Gayler's study stated in regards to the test (called the "SOL" in this jurisdiction) "if it's not on the SOLs, don't teach it" (p. 13). McMillan, Myran, Workman (1999) also studied the impact of the Standards of Learning (SOL) tests in Virginia and of 722 teachers surveyed, more than 80% indicated these tests impacted the content of their daily lessons, with content tested on the SOL receiving emphasis in lessons. Similar findings of elimination and de-emphasis of particular topics or skills within a subject-specific test environment have been reported by Scot, Callahan, and Urquhart (2009), Diamond (2007), Harper, Platt, Naranjo, and Boynton (2007), Koretz (2005), McNeil (2000a), McNeil and Valenzuela (2000), Smith (1991), and Smith and Rottenberg (1991).

Freire (1989) spoke of how in such circumstances:

> Education thus becomes an act of depositing, in which the students are the depositories and the teacher is the depositor. Instead of communicating, the teacher issues communiques and makes deposits which the students patiently receive, memorize, and repeat. This is the 'banking' concept of education, in which the scope of action allowed to the students extends only as far as receiving, filing, and storing the deposits. (p. 58)

Freire (1989) further stated this situation, where curriculum is narrowed to fact-memorization at the expense of other forms of learning, is problematic because "whereas banking education anesthetizes and inhibits creative power, problem-posing education involves a constant unveiling of reality. The former attempts to maintain the *submersion* of consciousness; the latter strives for the *emergence* of consciousness and *critical intervention* in reality" (p. 68).

Generalist teacher examples. For teachers who are generalists and teach a wide variety of subjects, such as elementary or middle school educators, a tremendous volume of research has shown subjects not included on standardized tests are de-emphasized or completely eliminated. For example, Dee, Jacob, and Schwartz (2013), the Center for Education Policy (2007), McGuire (2007), Marx and Harris (2006), Wills (2006), and Spillane, Diamond, Burch, Hallett, Jita, and Zoltners, (2002) asserted that such testing induces a trend where decreased attention is paid to the often untested areas such as social studies, science, art, music, and physical education as teachers face pressures to raise scores in tested areas such as literacy and mathematics. In fact, Fitzgerald (2008) and Koretz, Barron, Mitchell, and Stecher (1996) reported 88% and 87% respectively of teachers surveyed in their studies admitted pressures associated with preparing students for tests led them to ignore important parts of the curriculum in favour of tested material, instead favoring "modes of learning that promote passivity and rule-following rather

than critical engagement on the part of teachers and students" (Giroux, 1983, p. 158). Further, the Center for Educational Policy (2007) found in a US nation-wide survey of 349 school districts that instructional time devoted to non-tested subjects dropped by nearly one-third following the variety of state and local testing programs that accompanied implementation of *No Child Left Behind* (2002). Recent studies from the last decade reporting similar findings include Alexander (2010), Collins, Reiss, and Stobart, (2010), Fitchett and Heafner (2010), Wills and Sandholtz (2009), McMurrer (2008), Wearmouth (2008), Berry (2007), Crocco and Costigan (2007), Hamilton, Stecher, Marsh, McCombs, Robyn, Russell, and Barney (2007), Moon, Brighton, Jarvis, and Hall (2007), Rock, Heafner, Oldendorf, Passe, O'Connor, Good, and Byrd (2006), Boyle-Baise, Hsu, Johnson, Serriere, and Stewart (2008), Boyle and Bragg (2005), Rosenbusch (2005), Van Fossen (2005), Yeh (2005), Abrams (2004), Jones and Egley (2004), Sunderman, Tracey, Kim, and Orfield (2004), and von Zastrow (2004).

Further research suggests both district and school policies may exacerbate this phenomenon by forcing teachers to spend more time focussed on tested materials in the name of raising test scores. Researchers have reported many schools and districts have completely eliminated non-tested subjects such as gym, art, music, social studies, and even recess (Center on Education Policy, 2006, 2008; McCarthey, 2008; McLaren & Farahmandpur, 2006; Renter, Scott, Kober, Chudowsky, Joftus, & Zabala, 2006). Schemo (2007) reported that some schools have extended the school day to allow for more test preparation and/or the teaching of subjects that may otherwise be eliminated from the curriculum. Jones, Jones, Hardin, Chapman, Yarborough, and Davis (1999) stated findings such as these "demonstrate that assessment does indeed drive instruction, at least in terms of the time teachers devote to specific subjects" (p. 200).

Impacts on schools serving low socioeconomic and high minority populations.

Research generally conducted in the United States indicates the problem of curriculum narrowing due to testing pressures is further exacerbated in schools serving high minority and low socioeconomic populations. McNeil (2000a) reported teachers in Texas schools that were historically low-performing and contained high minority and low socioeconomic populations were being increasingly required to stop teaching untested areas of the curriculum in order to use this class time to instead prepare students for the state tests. Three successive years of national studies by the Center on Education Policy (2006, 2007, 2008) arrived at similar conclusions, noting teachers in high-poverty and urban districts reported decreased time devoted to non-tested topics and subjects. Similar findings have been reported by Pace (2011), Stullich, Eisner, McCrary, and Roney (2006), and Moon, Callahan, and Tomlinson (2003), with Pace suggesting the increased curricular narrowing in low socioeconomic and heavy minority population schools serves to further exacerbate educational inequalities between rich and poor and whites and non-whites.

Freire (1989) argued how learning in such a system, where memorization of facts is emphasized over other forms of learning, serves to exacerbate oppression of societal groups. Freire stated, in regards to his previously-described "banking" system of education and the oppressed, that:

> It is not surprising that the banking concept of education regards men (*sic*) as adaptable, manageable beings. The more students work at storing the deposits entrusted to them, the less they develop the critical consciousness which would result from their intervention in the world as transformers of that world. The more completely they accept the passive role

> imposed on them, the more they tend simply to adapt to the world as it is and to the fragmented view of reality deposited on them.
>
> The capability of banking education to minimize or annul the students' creative power and to stimulate their credulity serves the interests of the oppressors, who care neither to have the world revealed nor to see it transformed. (p. 60)

McLaren (1989) concurred with Freire's assessment, stating that "economically disadvantaged children are being groomed by society at an early age to fail, doomed to perpetuate a viscous and endless cycle of poverty created by a culture obsessed with success and wealth" (p. 150).

Impact of test "stakes" on curricular narrowing. Research further suggests the degree to which curriculum is narrowed may be related to the "stakes" of the test teachers and students are working under. Abrams, Pedulla, and Madaus (2003) reported 43% of teachers in high stakes environments, compared to just 17% in low stakes settings, indicated the time they spent on tested areas increased a great deal since the implementation of exams. Further, while teachers in high stakes environments reported a greater likelihood of eliminating untested subjects from their practice, they also reported significant decreases in activities such as field trips and enrichment activities. Teachers in low stakes environments did not report such decreases. Yeh (2005) also stated low stakes environments are associated with little to no curricular narrowing while teachers in high stakes environments face greater pressures to narrow curriculum to focus more on tested areas; similar findings have been reported by Valli and Buese (2007), Hampton (2005), Clarke, Shore, Rhoades, Abrams, Miao, and Li (2003), Debray, Parson, and Avila (2003) and Pedulla, Abrams, Madaus, Russell, Ramos, and Miao (2003).

Emphasis on rote memorization over higher order skills. Research intimates large scale testing environments can have a large impact on not only classroom content but how this content is delivered to students. Specifically, research seems to suggest these conditions can lead to the delivery of an overabundance of fact-based information to students at the expense of development of critical thinking and problem-solving skills.

Wideen, O'Shea, Pye, and Ivany (1997) examined differences in British Columbia teacher strategies in Grade 8,10, and 12 science courses at a time when only Grade 12 courses concluded with a provincial exam (worth 40% of the student's mark at the time of this study). These researchers reported many Grade 12 science teachers revealed that not only had science classes become "content oriented" but also had been reduced to little more than the presentation of a string of facts to be memorized for the final examination. This dilemma was likely not helped by the manner in which the authors described Grade 12 students, stating "nor did the students' desire for factual information lend itself to a constructivist approach. Students wanted only information useful in examinations; they did not want to be bothered by understanding" (p. 441).

This emphasis on the rote memorization of facts to "best prepare" students for an exam may come at the expense of the development of other skills. In their study of the Grade 12 provincial exam system in British Columbia Anderson, Muir, Bateson, Blackmore, and Rogers (1990) reported the implementation of exams had, in the view of teachers, led to classroom and teaching environments focussed more on memorization and less on skills such as critical thinking, problem solving, and creativity. Similarly, a study by Calder (1990) focussing on Grade 12 school leaving exams in Alberta concluded "there is general concern that the

examinations force a certain type of shallow recall learning at the cost of innovative teaching geared towards higher levels of learning" (p. 4).

This priority on information is underlined by a quote from Jones, Jones, Hardin, Chapman, Yarborough, and Davis (1999) who stated "standardized tests typically emphasize discreet facts and skills because they are easy to measure and avoid questions that require students to analyse and synthesis information at higher levels" (p. 200). A potential consequence is teachers may feel it necessary to deliver a large volume of fact-based information, to be memorized in a rote fashion, in the hope students will correctly answer a maximum number of exam questions. This emphasis on facts over the development of other skills and competencies has been the finding of a large volume of studies (e.g. Clarke, Shore, Rhoades, Abrams, Miao, & Li, 2003; Collins, Reiss, & Stobart, 2010; Crocco & Costigan 2007; Gayler, 2005; McGuire 2007; McNeil, 2000a; McNeil & Valenzuela, 2000; McCarthey 2008; Sacks, 2000; Toch 2006; Vogler 2005).

A large quantity of investigators suggest that in an effort to prepare students for tests through memorization of facts and test-taking skills, teachers have begrudgingly decreased or eliminated emphasis on critical and higher-order thinking, data analysis, writing skills, problem solving skills, creativity, cognitively complex instruction, and questioning of students (Cozart & Gerstl-Pepin, 2002; Gayler, 2005; Hong & Youngs, 2008; Massa & Pinhasi-Vittorio, 2009; McClaskey, 2001; McNeil, 2000a; Mitchell, 1997; Scot, Callahan, & Urquhart, 2009; Traub, 2002; Valli & Buese, 2007; Wenglinsky, 2005). Higgins, Miller, and Wegmann (2006) concluded "instructional time is spent practicing for the test, while important and challenging topics and activities are dropped from the curriculum" (p. 310) while Berry (2009) stated

"students are supplied with material in a 'drill and kill' fashion, which ruins their academic experience" (Berry, 2009, as cited in Rubin and Kazanjian, 2011, p. 97).

McLaren (1989) spoke of how such environments and pedagogies move teachers and students away from:

> Any recognition of the importance of viewing schools as sites for the social transformation and emancipation, as places where students are educated not only to be critical thinkers, but also to view the world as a place where their actions might make a difference. (p. 6)

The result, McLaren (1989) stated, was that schools "turn out to be strange and disturbing institutions that not only *teach* subjects but also *produce* unreflective human subjects who, in their day-to-day activities, play out the ideologies of the dominant culture" (p. 164).

Changes in teaching methods and pedagogy. A large portion of research on standardized testing focusses on pedagogical changes teachers make in an attempt to accommodate these exams. This research documents a wide variety of changes, which will be discussed in the subsequent sections.

***Movement toward teacher-centred pedagogies*.** Au (2007) examined 49 articles on high stakes testing and teaching practices and concluded:

> A significant number of participants in qualitative studies reported that their pedagogy changed in response to high-stakes tests and that a significant majority of the changes included an increase in teacher-centred instruction associated with lecturing and the direct transmission of test-related facts. (pp. 262-263)

In their examination of Grade 12 courses in British Columbia following the 1983 implementation of provincial exams, Anderson, Muir, Bateson, Blackmore, and Rogers (1990)

compared classes containing course-ending exams with those that didn't and concluded courses featuring exams spent a greater amount of time on whole-class instruction. Further, Wideen, O'Shea, Pye, and Ivany (1997) examined science courses in Grades 8, 10, and 12 in British Columbia at a time when only Grade 12 courses ended with a provincial exam. These authors reported the presence of an exam narrowed the range of instructional practices employed by Grade 12 teachers compared to Grade 8 and 10 educators. Specifically Grade 12 teachers described having little time for any strategy other than a direct instruction/lecture format to cover the extensive curriculum. In this format the teacher talked most of the class and transmitted facts, information, and ideas needed by students for the exam. The authors concluded the use of direct instruction by Grade 12 science teachers was significantly greater than that employed by Grade 8 and 10 teachers. Samiroden (1990) surveyed Grade 12 teachers in Alberta and arrived at similar conclusions regarding exams leading to teacher-centred pedagogies. Interestingly, several Grade 12 teachers in the Wideen et al. investigation reported they would lecture less if there were no provincial exam at the end of the course.

Many studies conducted outside British Columbia and the Grade 12 level have reached similar conclusions. Galton (2007) assessed teacher practices over a 20 year span, both before and after the implementation of a standardized test, and concluded teachers working under testing conditions were almost 2.5 times more likely to use teacher-centred, whole class teaching strategies where pupils had little opportunity to question or explore curricular ideas. Both Crocco and Costigan (2007) and Moon, Brighton, and Callahan (2003) reported teachers expressed this teacher-centred approach was the most efficient way to deliver the large volume of information required to prepare students for tests. Similar findings regarding a shift to more teacher-centred pedagogies under testing conditions has been reported by, among others, Diamond (2007),

Anagnostopoulos (2006), Booher-Jennings (2005), Gayler (2005), van Hover and Heinecke (2005), Vogler (2005), Diamond and Spillane (2004), Valenzuela (2004), and McNeil (2000a).

Decreased laboratory and "hands-on" opportunities. Literature also intimates the focus on teacher-centred instruction may cause a reduction in the number of laboratory investigations and "hands-on" activities carried out by students. Anderson, Muir, Bateson, Blackmore, and Rogers (1990) found the number of labs in Grade 12 science courses, as well as the time available for labs, decreased following the implementation of provincial exams. Similarly, Wideen, O'Shea, Pye, and Ivany (1997) found Grade 12 science classes in British Columbia performed far less lab activities than their Grade 8 counterparts. Samiroden (1990) also reported a decrease in lab activities undertaken by Alberta Grade 12 students following the implementation of provincial exams. While not focussing on the Grade 12 level, similar reports of less laboratory investigations and hands-on activities for students in science classes working in testing environments have been reported by Collins, Reiss, and Stobart (2010), Gayler (2005) and Smith (1991).

In addition to labs, literature suggests field trips may be a casualty of the movement towards teacher-centred pedagogies in testing environments. Anderson, Muir, Bateson, Blackmore, and Rogers (1990) reported that the frequency of field trips was reduced in British Columbia Grade 12 classes following the implementation of provincial exams. Both Wideen, O'Shea, Pye, and Ivany (1997) and Samiroden (1990) studied Grade 12 exam programs in British Columbia and Alberta respectively and reached similar conclusions, as did Abrams, Pedulla, and Madaus (2003) in a US-based investigation.

Movement away from best practices. It can be argued the term "best practices" as it relates to teacher pedagogy is a very subjective term. What serves to enlighten one student may

not bring the same effects to another. However, Au (2011) stated, “teachers’ classroom practices are increasingly standardized by high-stakes testing” (p. 25) and “high stakes testing is effectively restricting the way knowledge itself is structured in teachers’ practices” (p. 31). A teacher in a paper authored by Volger (2005) seemed to concur by stating:

> My choice of instructional delivery and materials is completely dependent on preparation for this test. Therefore, I do not use current events, long-term projects, or creative group/cooperative work because this is not tested and the delivery format is not used. All my tests reflect the testing format of the subject area tests - multiple-choice and open ended questions. (p. 19)

In this vein, Abrams, Pedulla, and Madaus (2003) reported 76% of high-stakes teachers and 63% of low-stakes teachers revealed the testing program they worked in led them to teach in ways that conflict with their beliefs in what constituted best educational practices. Teachers disclosing that the pedagogy they choose to maximize test preparation isn’t what they feel, or what research says, is best practice has also been reported by Valli and Buese (2007), Crocco and Costigan (2006), Brimijoin (2005), van Hover and Heinecke (2005) and Wenglinsky (2005), Agee (2004), Abrams, Pedulla, and Madaus (2003), and Moon, Callahan, and Tomlinson (2003).

Other notable pedagogical changes. The pace at which information is given to students in testing environments has also been an issue raised in the literature. In order to ensure all testable material is covered, teachers move at a faster pace through class material, even at the potential expense of students who may not yet grasp the material presented (Gayler, 2005; Valli and Buese, 2007). This quick pace and sense of pressure to cover all tested material in an “efficient” manner has not only led to the pedagogical issues discussed in the preceding paragraphs, but has also been suggested by researchers to lead to a decrease in enrichment

activities for students (Abrams, Pedulla, & Madaus, 2003; Moon, Callahan, & Tomlinson, 2003; Pedulla, Abrams, Madaus, Russell, Ramos, & Miao 2003; Taylor, Shepard, Kinner, & Rosenthal, 2003), less inquiry-based work and student projects assigned by teachers (Valli and Buese, 2007; Russell & Abrams, 2004; Wideen, O'Shea, Pye, & Ivany, 1997), and a diminished focus on library-based research (Anderson, Muir, Bateson, Blackmore, & Rogers, 1990; Samiroden, 1990). Further, literature links such environments to less group and co-operative learning (Anderson, Muir, Bateson, Blackmore, & Rogers, 1990; Crocco & Costigan, 2007; Gayler, 2005; Kohn, 2000), more individual student seatwork (Anderson, Muir, Bateson, Blackmore, & Rogers, 1990; Wideen, O'Shea, Pye, & Ivany, 1997), less focus on students' individual interests (Anderson, Muir, Bateson, Blackmore, & Rogers, 1990), and a decrease in time devoted to class discussions (Wideen, O'Shea, Pye, & Ivany, 1997). Testing environments have also been linked to a general decline in creativity of teacher lessons (Anderson, Muir, Bateson, Blackmore, & Rogers, 1990; Crocco & Costigan, 2007; Day, 2002; Jones, Jones, Hardin, Chapman, Yarborough, & Davis, 1999; McCarthey, 2008; Scot, Callahan, & Urquhart, 2009; Wideen, O'Shea, Pye, & Ivany, 1997), increased emphasis on drill and practice activities (Moon, Brighton, Jarvis, & Hall, 2007; Popham, 2000), and a lessening in the use of technology in teaching (Russell & Abrams, 2004). Finally, high stakes testing has been connected to an enhanced reliance on textbooks as a teaching and learning resource and an increased volume of homework for students (Anderson, Muir, Bateson, Blackmore, & Rogers, 1990).

Chapter 3 – Researching the Elimination of Grade 12 Provincial Exams

The question considered in this investigation centred upon the August 2011 British Columbia Ministry of Education (to be referred to henceforth as "the Ministry") decision to eliminate Grade 12 provincial exams in Chemistry, Biology, and Physics and the subsequent effect(s) this decision had on the pedagogy and work environment of teachers. Specifically, this study focussed upon teachers in one British Columbia school district, to be referred to henceforth as "the district".

To obtain answers to this question, the primary source of data in this study consisted of interviews with a wide variety of teachers from the district. In addition, multiple sources of secondary data were gathered and examined. These evidence sources contained several publications from the Ministry including curriculum guides for the three subjects under investigation, Teacher Regulation Branch standards, provincial exam data reports, graduation requirements, examples of past provincial exams, statements regarding the purposes of provincial exams, and reports surrounding provincial scholarship programs. In addition, school and district-level data were collected including school calendars and district achievement contracts. Finally, documentation gathered from teachers was comprised of course outlines, teacher-generated final examinations, and in-class assessment instruments. This chapter will elaborate on these data sources and their purposes.

This research used exploratory case study research methodology. There are five reasons why this method was the best choice to investigate teachers' experiences with the elimination of provincial exams. Firstly, teachers in the district work in a complex environment that involves, but is not limited to, their own individual strengths and weaknesses, a vast array of student differences, and social, economic, and political forces. These factors vary greatly from teacher to

teacher and school to school. These complexities and variables cannot, and should not, be eliminated or controlled, but instead should be embraced and investigated when studying the effects of elimination of exams on teachers due to their potential effects on the conclusions of the research. Hodkinson and Hodkinson (2001) stated that case studies "relate to the experiences of individuals, small groups, or organizations" (p. 3) and are able to "retain more of the 'noise' of real life than many other types of research" (p. 3), noise that "may be a highly significant part of the story" (p. 3). Hodkinson and Hodkinson supposed this aspect of case study methodology "brings it closer to the experiences of teachers… than is possible with some other forms of research" (p. 4).

Therefore this investigation employed case study methodology with the intention of gaining a holistic understanding of the effect exam elimination had on teachers in the district, an understanding that would likely be very difficult to obtain through a strictly quantitative study. Professor and author Sharan Merriam (2009) argued that:

> The case study offers a means of investigating complex social units consisting of multiple variables of potential importance in understanding the phenomenon. Anchored in real-life situations, the case study results in a rich and holistic account of the phenomenon. It offers insights and illuminates meanings. (pp. 50-51)

Zainal (2007) concurred, pointing out that:

> The detailed qualitative accounts often produced in case studies not only help to explore or describe the data in real-life environment, but also help to explain the complexities of real-life situations which may not be captured through experimental or survey research. (p. 4)

Similar statements regarding the ability of case studies in regards to their capacity for producing in-depth analysis of actual, complex social phenomena were found in writings by Becker et al. (2012), Yin (2009), Shuttleworth (2008), Hodkinson and Hodkinson (2001), Tellis (1997), and Hammersley (2008). In terms of this study, the district provided this real-life context in which to investigate the effect elimination of exams had on the actions of teachers.

Secondly, case studies paint a picture of an event or behaviour, with the event normally considered to be pivotal in nature (Yin, 2009). In the context of this dissertation, the elimination of Grade 12 exams in August 2011 may be considered the pivotal event, with ensuing behaviours and actions of teachers in the district being the result of said event.

Thirdly, Yin (2009), Creswell (2007), Zainal (2007), Gerring (2004), Hodkinson and Hodkinson (2001), Soy (1997), and Stake (1995) spoke extensively of case studies being within a "bounded system" in terms of time, place, events, and participants. Zainal (2007) stated "in most cases, a case study method selects a small geographical area or a very limited number of individuals as the subjects of study" (p. 1) and "a limited number of events or conditions, and their relationships" (p. 2). Stake (1995) added that case studies have interrelated parts that form a whole. In this investigation the geographical borders of the district represent the "place" boundaries while the elimination of Grade 12 science exams, and the time following this action, constitute the "event" and "time" restraints spoken of by the above authors. The various factors influencing education in the district, students, teachers, parents, administrators, politics, only to name a few, all formed the interrelated parts of a whole spoken of by Stake (1995). Finally, the finite number of Grade 12 science teachers in the district constituted the "very limited number of individuals as the subjects" (p. 1) described by Zainal (2007).

Fourthly, writings by Becker et al. (2012) and Soy (1997) advocate for the use of case study methodology when the researcher is seeking to answer "how" or "why" questions. Since the focus of this study was *how* elimination of Grade 12 exams in Physics, Biology, and Chemistry affected teachers in the district, case study methodology dovetailed with the manner in which this research question was framed.

Finally, to gain sufficient breadth and depth of understanding of the question under investigation, a wide variety of data sources needed to be collected and analyzed. Literature indicates one strength of case studies is the use of, "multiple sources and techniques in the data gathering process" (Soy, 1997, para. 9). Literature advocates for data sources to include documents, archival records, protocols, tests, interviews, direct observations, participant observations, and physical artifacts (Becker et al., 2012; Soy, 1997; Yin, 2003).Yin (2009) explained how these multiple sources of data help to address validity issues within the case study by allowing for multiple measures of a particular phenomenon. Yin also stated "the most important advantage presented by using multiple sources of evidence is the development of converging lines of inquiry, a process of triangulation and corroboration" (p. 115). Further, Becker et al. (2012) stated "case studies are likely to be much more convincing and accurate if they are based on several different sources of information, following a corroborating mode" (para 44). The section titled Data Collection and Analysis will provide a thorough explanation of the multiple and varied sources of data collected as part of this investigation.

Strengths and Limitations of Case Study Research

Limitations of case study research in education. A large volume of research focuses on the potential negative aspects of case study research. The following drawbacks, perceived or real, emerge as common themes in the literature.

Lack of generalizability. A common criticism of case study research is the dependency of this methodology on a single case is identified as a barrier for generalizing findings to a larger population (Tellis, 1997). Though not a subscriber to this theory Flyvbjerg (2006), noted a common criticism is "one cannot generalize on the basis of one individual case and therefore, the case study cannot contribute to scientific development" (p. 221). Further, Hodkinson and Hodkinson (2001) stated "by definition, case studies can make no claims to be typical" (p. 10) and "there is no way to establish the probability that the data is representative of some larger population" (p. 10).

Yin (2009) attempted to refute this perceived drawback by reversing the critique and asking how one can generalize based upon a single scientific experiment. Yin argued that:

> Scientific facts are rarely based on single experiments; they are usually based on a multiple set of experiments that have replicated the same phenomenon under different conditions. The same approach can be used with multiple case studies… case studies, like experiments, are generalizable to theoretical propositions and not to populations or universes. (p. 15)

In a further retort to this perceived drawback, Flyvbjerg (2006) stated, "predictive theories and universals cannot be found in the study of human affairs. Concrete, context-dependent knowledge is, therefore, more valuable than the vain search for predictive theories and universals" (p. 224).

Length of research study. To prevent an incomplete investigation, case study researchers collect large volumes of data from a variety of sources. Becker et al. (2012), Yin (2003), and Soy (1997) stated this data might include documents, archival records, protocols, tests, interviews, direct observations, participant observations, and physical artefacts. This can lead to an

overwhelming body of evidence to analyze. For example, Hodkinson and Hodkinson (2001) noted one of their case studies generated 198 taped interviews. Based upon examples such as this, a common criticism of case study research is the collection and analysis of data can be a very time consuming process.

Creswell (2007) remarked this problem may be at least partially overcome if researchers are diligent in regards to establishing boundaries for their case study. Creswell asserted:

> Deciding the 'boundaries' of a case – how it might be constrained in terms of time, events, and processes – may be challenging. Some case studies may not have clean beginning and ending points, and researchers will need to set boundaries that adequately surround the case. (p. 76)

Further to this point, Yin (2009) warned if a system for organizing and analysing data is not implemented, the study may become too long, difficult to conduct, produce an overwhelming amount of documentation, and result in a final paper that is unreadable. Considering this insight on setting boundaries for the case, the subject pool was restricted to secondary school teachers of Biology 12, Chemistry 12, and Physics 12 from a single British Columbia school district. Further, potential subjects were required to have taught at least one of the subject areas both prior to and following the cancellation of provincial exams in August of 2011. It was felt since this subject pool was informed experientially on the topic under investigation that they would give the most informative and relevant data regarding the effects of exam elimination on teachers.

Summarizing findings using the written word. As mentioned, case studies tend to collect large amounts of data from various sources. As such, when data is analysed it may reveal several complex and interconnected issues that are difficult for the researcher to describe using the

written word. Hodkinson and Hodkinson (2001) stated "when case studies are successful in revealing some of the complexities of social or educational situations, there is often a problem of representation. It is often difficult to present accessible and realistic pictures of that complexity in writing" (p. 9).

While authors have attempted to address this issue by offering templates for writing case study reports (Lincoln & Guba, 1985; Stake, 1995; Yin, 2009), Merriam (1988) assessed the situation accurately by stating "there is no standard format for reporting case study research" (p. 193). Therefore, this stage of the research process can be overwhelming for a writer trying to assemble a report. As Yin (2009) stated "as a general rule, the compositional phase puts the greatest demands on a case study investigator" (p. 165).

Cost. Due to the time involved in collection and analysis of such substantial volumes of data, large case studies can be very costly to conduct. As an example, Hodkinson and Hodkinson (2001) noted that a single study they conducted in the late 1990's cost in excess of £800,000, which is over $1.4 million Canadian. However, as Hodkinson and Hodkinson stated, "yet cutting corners… is likely to seriously weaken the value and credibility of any findings produced" (p. 9). As a point of clarification, it should be noted the issue of cost is dependant on the size of the study. The investigation undertaken herein did not require an overwhelming financial investment.

Biases. Like many investigative strategies, case studies may involve a single examiner or a small team of investigators. A concern among critics of case study methodology is this can lead to a bias in data collection and analysis processes and ultimately influence the findings of the study. Therefore, it is felt this methodology may have a tendency towards simply verifying the researcher's pre-conceived notions.

As mentioned previously, case study research involves collecting both a large quantity and variety of data. When such a large volume of information is assembled, decisions must be made about what to focus on and what to omit. These decisions reflect judgements based on personal biases of the investigator(s), whether these biases are conscious or unconscious. Perhaps another researcher examining the same data may have focussed on different issues and arrived at entirely different findings. This subjectivity causes some to view case study findings with a skeptical eye. Diamond (1996) stated:

> The case study method, as it is usually pursued, suffers from a crippling drawback. It does not apply 'scientific methods'—a phrase that makes non-scientists uneasy, but that really means nothing more than is implied by its Latin root, scientia (knowledge): methods useful for extracting knowledge, and for curbing one's tendencies to stamp one's pre-existing interpretations on data as they accumulate. (p. 5)

Despite these criticisms, it is worth noting that even in a "true experiment" decisions must be made about what data to collect and examine, and what potential areas of information are ignored. Decisions in these areas are made by researchers and are thus subject to human biases, just as they are in qualitative studies.

Case study methodology does not follow the scientific method. The mention of scientific methods in the previous paragraph leads to another criticism of case studies. Many detractors declare case studies are not "true experiments" following a standardized structural framework and producing quantitative data establishing a cause and effect relationship between a treatment and an outcome. Part of this problem may lay in the fact that there is not a standardized format for conducting case study research, although some authors have offered approaches (Stake, 1995; Yin 2009). Yin (2009) noted:

> Perhaps the greatest concern has been over the lack of rigor [sic] of case study research. Too many times, the case study investigator has been sloppy, has not followed systematic procedures, or has allowed equivocal evidence or biased views to influence the direction of the findings and conclusions. (p. 14)

Further in this area, much of the data collected in case studies does not by its nature lend itself to tidy numerical categories and representations. While Hodkinson and Hodkinson (2001) stated "this lack of precision is regarded as a serious weakness by many other researchers" (p. 10) they also noted that in one of their case study investigations "attempts to break down data into numerical categories undermined the essential richness of the interrelationships we were interested in" (p. 10).

***Easy to dismiss the findings*.** Hodkinson and Hodkinson (2001) noted due to the numerous drawbacks associated with case studies, their findings may be easy to dismiss for any individual or group that does not concur with the results of an investigation. For example, if conclusions of a case study were unfavorable to the policy direction an educational governing body was taking, it would be easy for said governing body to reject these results. This could be done by raising any or all of the above-discussed drawbacks such as researcher bias, findings not being generalizable, small sample size, or that the study did not produce numerical frequencies and therefore was not conducted in a scientific manner.

Values of case study research in education. Despite the large volume of criticism directed toward case study research methodology, many scholars feel this mode of investigation affords many advantages over a lock-step study focussed strictly on quantitative analyses. These advantages are addressed in the following sections.

In-depth analysis. A case study allows the researcher to go beyond the numerical cause and effect presentation and, through the eyes of participants, gain an understanding of the core conditions leading to the documented results. Essentially, case study research allows for a holistic comprehension of how a particular action may have worked or why the action had the effect it did. This type of understanding is not usually provided in the classic quantitative study. As Yin (2009) stated "experiments, though establishing the efficacy of a treatment (or intervention), are limited in their ability to explain 'how' or 'why' the treatment necessarily worked, whereas case studies could investigate such issues" (p. 16).

Therefore, case studies may be a valuable tool in a field such as education. For example, in this inquiry the primary subjects (teachers) work in an environment acted upon by a multitude of complex social, political, and educational factors. In a reality such as this, unwanted variables cannot always be excluded or controlled for as they are in many quantitative studies. Through in-depth data collection from a wide variety of sources, the case study embraces such variables and attempts to understand the complexities of real-life situations, complexities and variables a quantitative study may try to minimize. Zainal (2007) stated, "in education, evaluative applications are conducted to assess the effectiveness of educational programmes and initiatives. In these types of study, limiting to only quantitative method would obscure some of the important data that need (sic) to be uncovered" (p. 1). Thus, for the purposes of the investigation reported in this dissertation, case study methods were chosen because this approach allows for the unearthing of deep insights from participating teachers and the exploration of "how" and "why" questions in a fashion other methodologies may not.

Flexibility. During the process of a research project, new and unexpected findings may arise. Becker et al. (2012) remarked:

> It is important to note that in case studies… while researchers begin their studies with one of several questions driving the inquiry (which influence the key factors the researcher will be looking for during data collection), a researcher may find new key factors emerging during data collection. (para. 46)

In this way, case study methodology allows the researcher the freedom to pursue unanticipated avenues. Shuttleworth (2008) advised that:

> The other main thing to remember during case studies is their flexibility. Whilst a pure scientist is trying to prove or disprove a hypothesis, a case study might introduce new and unexpected results during its course, and lead to research taking new directions. (p. 2)

Shuttleworth (2008) argued that following the rigid guidelines of a classic quantitative scientific experiment, researchers may not be open to possible alternative paths or may not have the freedom to explore new avenues that arise. Shuttleworth reasoned the case study method allows researchers the freedom to explore these new and unexpected possibilities, even as they arise during the process of an investigation.

In the research reported in this dissertation, I brought pre-conceived notions about what teachers would tell me in interviews and what would be revealed by the documents I analysed. However there were unexpected considerations, to be discussed in Chapter 4, that revealed themselves during the research. Case study methodology allows for the pursuit of these considerations.

***Atypical cases*.** Case studies may be conducted on rare instances where large samples of similar participants are not available. Hodkinson and Hodkinson (2001) stated "such cases are often excluded from other forms of investigation, which concentrate upon common patterns and themes in the data" (p. 5). In terms of education, this means case studies can be conducted to

illuminate atypical educational situations, such as teachers working amid students with rare forms of autism, uncommon reading disorders, or specific behavioural issues.

This ability to study the atypical is critical in the field of education as teachers, in dealing with perhaps over 200 students per year, will encounter many learners who fall outside the bounds of what we may consider “typical”. When dealing with atypical students, research findings focussed strictly on the typical may be of little use to some educators. Therefore, information learned through investigating the atypical adds to the body of knowledge surrounding best practices for educators.

With its positive aspects and its drawbacks, case study methodology, like all modes of inquiry, is imperfect. In this particular investigation, it was felt this approach allowed for the illumination of new information while other potentially valuable information remained obscured. This will be discussed further in a later section of this chapter.

Study Location/Research Site

As mentioned previously, this study was conducted in a British Columbia school district. The justification for this location centres on a variety of factors including access and statistical indicators of ethnicity, employment, income, and education that suggest this district could be considered an “average” district in the province of British Columbia.

In the area of access, I have lived and worked in the district for the past 21 years. This provided a familiarity and accessibility to key people and data that simply may not be otherwise possible. For example, if this study were conducted using a remote northern British Columbia district as the case, access to local documents would be much more problematic and face to face interviews with an appropriate number of subjects would be logistically and financially more difficult.

In terms of ethnic demographics, employment, education, and income the BC Stats website contains data suggesting the location is a "typical" school district in British Columbia. For example, in 2006 the district ranked 19th out of 57 school districts in terms of visible minority population. In the realm of financial statistics, in 2005 residents of the district were very close to the provincial mean in terms of households paying more than 30% of income on housing (28.3% compared to the 29% provincial average). In terms of poverty, 7.7% of district households earned under $20,000 in 2005, very close to the provincial norm of 8.0%. In the area of unemployment, district residents over the age of 15 collecting employment insurance benefits in September 2011 was right at the provincial average of 1.8% (BC Stats, 2012).

In terms of post-secondary education, in 2006 39.7% of district residents between the ages of 25-54 held no post-secondary credentials, only slightly above the provincial average of 37.2% (BC Stats, 2012). Further, in terms of 18 year-olds not graduating from high school between 2008/09 – 2010/11, the location of this investigation ranked 26th out of 57 school districts (BC Stats, 2012). Finally, district-wide student involvement in the courses that are the focus of this study – Chemistry 12, Biology 12, and Physics 12 – mirror provincial trends in terms of participation between 2001 up to 2011.

Considering the above information, the district community may be considered somewhat representative of many districts in British Columbia. While it does not have the ethnic diversity of communities such as Richmond or the personal wealth of municipalities such as West Vancouver, it is close to provincial averages in a majority of the statistical categories presented for each school district according to the BC Stats (2012) website.

Generalizability Issue

At this point an inherent irony of this study needs to be addressed. In the previous paragraphs, arguments were made that the district can be considered to be "typical" of other school districts in the province. However, it was also noted in an earlier section that a delimitation of case study research is it does not purport to provide findings that are generalizable from one case to another. I believe this irony can be reconciled in the following ways:

Original research and provisional truths. Hodkinson and Hodkinson (2001) declared that a common argument against case studies is that "there is no way to establish the probability that the data is representative of some larger population" (p. 10). Yin (2009) attempts to refute this perceived drawback by reversing the critique and asking how one can generalize based upon a single scientific experiment. Yin stated "scientific facts are rarely based on single experiments; they are usually based on a multiple set of experiments that have replicated the same phenomenon under different conditions. The same approach can be used with multiple case studies" (p. 15).

According to the literature, there appears to be little to no previous investigations focussing on the issues I explored. Therefore, this investigation may be the first of "multiple case studies" spoken of by Yin. Additionally, Hodkinson and Hodkinson (2001) spoke of original research in an area as providing truths in a "Popperian sense" (p. 11) and elaborated by saying a case study may provide "a provisional truth… until contradictory findings or better theorising has been developed" (p. 11).

Generalizability and practicality to others. In terms of generalizability, many authors argue for at least the possibility of generalizations from one case to another. Guba and Lincoln

(1994) stated "generalization can occur when the mix of social, political, cultural, economic, ethnic, and gender circumstances and values is similar across settings" (p. 114). The statistics noted previously indicate a large number of these circumstances may be similar between the district and many other districts in British Columbia.

Further to this issue, Erickson (1986) argued that generalizations lie in particulars, and what is learned in one particular case may be applied or adapted to similar cases. Erickson further argued that it is not the researcher, but the reader of research, who determines what findings may apply to their particular context. Stake (1995) elaborated on Erickson's statements by explaining that, in the process of knowledge being transferred, case study researchers:

> Will, like others, pass along to readers some of their personal meanings of events and relationships – and fail to pass along others. They know that the reader, too, will add and subtract, invent and shape – reconstructing the knowledge in ways that leave it... more likely to be personally useful. (p. 455)

Further to this point, Hodkinson and Hodkinson (2001) stated that, "readers of case study research can judge whether or not the analysis presented sounds convincing, based upon what they know of similar situations and circumstances" (p. 11). Therefore, it is hoped the findings of this study can generate new thinking in terms of possibilities and issues for those in different contexts and be used to stimulate conversations, actions, and/or similar research in other jurisdictions.

Information for the district. Guba and Lincoln (1994) argued that research in education can allow for the development of rich local understandings in regards to the experiences of teachers and their students. Since there are roughly 14, 000 students in the district (School District #XX, 2013), all of whom will face various incarnations of province-wide standardized

exams in Grades 4, 7, 10, 11, and 12, a study examining the educational circumstances vis-à-vis standardized exams of such a large student population makes this investigation a potentially valuable undertaking.

In addition, as a retort to perceived drawbacks of case study research, Flyvbjerg (2006) stated "predictive theories and universals cannot be found in the study of human affairs. Concrete, context-dependent knowledge is, therefore, more valuable than the vain search for predictive theories and universals" (p. 224). A primary goal of this investigation was to provide such rich local understanding and context-dependent knowledge in the form of information for and about the district studied to help illuminate the impact of removal of Grade 12 provincial exams in science courses in this particular context and to inform district teachers and administrators in regards to future policy decisions in the area of high stakes examination programs.

Participants

The target population for this study was secondary school teachers. Specifically, participants were educators who have taught the subjects of Biology 12, Chemistry 12, and Physics 12 in the district. Further to this, all participants needed to have taught one of the three subjects under investigation prior to the 2011/2012 school year, as this would give them experience both in the time of mandatory provincial exams and in the time of no provincial exams. There were 18 teachers in the district who fit this description, 9 of whom agreed to be interviewed for this study.

Interviewees ranged in age from the early 30's up to those in their late 50's. There were six male and three female participants. This 2:1 male to female ratio for interviewees was proportional to the overall potential district subject pool of 18, which had 12 males and 6

females. Individual characteristics such as race, religion, ethnicity, sexual orientation, and social class were not considered to be factors in selection.

This population was of interest because it was felt they would provide the richest and most accurate data on how elimination of exams affected teacher behaviours. This statement is based on the fact that this group of interviewee's had teaching experience both in the time of exams and during the time when provincial exams were not required.

Recruitment

The district imposed two stipulations in order for this research to be conducted. Firstly, individual principals of each school where research was to be conducted were required to grant consent. I contacted each principal and all granted this consent. Secondly, no district e-mails, or any other district internal communication services, were to be used to contact potential participants. With this in mind, potential interviewees were contacted, as per district suggestion, through a brief letter distributed by principals at their schools (see *Appendix C)*. Respondents to this letter were given further description of what their participation would entail before arrangements were made to conduct interviews. It should be noted that the researcher had no power or authority over any individuals who responded to this invitation to become participants.

Possible Benefits, Risks, and Inconveniences to Participants

Benefits. This study intends to benefit three groups: teacher participants, students, and the state of knowledge in the field of education. In terms of participants, through partaking in this study teachers will have had an opportunity to reflect on their own practice. In addition, the findings of this study may benefit the field of education by contributing to knowledge concerning teaching practices and standardized exams. The knowledge gained from this research could also inform educational policies and practices. More specifically, it is the intent of the investigation to

reveal how Grade 12 provincial science exams in British Columbia impeded the ability of teachers to implement rich and diverse learning experiences for their students by triggering the use of a narrow range of teacher-centred pedagogical strategies and a focus on shallow learning centred on recollection of facts.

Inconveniences. The only potential inconvenience for participants was the donation of their time. For the nine participants, interviews ranged in time from 18 minutes to just under one hour.

Risks. Potential risks to participants in this study were considered to be low. For example, it was considered very unlikely a participant could feel demeaned or embarrassed during their participation in the research. In addition, there was a low probability a participant would feel fatigued or stressed due to this research or experience any emotional or psychological discomfort as a consequence of participation. Further, it was also doubtful that there was any social risk, possible stigmatization, loss of status, privacy and/or reputation to the participants in this study. Since all participants were fully informed of everything required of them prior to the start of the research/interview session, there was no danger of deception. Finally, there was no perceived physical or economic risk to participants.

Compensation

Seven of the nine interviews were conducted after school at teachers' work sites. The remaining two, at the suggestion of the participants, were conducted at participant residences. Due to these circumstances the need to compensate participants for expenses such as transportation, parking, or childcare was not seen as an issue that required addressing. In terms of compensation for participating in this study, subjects were not compensated for volunteering to be interviewed.

Consent

All prospective participants for this study were competent adults capable of providing free and informed consent. Participants were asked to provide signed consent on the participant consent form (see *Appendix B*).

To obtain consent, prior to each interview the participant was provided with a written copy of the consent form. Prior to beginning the interview, I read over the form with the participant. Upon completion of the verbal discussion of the consent form and prior to obtaining the participant's signature, I provided an opportunity for the participant to ask any questions or discuss any concerns they had. When this process was complete to the satisfaction of both participant and researcher the signature of the participant was obtained and the interview process commenced.

Further to this procedure, prior to acquiring signed consent participants were informed both verbally and in writing that it was their right to withdraw from the research project at any time without consequence or explanation. Participants were informed that if they wished to withdraw from the study, their wishes would be honoured without question. Any data collected from the subject prior to their withdrawal would be destroyed and not used in the study's final analysis.

Anonymity and Confidentiality

The identity of all interviewed participants remained confidential during all phases of this research and will continue through to, and including, the dissemination of the final results of the study. In addition, all possible courses of action were taken to protect the identity of participants. Steps taken in this area included the use of pseudonyms for participants in the final written draft of the research paper. In addition, the school district and individual schools will not be

mentioned by name in the final draft. Participants will not be put on a roster for any future studies or have their identities revealed to any future researchers.

However, due to the context of the study, there is a potential limit in this area that must be noted at this time. The school district in which the research was conducted has seven high schools. This *may* make it possible for someone intimately familiar with the district and this study to identify a participant based on a quote.

Data Collection and Analysis

As discussed in an earlier section, Becker et al. (2012), Soy (1997), and Yin (2003) advocated for the collection of multiple sources of data to help address validity issues within the case study by allowing for multiple measures of a particular phenomenon. Yin (2009) also stated "the most important advantage presented by using multiple sources of evidence is the development of converging lines of inquiry, a process of triangulation and corroboration" (p. 115). With this in mind, multiple sources of data were collected and analysed through the course of this investigation. The primary data source was interviews with teachers while several forms of evidence were collected as secondary data sources. These are described in the subsequent sections.

Interviews. Hancock and Algozzine (2011) stated "the researcher should identify key participants in the situation whose knowledge and opinions may provide important insights regarding the research questions" (p. 44). In an investigation focussed on the effect of elimination of exams on teachers the importance of interview data from teachers is self-evident.

Questions put to volunteers during the interview process focussed on areas of the teaching process that literature suggests may be affected by standardized testing programs. Interviews were semi-structured and focussed on the effects of the removal of Grade 12 exams

on the teachers' pedagogy and general teaching practices, classroom resource and time allocation, relations with colleagues, perceived student responses to courses, and data usage. All questions were researcher-generated; for a copy of the interview questions see *Appendix A*.

Each interview was face to face. Participants were asked for their permission to record each interview on an audio recording device and all verbally consented to this request. A written transcription of each conversation was made from each recording. Hancock and Algozzine (2011) noted a benefit of recording interviews is that "handwritten notes sometimes suffice, but the lack of detail associated with this approach inevitably results in a loss of valuable information. The best way to record interview data is to audiotape the interaction" (p. 45).

In terms of interviews, participants were given the freedom to select a time and environment they felt most comfortable in and/or one that was most convenient for them. No interviews took place during participants' office hours, instructional time, or any other scheduled work responsibilities.

Following each interview, teacher responses and statements were thoroughly analyzed and sorted into categories of emergent themes. As the number of interviewed subjects progressed, responses were manually sorted into major themes on how the elimination of exams have impacted Grade 12 science teachers in the district. These common categories and themes formed the basis of the findings of this case study.

Before findings from interviews were submitted as part of this report, all participants were offered a copy of the transcript of their interview to verify its accuracy. Subjects were also afforded the opportunity to examine how their voices were represented in this report. These steps were implemented as safeguards to ensure that I have not inadvertently misrepresented the words and thoughts of the interviewees in any manner.

Secondary sources of data. Case study literature suggests data collection is strengthened by the gathering of multiple sources of evidence and the subsequent establishment of converging lines of inquiry (Becker et al., 2012; Soy, 1997; Yin, 2003). Therefore to complement the primary data (teacher interviews), strengthen background information relevant to the case, and triangulate converging lines of evidence, multiple sources of data beyond the teacher interviews was collected and/or reviewed. Hancock and Algozzine (2011) stated "only those data that are potentially meaningful to the research effort" (p. 62) should be collected, as doing otherwise will lead to a collection of an overwhelming amount of data. With this in mind, the following sections will elaborate on which secondary sources of evidence were chosen and briefly outline how each was used to strengthen this case study. The sections of the investigation these data sources are pertinent to will be discussed in much greater detail in Chapters 4 and 5.

School district calendars. A major theme emerging from teacher interviews was that, during the time of provincial exams, a large portion of class time was used to prepare students for these exams. In order to gauge this time relative to total instructional time, school calendars from the district under investigation were obtained for the 2008-2009 and 2009-2010 school years (*see Appendix F*).

Data reports from Ministry of Education to schools. As discussed in the literature review, advocates of large scale testing feel data generated by such exams can provide useful feedback to educators and lead to improved teaching and learning. With this in mind, teachers were asked to what extent they used provincial exam data reports provided by the Ministry of Education to alter their practice. Multiple examples of such Ministry-provided reports for all three subjects under investigation are provided in *Appendix D*.

Teacher course outlines. During the course of interviews teachers discussed how they assessed students both during the time of the provincial exam and in the post-exam period. In addition, subjects spoke of how elimination of the provincial exams have not affected their coverage of the entire Ministry-prescribed curriculum. To help triangulate these statements, teachers were asked for copies of their course outlines; these documents normally contain information on what curricular topics will be covered in a course and how students will be assessed. Therefore, information contained in these documents (see *Appendix G*) was used to help verify interview statements given by teachers regarding curricular coverage and student assessment.

Teacher produced final exams, unit tests, and quizzes. As mentioned in the previous paragraph, teachers noted in interviews that despite the absence of a provincial exam, they continue to strictly adhere to Ministry-prescribed curriculum. In addition, when speaking of the effects the provincial exam had, teachers spoke of using old provincial exam questions as a basis for a great deal of their in-class assessments.

To triangulate these statements, teachers were asked for samples of past final exams they have administered as well as any in-class assessments. It is the assumption of the researcher that these final exams (see *Appendix H*) are reflective of content covered by both teachers and any textbooks that may have been used. The questions on these exams, and the curricular topics they covered, were compared to the curriculum guides for each subject (see *Appendix J*) as a means to verify statements that teachers continued to cover the full curriculum in their subject area(s).

In addition to final exams, some teachers also provided unit tests and quizzes (see *Appendix E*). Upon supplying these documents, teachers briefly reviewed with the researcher

which items on the tests and quizzes were taken from past provincial exams. In some cases entire assessment tools were based on past provincial exam questions.

Documents corroborating reporting of teacher stress. A large number of teachers in this investigation spoke to issues of stress and pressure they felt when their students were required to write a provincial exam. In order to corroborate these statements, several sources are cited in Chapters 4 and 5 of this paper. These include Ministry publications surrounding the impact of student exam scores on obtaining scholarships and graduation diplomas, the large impact of these exams on student grades, school district achievement contracts, and the large-scale reporting of school performances to the public. The multiple sources used in this area are cited in Chapters 4 and 5 and are contained in the references list for this paper.

Past provincial exams. Teachers reported copying large volumes of past provincial exams as a means of providing practice for students leading up to the writing of provincial exams. In order to provide examples of the size and scope of these assessments, one copy of a past provincial exam for each of Biology 12, Physics 12, and Chemistry 12 has been provided in *Appendix I*. In addition, electronic links to further examples have been provided in Chapter 4.

Teacher Regulation Branch standards. The Teacher Regulation Branch (TRB) is a division of the British Columbia Ministry of Education that details and enforces codes of conduct expected of educators in the province. Select standards listed by the TRB have great relevance to this study and are quoted and discussed in Chapters 4 and 5.

Curriculum guides for Grade 12 courses in biology, chemistry, and physics. The Ministry provides teachers with publically-available documents outlining not only the curriculum of each course, but course goals, objectives, and suggested teaching and evaluation strategies.

These guides, which contain a great deal of information pertinent to this study, are quoted frequently and are contained in *Appendix J*.

Data Audit Trail

Yin (2009) strongly advocated for careful documentation during the data collection phase of the investigation in order to maintain a strong "chain of evidence" (p. 122). Further, Hancock and Algozzine (2011) stated "as a minimum, every piece of information gathered must be labelled with the date, location, persons involved, and circumstances surrounding the collection of that piece of information" (p. 63). Therefore, care was taken during the interview process to note the time and place that each conversation occurred and each interview was coded for the purposes of referencing in the text of the final written draft. Similarly any documents and data collected during the investigation were coded for purposes of reference. In addition, each of these data sources were dated in regards to the time of their release and/or collection.

Data Use, Storage, and Disposal

At this point in time, all data collected has been used solely for the purposes of this study. However, it may be a future possibility that findings of this study will be presented at scholarly meetings and/or be submitted for publication in a journal. In terms of data storage, verbal data collected during the interview process was stored on a password-protected recording device that is kept in a locked filing cabinet. Any written data, notes, etc. collected have been stored in the exact same manner. Data will be stored until 2019, at which time it will be destroyed. Verbal data stored on electronic devices will be deleted. Data in the paper/document format will be shredded.

The results of this study were shared with participants and the administration of the district. As part of granting approval to do research in their district, the district research in schools policy states:

> On completion of a research project undertaken in school district XX, a full report of the research results must be submitted to the Superintendent/designate. Copies of the full reports are to be made available to all participants and other interested persons on request. (School District #XX, 2013)

Description of the Philosophical Underpinnings of This Research Project

Paradigms and their importance. The popularization of the term "paradigm" is generally attributed to the writings of Thomas Kuhn, and specifically his book *The Structure of Scientific Revolutions* (1962). Today, the term is often used in reference to the philosophical framework of a researcher. Hammersley (2012) stated:

> In the context of research methodology, the term has also come to mean a set of philosophical assumptions about the phenomena to be studied, about how they can be understood, and even about the proper purpose and product of research. (para. 5)

Further, Willis (2007) described a paradigm as "a comprehensive belief system, world view, or framework that guides research and practice in a field" (p. 8) while Taylor (2013) asserted:

> From a philosophical perspective, a paradigm comprises a view of the nature of reality (i.e., ontology) – whether it is external or internal to the knower; a related view of the type of knowledge that can be generated and standards for justifying it (i.e., epistemology); and a disciplined approach to generating that knowledge (i.e., methodology). (para. 3)

The importance of an investigator understanding their own research paradigm was emphasized by Grix (2004), who cautioned that before embarking on a clean and precise research project investigators must identify philosophical underpinnings related to their choices in the areas of research questions, methodology, and overall intention of their exploration. Grix (2004) stated research is best done by:

> Setting out clearly the relationship between what a researcher thinks can be researched (her ontological position) linking it to what we can know about it (her epistemological position) and how to go about acquiring it (her methodological approach), you can begin to comprehend the impact your ontological position can have on what and how you decide to study. (p. 68)

Saunders, Lewis, and Thornhill (2012) expanded on this position by declaring:

> The research philosophy you adopt contains important assumptions about the way in which you view the world. These assumptions will underpin your research strategy and the methods you choose as part of that strategy... the main influence is likely to be your particular view of the relationship between knowledge and the process by which it is developed. (p. 4)

Paradigm labels. Before a discussion of my philosophical approach begins, it bears mentioning that examining various research paradigms is made difficult by the fact labelling and description of paradigms differs from author to author. A review of the literature makes it apparent there is no single, agreed-upon manner of drawing distinctions between the various approaches to education research (Hammersley, 2008; MacKenzie & Knipe, 2006; O'Leary, 2004). Hammersley (2012) noted “the labels for different approaches are not used in standard ways and do not form part of a single, well-defined typology” (para. 7). In addition, MacKenzie

and Knipe (2006) stated “the use of different terms in different texts and the varied claims regarding how many research paradigms there are, sometimes leads to confusion” (para. 5). Therefore paradigm names and descriptions used in the following discussion were derived from common and reoccurring labels and explanations.

Paradigm status. Further, the literature contains no consensus in terms of the pre-eminence of any given paradigm. Guba and Lincoln (1994) spoke of paradigms as being human constructions, and contended one therefore cannot be held as superior to another. They argued:

> They are all inventions of the human mind and hence subject to human error. No construction is or can be incontrovertibly right; advocates of any particular construction must rely on persuasiveness and utility rather than on proof in arguing their position. (p. 108)

Additionally, Taylor (2013) argued, “no research paradigm is superior, but each has a specific purpose in providing a distinct means of producing unique knowledge” (para. 2). Similarly, Gage (1989) stated that the various paradigms are “simply concerned with different, but important, topics and problems” (p. 7) while Guba and Lincoln (1994) contended the paradigm a researcher aligns with is dependant upon questions surrounding individual beliefs in the areas of ontology, epistemology, and methodology as they pertain to a chosen research project.

With these statements in mind, the subsequent section will outline my rationale, based largely on ontological, epistemological, and methodological reasons, for the choice of a critical theory approach in this investigation. However, it should be noted that while undertaking a research project from the perspective of one theoretical lens may open up certain possibilities, it may serve to sever access to other potentially valuable sources of information and the subsequent

findings they may reveal. For this study, a critical theory lens allows an analysis that best suits the end goals of this research.

Rationale for the choice of critical theory.

Ontology. While each research paradigm has specific applications, not all paradigms are equally applicable in every research situation. An education-oriented study such as this rejects the positivist and post-positivist ontological assumptions of an external reality that can be captured, measured, discovered, and described (Guba & Lincoln, 1994; Mack, 2010; Remenyi, Williams, Money & Swartz, 1998; Saunders, Lewis, & Thornhill, 2012). Social phenomenon such as the educational process is vastly different from the work done, for example, by a natural scientist working from a positivist paradigm. Teachers and students bring different subjectivities such as strengths, weaknesses, interests, behaviours, and views of the world to everyday educational settings. While there may be strong similarities between two situations such as socioeconomics, ethnicity, and culture that make for similar realities between two settings, the multitude of variables between settings creates a condition where there is no one indisputable truth that can be universally applied across all situations in education. No one single reality can possibly be captured and made into laws applicable to all teaching and learning situations. In this vein, Gage (1989) stated "prediction and control that can be achieved in the natural sciences are not possible in human affairs" (p. 5) and "scientific methods can be applied only to natural phenomena that are stable and uniform across time, space, and context in a way obviously untrue of the human world of teaching and learning" (p. 4).

Further, the ontological view of critical theory supposes a social reality defined from persons in society, with often-subversive societal influences playing a large role in this construction. In this regard, Mack (2010) declared reality is "constructed through media,

institutions, and society" (p. 9) while Guba and Lincoln (1994) stated critical theory "assumes an apprehendable reality consisting of historically situated structures that are, in the absence of insight, as limiting and confining as if they were real" (p. 111). Further, Cohen, Manion, and Morrison (2007) stated, from the critical theory viewpoint, social behaviour is the outcome of "particular illegitimate, dominatory and repressive factors" (p. 26). As discussed at length in Chapter 2, pervasive neoliberal influences in society and education have led to a "regime of truth" (McLaren, 1989, p. 181) that high-stakes exams bring great value and benefit to the education system. This research will provide insights challenging this belief by revealing the limiting, confining, dominatory, and repressive role these exams play in the education system.

Epistemology and methodology. Positivist and post-positivist, based upon epistemologies and methodologies, arrive at knowledge through an "objective" research process (Bryman, as cited in Grix, 2004; Creswell, 2007; Dash, 2005; Gill & Johnson, 2002; Guba & Lincoln, 1994; Hammersley, 2012; Hughes & Sharrock, as cited in Grix, 2004; Taylor, 2013). This process is comprised of stringent methodology often focusing on observation, experiment, reductionist logic, and quantitative data with a goal to "confirm and predict law-like patterns of behavior" (Taylor, 2013, para. 5). McLaren (1989) disputed this type of approach, stating, "critical educators argue that knowledge should be analysed on the basis of whether it is oppressive and exploitative, and not on the basis of whether it is 'true'" (p. 182).

The potentially rich insights of participant teachers in this investigation would be made more accessible through critical theory's methodological emphasis on interaction between investigator and subject(s), interactions that have the potential to produce conversations that lead to transformation. This type of interaction serves "to transform ignorance and misapprehensions (accepting historically mediated structures as immutable) into more informed consciousness

(seeing how structures might be changed and comprehending the actions required to effect change)" (Guba & Lincoln, 1994, p. 110). In addition, the reliance on a stringent methodology does not necessarily allow for the pursuit of new and unexpected issues that may reveal themselves during the process of the investigation. As Hammersley (2012) stated in a criticism of positivist methodology:

> People - unlike atoms, chemicals, or even most non-human forms of life - interpret or give meaning and value to their environment and themselves, that the ways in which they do this are shaped by the particular cultures in which they live, and that this generates the actions and institutions in which they participate. (para. 11)

Further, a focus on quantitative data may reveal patterns, but fails to get at the "how" and "why" questions behind these patterns, questions critical to gaining an understanding of the underlying goings-on in my research question. As Dash (2005) stated in regards to positivist methodology "it regards human behavior as passive, controlled and determined by external environment. Hence human beings are dehumanized without their intention, individualism and freedom taken into account" (para. 5). Giroux (1983), when speaking to the emancipatory capacity of critical theory, stated this potential "is based on the principles of critique and action. It is aimed at criticizing that which is restrictive and oppressive while at the same time supporting action in the service of individual freedom and well-being" (p. 190).

Goals of this investigation. Habermans (as cited in Dash, 2005) postulated three types of interest in the area of generating knowledge. The first is an interest in controlling the physical environment, which would appear to align with the positivist and post-positivist paradigms. The second is an interest in gaining a practical understanding of a situation, which seems to dovetail with goals of interpretivist and constructivist researchers (Cohen & Manion, 1994; Creswell,

2003; Guba & Lincoln, 1994; Hammersley, 2012; Mack, 2010). The third is an interest in producing knowledge that leads to exposing of constraints and providing avenues for growth and advancement, a reason that allies with critical theory (Guba & Lincoln, 1994; Taylor, 2013). Further to Habermans' postulations, Mack (2010) stated, "while the positivist researcher seeks to explain social phenomena, and the interpretivist researcher seeks to understand social phenomena, the researcher who seeks to change and to challenge… is not represented" (p. 9). This is represented in critical theory where "the researcher's role is one of advocacy, a change agent" (Taylor, 2013, para. 15).

In this same vein, Taylor (2013) spoke of this desire for action as being a cornerstone of critical research in the field of education. Taylor stated the education researcher must ask the question "whose interests are not being (and should be) served by particular social policies and practices" (para. 15) and that critical research "involves identifying and transforming… social structures, policies, beliefs and practices. Its primary purpose is to identify, contest and help resolve" (para. 15). Further, Bassey (1999) stated critical research in education should be "aimed at informing educational judgments in order to improve educational action" (p. 39) and "should have immediate relevance to teachers and policy makers" (p. 39). If the end result of this project is the growth, change and advocacy spoken of in the preceding paragraphs, and not simply the understanding of the situation afforded by the constructivist/interpretivist approach, the critical theory lens and its focus on transformation and liberation is the best tactic for realization of these goals. In the words of MacDonald (1977) "by acquiring an awareness both of the nature of social conditioning and the potential for acting upon it, the individual or groups of individuals… can learn not only to formulate alternatives but also to bring about change" (p. 60).

Part of this alignment comes from my background as a teacher. I became an educator largely for the opportunity to positively influence the lives of young people and help improve the education system by finding ways to create environments to best develop the skills and abilities of students. These goals and desires have been carried into my role as an educational researcher, goals that are encompassed by the critical paradigm, which allows not only for the understanding of behaviours but also aims to change these behaviours.

The aim of any assessment program should be to improve the education and instruction that each child receives. However, research discussed previously in the literature review strongly suggests programs such as the former British Columbia Grade 12 science exams do the exact opposite, at least in part by limiting the role of the classroom teacher to implement what research deems to be best educational practices. In addition, it would appear political and societal forces, with the aid of the media, have created a discourse and attitude in our society which holds that exams are the ultimate tool for measuring virtually all facets of our education system. The purpose of this research then is to "confront ignorance and misapprehensions" (Guba & Lincoln, 1994, p. 115) and facilitate change by helping individuals "develop greater insight into the existing state of affairs and… to act on it" (Guba & Lincoln, 1994, p. 115).

Critical theory, in combination with research literature surrounding negative effects of exams on the teaching and learning process, enhance the analysis of data sources. For example, findings discussed in the literature review section outline adverse impacts high stakes exams have in areas such as teacher pedagogy. Changes uncovered in this area following elimination of Grade 12 exams, particularly changes made in the direction of what research deems to be "best practice", were reviewed from a critical perspective. This approach allows for the production of

knowledge exposing the constraints high stakes exams have on implementation of best teaching practices in the district.

Such an approach will allow this research to take the role of "advocacy" and "change agent" spoken of by Taylor (2013, para. 15), with the aim of inciting improvements in our schools and the policy decisions that guide them by illuminating the oppressive nature high stakes exams have on the ability of teachers to design and implement diverse, meaningful, and rich educational experiences for their students. The research from this study challenges the dominant social and political discourses regarding exams that permeate our society today.

What May Remain Obscured Following This Study

Like all methodologies, the case study is not a perfect means of research. While it was the intention of this project to contribute new knowledge to the literature, much may remain obscured at its conclusion. The following is a discussion of areas likely not illuminated by this study.

Comparisons and outliers. While not the sole reason, the chosen district of study was selected in part based on the fact the population of this district may be considered "average" for the province of British Columbia. For example, the BC Stats (2012) website revealed the demographics of the district are near provincial norms in terms of ethnicity, employment, education, and income. While I attempted to resolve the issue of generalizability earlier in this chapter it was felt that, in the interest of full disclosure, the issue of comparisons and outliers at least warranted mention at this point in time. This is due to the fact that concerns by some researchers may arise about the applicability of potential findings to what may be termed "outlier" districts.

For example, much educational research suggests the effects of standardized testing differ greatly based on the socio-economic status of the student clientele, with students from impoverished groups suffering far more ill-effects than those from upper income brackets (Atkinson & Geiser, 2009; Dee & Jacob, 2006; Gerald & Haycock, 2006; Soares, 2007; Warren, Jenkins, & Kulick, 2006). With this in mind, the BC Stats (2012) website reported that in 2005 the district ranked 16th out of 57 school districts in terms of average annual income at $29,395. This is well above the lowest district, Nisga'a ($21,063), but far behind the top district of West Vancouver ($71,269). Since achievement levels on Grade 12 provincial exams most likely varied from district to district based in part on socio-economic factors, removal of such exams may impact teaching strategies and policies in districts at opposite ends of the socio-economic spectrum in different ways.

Similarly, standardized exams have been shown to affect those from ethnic and English as a second language backgrounds in potentially negative ways compared to students from the Anglo-European population (Dee, 2003; Dee & Jacob, 2006; Education Trust, 2005; Giambo, 2010; Glenn, 2006; Haney, 2000; Natriello & Pallas, 2001; Reardon, Atteberry, Arshan, & Kurlaender, 2009; Rogers, Holme, & Silver, 2005). This considered, the BC Stats (2012) website stated that in 2006 the district ranked 19th out of 57 districts in terms of visible minority population with 6.6%. This is roughly one-tenth that of the Richmond district (65.1%) but over seven times greater than that of the Central Coast (0.9%). With these enormous differences, and potential impacts on teaching practices, it must be questioned how applicable findings may be to districts with significantly large or small ethnic populations.

While a thorough statistical and literary analysis of every potential outlier situation is beyond the limits of this paper, similar cases can be made for additional circumstances. For

example, in terms of population, findings in a medium sized district, like the one that is the focus of this investigation, may not be generalizable to the largest urban centres or remote rural settings. Similar claims may be made about districts with higher and lower parental education levels and differing traditional academic standards.

As mentioned earlier, it is hoped that regardless of the similarities or differences between the district and any other district, the findings of this study will provide provisional truths as well as stimulate conversations and further research in other locations. In addition, those in other locations who read the final report will be able to decide for themselves what aspects of this report are applicable to their own individual situations.

Subject transferability. When Grade 12 provincial exams were eliminated in August 2011, tests were being administered in 21 different courses. Since case study research relies heavily on thorough and exhaustive data collection from multiple sources, to have a single researcher studying all of these courses would be an unmanageable task. In large part this is why the choice was made to focus on removal of Grade 12 provincial exams in the subjects of Biology, Chemistry, and Physics.

In terms of curricular content and potential teaching strategies, these courses are potentially very different from disciplines such as languages, History, and First Nations Studies, only to name a few. Due to the differing nature of the content, the elimination of provincial exams may have had differing effects on the various courses and programs under the provincial exam umbrella. Therefore, it is possible the findings of this study may not be transferrable to subjects such as French 12, Spanish 12, and History 12.

Perspectives of those not spoken to. While case study researchers must be prepared to embrace new and unexpected findings that emerge during the course of their investigation

(Becker et al., 2012; Shuttleworth, 2008), choices must still be made surrounding research planning. For example, Creswell (2007) spoke of the need for diligence in establishing boundaries for case studies, with attention to time, events, and processes being emphasized. Further to this, Yin (2009) warned about the collection of an overwhelming amount of data. With these issues in mind, decisions needed to be made about who would provide the most fruitful evidence in terms of what this project is seeking to uncover. Therefore, boundaries were set in terms of the type of documents collected and who would be interviewed for this study.

These choices, made at least in part to keep data collection at a manageable level, may include the decision to speak with one group of people but not another. These decisions may have resulted in the unwitting loss of key perspectives and/or data during the course of the research study.

Potential effects on other exam programs. The subject-specific exams Grade 12 students wrote in British Columbia were "high stakes". For starters, each exam counted for 40% of a student's course mark, meaning it had a significant impact on final letter grades. The course and exam grades were also used to judge students for both post-secondary placements and scholarships. In addition, school and district test scores were published and scrutinized by the public and media of British Columbia. Consequently, there was significant importance attached to these exams for teachers and students.

Further, the content of these courses was dictated by a very detailed and rigid curricular document. Essentially, if an item was in the curricular document, it was a testable item. If it wasn't in the curricular document, it wasn't a testable item. Thus at the Grade 12 level the curriculum documents and exams came to routinize the work of teachers and students.

Many exam programs differ in nature from the former Grade 12 program. For example, the Foundation Skills Assessment tests conducted at the Grade 4 and 7 levels in British Columbia do not test content-laden material from a rigid curricular document; they test basic skills learned over many years. In addition, these tests do not count towards student marks, carry no weight in grade placement, and do not count for scholarships or university entrance. While the results are publicly scrutinized, essentially they have little to no bearing on the future educational path of a student and may be considered “low stakes”.

Due to these differences in programs and how they are approached by teachers and students, questions are raised as to whether the findings of this case study could be generalized to other large-scale standardized testing situations. For example, in a testing situation where skills and not content are examined, is teacher pedagogy affected in the same way? Are teacher morale and colleague relationships different in a high stakes vs. low stakes exam setting? Do exam effects differ in elective versus mandatory courses? These questions will go unanswered by this study.

Long term effects. This research project was undertaken during the third full school year following the elimination of Grade 12 provincial exams. Since these exams came into effect in the 1983-84 school year, all but one of my interview subjects spent their entire pre-August 2011 career working under this system (one interview subject began teaching in 1979). Essentially, provincial exams at the Grade 12 level have been all eight of the nine have known.

The question then becomes, when exams were removed in 2011, were significant changes immediately made to teaching practices or did these educators continue on as before because they did not know any different way of teaching? It may be that changes may occur incrementally over time and may not take full effect for a number of years. In addition, changes

may require new teachers who never worked under the provincial exam program infusing fresh ideas and perspectives into the system. Therefore, the full effect of removal of Grade 12 science exams may take several years to manifest themselves. If this is the case, only a longitudinal case study done over many years could answer these questions.

Biases. Many who write about case study investigations (Creswell, 2007; Hodkinson & Hodkinson, 2001; Yin, 2009) speak extensively about researcher bias. Consciously or subconsciously, case study researchers decide based on their own biases what data to emphasize and de-emphasize during the analysis process. Since the researcher has worked as a Grade 12 teacher both in the time of subject specific exams and in the time since these exams were eliminated, many years of experiences, and therefore potential biases, may have been brought into this study.

Chapter 4 – Uncovering the Control of Exams on Teacher Practice

Nine teachers were interviewed during this investigation. Interviews took the form of semi-structured conversations centring upon how removal of Grade 12 exams may have affected pedagogy and general teaching practices, classroom resource and time allocation, teacher relations with colleagues, student responses to courses, and data usage. All interview questions were researcher-generated. A copy of these questions has been attached as *Appendix A*.

All interviews were recorded and transcribed. As the number of interviewed subjects progressed, participant responses were thoroughly analyzed and manually sorted into categories of common themes on how the elimination of exams have impacted Grade 12 science teachers in the district under investigation. Information gathered in interviews was triangulated with evidence from a variety of sources, including teacher-made assessment tools, past provincial exams, school calendars, course outlines, curriculum guides, exam data reports, the findings of past investigators, and numerous documents produced by both the Ministry of Education and the district. At the conclusion of the analysis process, eleven themes emerged from the interviews.

Emergent Theme #1 – Provincial Exam Data Were Not Widely Used by Grade 12 Science Teachers to "Improve" Teaching Practice

Following the marking of each Grade 12 provincial exam sitting, the British Columbia Ministry of Education provided schools and teachers with data reports. These reports were provided for each subject that concluded with an exam and gave schools and teachers information on individual student grades, average marks for schools compared to their own district and the entire province, how individual classes performed on the various topics within an exam, and overall student participation rates in examinable courses for each school, rates that

were then compared to provincial averages. Examples of such reports are contained in *Appendix D* of this paper.

The Ministry-described purpose of this data was outlined by former Minister of Education Shirley Bond who stated, "teachers and principals will be able to use these results to help determine where they need to make improvements" (British Columbia Ministry of Education, 2005). Further, the Ministry's *Accountability Framework* document speaks of the importance of "data-driven decision making with a focus on assessment for learning" (British Columbia Ministry of Education, 2002c) while their *Large-Scale Assessment* policy document states these assessments "provide outcome data for decision-making and planning at all levels of the education system" (British Columbia Ministry of Education, 2013). Many authors in literature examined for this investigation also addressed the potential for exam-generated data to aid teachers in improving their practice (Borko & Stecher, 2001; Buck, Ritter, Jensen, & Rose, 2010; Center on Education Policy, 2006; Dee & Jacob, 2006; Massell, 2001; McMillan, 2000; Murnane & Papay, 2010; Yeh, 2005). These statements and findings were taken into consideration and teacher interviewees were presented with the question: *Did you ever use data from exam results to change your teaching*?

Of the nine teachers spoken to, seven stated unequivocally that they did not. Many mentioned perusing the test scores of their students out of curiosity, but that they did not use the data provided by the Ministry, such as that displayed in *Appendix D*, in any way to alter the manner in which they taught their courses in the future. The general tone of the answers given by the seven teachers stating they did not use exam results can be summed up in a comment by Joe (it should be noted that in order to protect the identity of participants pseudonyms have been used in the ensuing discussions), who stated:

> When I first started teaching the course I looked at this data out of curiosity to see how my kids did and then after a couple of years I hardly ever bothered to even look at it. So I would have to say no, I didn't use it to alter anything I did from year to year. It didn't cause me to make any changes in the way I did things.

Of the two teachers who revealed they did use the Ministry-provided data, Joanna said it let her know areas where her students performed poorly, thereby informing her where she needed to "beef things up" for the following year. The second teacher did not specify how data was used to improve practice, despite attempts by the interviewer to coax an elaboration on this statement.

Emergent Theme #2 – Provincial Exam Questions Played (and Still Play) a Large Role in How Teachers Assess Students

When teachers were asked the question: *Did you ever use data from exam results to change your teaching*? All originally misinterpreted the meaning of this query, proceeding to speak to how they used items from past provincial exams on their in-class assessments of students. While time was taken to correct interviewees and politely explain the actual intent of the question, and derive an answer vis-à-vis this original intent, the issue of use of past exam questions was pursued with each interviewee.

Literature examined for this investigation suggested the use of items from past large-scale examinations is a practice commonly employed by teachers (Anderson, Muir, Bateson, Blackmore, & Rogers, 1990; Collins, Reiss, & Stobart, 2010; Gayler, 2005; Wideen, O'Shea, Pye, & Ivany, 1997). When discussions with subjects morphed to this topic, teacher revelations were very consistent across all respondents and centred around two sub-themes. First, many teachers looked at past provincial assessment questions for feedback on the types of questions exams contained in order to best prepare students to answer similar questions on future tests.

Second, every teacher interviewed spoke of using old provincial exam questions as the basis for in-class unit tests and quizzes, while some revealed even using these questions on in-class assignments.

The power these exams had over teacher evaluation is underlined by a comment from Mackenzie, who when discussing if she used questions from past exams in classroom assessments replied “all the time. They were my unit tests. And quizzes, and stuff to work, worksheets. They still are”. Duke gave a similar reply, stating, “I still use the old provincial exams. They’re good questions” while Evan described how he has developed a computer data bank with every provincial exam question dating back to the 1980’s.

As a means of triangulating verbal evidence provided by teachers that past provincial exam questions were used on in-class assessments, some teachers were asked to provide examples of assessments where such questions were used. Four examples provided are displayed in *Appendix E*. Two of these documents are unit tests and two are quizzes. While teachers providing these documents could not recall exactly which past provincial exam each question was from, all stated questions contained in these assessments were derived from past provincial exam questions. To further verify these statements, the four assessment tools shown in *Appendix E* were cross-referenced against past provincial exams, a process that substantiated teacher claims.

For example, a Biology 12 unit test provided by Joe asked the question *The hormone that initiates the “fight or flight” response is produced by the*, with this question being followed by four answer choices. This question, and the answer choices that followed, was taken directly from question #40 of the January 1998 Biology 12 provincial exam. Further, a Chemistry 12 unit test provided by Gillian contained a question that stated *A buffer solution may contain equal*

moles of, which, like Joe's question, was followed by four potential answers students were to select from. This question, and all of its potential answers, was taken directly from question #36 of the April 2000 Chemistry 12 provincial exam.

Emergent Theme #3 – Teachers Produced and Used Large Volumes of Practice Tests and Review Packages to Prepare Students for Provincial Exams

A sizeable volume of research speaks of teachers in large scale testing environments using past exams as practice tests and purchasing large quantities of commercially produced materials as strategies for preparing students for exams (McClaskey, 2001; McNeil, 2000a & 2000b; Mitchell, 1997; Nathan, 2002; Pedulla, Abrams, Madaus, Russell, Ramos, & Miao, 2003; Pringle & Martin, 2005; Traub, 2002; Valli & Buese, 2007). Taking these findings into consideration, interviewees were asked the question: *During the time when exams were required, what resources did you allocate to exam preparation (such as, purchasing test preparation materials, photocopying practice exams, etc.)?*

While a small number of teachers spoke of informing students about the availability of commercially produced study guides, all were quick to point out these materials were not mandatory and were never purchased from school budgets. Students who purchased such materials did so at their own expense.

However, every teacher interviewed described how, during the time of provincial exams, they would photocopy class sets of past tests, providing these to students as part of exam preparation. Each of these exams varied in length but roughly averaged between 30-50 pages. For triangulation purposes to verify the length of each exam, *Appendix I* contains one teacher-provided example of each of the Biology 12, Chemistry 12, and Physics 12 exams. For further verification of exam length, numerous copies of past exams can be found on various internet

websites, including Biology 12 at http://www.angelfire.com/geek/chem12/, Chemistry 12 at http://www.angelfire.com/hero/biol12/, and Physics 12 at http://www.questionbank.ca/?dir=Grade%2012%20Subjects/Physics/Exams.

Many teachers spoke of copying multiple past provincial exams for each student. Joe stated:

> I used to photocopy a pile of old provincial exams to use as practice for the students. I also made up fairly extensive review packages for each section of the course, the 10 or 11 sections, that I would give them. It was a pretty exorbitant amount of copying. Piles and piles of paper. I felt guilty about it. A lot of trees died to get my kids ready for the exam and it probably cost the school district a small fortune in photocopy costs.

If each student in a class of 30 received two practice tests of 40 pages each, this is 2400 pages of copying, just in practice tests alone. At a cost to the school district of 1 cent per page (Dean, 2014), each time a teacher photocopied practice exams for students the cost would be roughly $24.

These findings unveil a problematic issue surrounding student access to success in the area of large-scale standardized testing programs such as the one examined in this investigation. These practices, students purchasing supplemental material and teachers photocopying large volumes of documents for exam preparation purposes, come at a financial cost to the school and/or the individual student. These costs, and the ability to incur them, give advantage in the area of exam preparation to students who come from affluent homes and attend schools capable of absorbing the photocopy costs described above. McLaren (1989) underlined this inequity in schools by stating that, “schools constitute a loaded social lottery in which the dice fall in favor of those who already have money and power” (p. 9).

Emergent Theme #4 – Cancellation of Exams Has Not Greatly Impacted Teachers' Relations With Colleagues

Literature addressing the issue of how teaching in a large-scale testing environment impacts relationships between colleagues is somewhat mixed. Some research suggests such environments may facilitate increased co-operation and collaboration in areas such as planning, as well as leading to greater communication between classroom and special education teachers (Buck, Ritter, Jensen, and Rose, 2010; Gayler, 2005; Valli & Buese, 2007; Yeh, 2005). Other findings suggest these environments create a hierarchy between tested and untested subjects and may induce unhealthy competition between colleagues (Anderson, Muir, Bateson, Blackmore, & Rogers, 1990; Gayler, 2005; Jones & Egley, 2004). Taking these findings into consideration, teachers were asked: *Have you noticed any differences in your professional relationships with your fellow science-teaching colleagues since the cancellation of exams? If yes, please give examples*.

Of the nine teachers interviewed, eight were emphatic in stating the presence or absence of the provincial exam in no way affected their relationships, for better or worse, with their colleagues. Most of these eight were brief and to the point when answering this question, such as Duke who chuckled and stated "None. None. None at all".

The one teacher who hinted the presence of the exam may have negatively impacted staff relationships spoke to disapproving comments colleagues would make towards teachers whose classes did not perform well on an exam. This seemed to be a very emotional topic for this particular teacher so, out of respect, no follow up questions were asked regarding this answer.

Emergent Theme #5 – Teachers Note a Less Serious/Less Academic Trend in Their Students Since Provincial Exams Were Eliminated

Advocates for large-scale standardized assessments often campaign for such tests based on the belief testing forces students to adopt a more serious attitude towards their studies. Taking this discourse into consideration, teachers were asked: *Have you noticed any differences in students' responses to your course(s) now that there no longer is a mandatory government final exam?*

While there was no seeming consensus answers to this question, curious responses were offered by teachers. Seven of the nine interviewees spoke to a perceived decrease in the overall "quality" of students taking their courses since the provincial exam was eliminated. Seven of the nine teachers spoke of how, since the exam was eliminated, they have noticed "more weaker/less academic kids" in their classes, "less effort" and "attendance issues" among some students that they feel were not seen in the time of the provincial exam. For example, in terms of student attendance, Evan noted:

> Other kids are concerned and don't like missing class. You still get that high end, but you certainly have a complete difference in regards to the number of, like, statistically how many kids in the class would be missing class. You never would have had that before. Now you get lots of it.

In the area of student focus and effort, RJ stated that, "students became a lot more focussed on the exam in January when there was a provincial exam than when there wasn't a provincial exam, even though they had an in-school final". Duncan echoed these sentiments, saying:

> I'm not sure that the provincial exam is the reason, but certainly over the last 2-3 years the focus of the class as a class is far less than it used to be. The um, a number of students come in desiring to go on to post-secondary but don't desire to do any homework.

In a similar vein Duke said, when speaking about the "quality" of student he is now seeing in his course:

> I'd say the quality of the kid. And that just may be they know there isn't a provincial exam that's 40% of their mark so they're not putting as much effort. But I've noticed that through all of my courses, you know, over the 22 years that I've taught.

In an attempt to triangulate statements made by teachers in the above paragraphs, a data request was submitted to the British Columbia Ministry of Education. This request sought longitudinal data on pass/failure rates and overall student grades for the courses under investigation as well as attendance data for Grade 12 students. Unfortunately, the Ministry is not in possession of the attendance data and information surrounding student grades was only collected up until the time of exam elimination in 2011, thereby not allowing for a comparison of student performance pre and post exam elimination.

Emergent Theme #6 – All Teachers Used Class Time to Prepare Students to Write Provincial Exams

Literature reviewed for this paper detailed how large-scale exams may lead teachers to use class time to prepare students for these exams. Two teams of researchers specifically studied the British Columbia Grade 12 context when provincial exams were in place. Anderson, Muir, Bateson, Blackmore, and Rogers (1990) found teachers spent a "large portion of time" preparing their students for exams while Wideen, O'Shea, Pye, and Ivany (1997) stated teachers spent "too much time" on this type of preparation. A multitude of researchers outside the British Columbia

setting have concluded teachers use class time to prepare students for standardized exams (Collins, Reiss, & Stobart, 2010; Diamond, 2007; Gayler, 2005; Hamilton, Stecher, Marsh, McCombs, Robyn, Russell, & Barney, 2007; Harlen, 2007; Hillocks, 2002; Hoffman, Assaf, & Paris, 2001; Jones & Egley, 2004; Jones, Jones, & Hargrove, 2003; Jones, Jones, Hardin, Chapman, Yarborough, & Davis, 1999; Mansell, 2007; McCarthey, 2008; McNeil, 2000a; Moon, Brighton, Jarvis, & Hall, 2007; Patterson, 2002; Pedulla, Abrams, Madaus, Russell, Ramos, & Miao, 2003; Reback, Rockoff, & Schwartz, 2013).

With these findings in mind, interviewed teachers were asked: *Did you spend time, either inside or outside of class, preparing students for how to write the provincial exam? If yes, can you estimate how much time was spent on this preparation?* Also, if yes was answered: *What are you now doing with your students in the time previously spent on exam preparation?* What teachers revealed to the third question will be discussed in a subsequent section. However, in dealing with the first two of the above three questions, two themes emerged during discussions with teachers. The first theme, Emergent Theme #6, will be discussed next, while the second will be discussed as Emergent Theme #7 in the following section.

All teachers interviewed stated they spent class time at the end of each semester preparing students for the provincial exam. Interviewees acknowledged the amount of time varied from year to year based on factors such as how many classes were lost to snow days, school assemblies, fire drills, etc. However, from information gathered through interviews, preparation ranged from one teacher saying two periods (150 minutes) to another saying the last 2-3 weeks of classes (750-1125 minutes). The average appears to be the final 4 or 5 periods of the term, amounting to roughly 300-375 minutes of class time spent solely on exam preparation.

Percent time spent on examination preparation. Based on teacher descriptions, the

general activity in this review time was students and teachers worked through past provincial exams as practice for the test. Gillian described the general tone of these sessions by stating:

> I used to take all of the online exams, I think it was called Angel Fire, was a website that has every single exam in existence. So I used to take them and make duo tangs that kids could sign out. Out of it, so, like booklets that kids would actually go through.

Pat described how he felt it important for students to develop skills on how to write exams, stating he spent a great deal of his class preparation time ensuring students:

> Were up to speed on exam writing and exam writing technique, just in terms of having the students make sure that they answered the questions appropriately, didn't spend too long on any one question, and that would penalize them later on. Nothing too specific, just general exam writing technique.

How teachers described the general purpose of this review was summed up by Joanna who declared, "review was not the principles of the course, but was just exam review and prep".

Two school calendars were obtained as part of the evidence-gathering process and are displayed in *Appendix F*. One calendar was from the 2008-2009 school year, another the 2009-2010 year. The district that was the focus of this investigation employed a "semester system" timetable where students and teachers have four classes from September until the end of January, then four new courses from February until the conclusion of the school year in June. Therefore, the two calendars contained in *Appendix F* detail a total of four semesters. Since teachers in this district taught each class once per day for an average of 75 minutes, these calendars can be used to calculate the total number of classes and minutes of teacher contact with students.

The two school years (four semesters) had no features making them distinctly different from any other school calendar. With professional development days and statutory holidays

excluded, there was an average of 85.25 class days in each semester. When multiplied by 75 minutes per class, this means teachers and students have a total contact time of just under 6400 minutes, or 106.5 hours. Assuming 3 classes are lost due to factors such as assemblies, evacuation drills, or snow days, teachers can expect to see students for roughly 6175 minutes or 102.75 hours.

For the teacher who spent 2-3 weeks of class time on exam preparation, this would mean roughly 12.2% – 18.2% of the course was spent on review specific to the provincial exam. For two classes of review, this constitutes 2.5% of course time, while the average of 4-5 classes encompasses between 4.9% – 6.1% of course time. It should be noted this time does not include the 3 hours that was allotted for students to write their provincial exams as this was conducted outside of class time during an "exam week" that followed the conclusion of classroom instruction.

Emergent Theme #7 – Time Was Spent on Provincial Exam Review External to Class Time

In addition to Emergent Theme #6 discussed in the previous section, a second theme surrounding time dedicated to exam preparation emerged when teachers answered the questions: *Did you spend time, either inside or outside of class, preparing students for how to write the provincial exam? If yes, can you estimate how much time was spent on this preparation?*

All teachers interviewed spoke of making themselves available to students outside of class time to help prepare students for the provincial exam. The format of this review varied from teacher to teacher, with one saying he simply made himself available for informal drop-in help while the remaining eight all spoke of providing structured exam preparation sessions outside of class in the time leading up to the exam. This commitment on the part of teachers ranged from two 2-3 hour sessions for one teacher up to what Joe described as his regime:

> I would also always do review sessions outside of class either after school, at night, during exam week, whatever. Depending on how much I would get to review in class this would be anywhere from 4 to 8 or 9 sessions outside of class.

All teachers stated that with no provincial exams they no longer provide these formal external review sessions, but many spoke to being available on an informal drop-in basis if students require assistance preparing for their school-based final exam that has replaced the provincial exam.

Emergent Themes #8 Through #11

Considering research cited in the literature review regarding time used by teachers to prepare students for exams and the confirmation from my interview subjects that they spent time both inside and outside class preparing students for exams, interviewees were asked: *How are you using any time previously allotted to exam preparation?*

The answers to this question overlapped a great deal with teacher responses to the question: *Overall, how has the removal of these exams affected your teaching practice?* Combined, four themes emerged from these two questions.

Emergent Theme #8 – Teachers Made Incremental Changes in the Manner in Which They Assess Student Performance After Exams Were Eliminated

Grade 12 provincial exams in British Columbia totalled 40% of a student's mark (Wideen, O'Shea, Pye, & Ivany, 1997), while teacher-assigned grades based on student work comprised the remaining 60%. Despite a course ending provincial exam no longer being in place, all teachers revealed in the absence of a summative government assessment they now administer a teacher-generated final exam. Seven of the nine teachers interviewed stated their final exams now constitute 20% of a student's mark. The remaining two indicated they vary the weighting of

this assessment from year to year but confirmed it constitutes 20-25% of a student's overall course mark. For the purposes of triangulation of these statements, teachers were asked to provide course outlines detailing these changes. Six course outlines currently used by teachers in this investigation were collected detailing this data and appear as *Appendix G*. The information contained on these outlines corroborates the statements regarding final exam weighting given by teachers during the interview process.

While the finding discussed in the above paragraph shows a definite de-emphasis in the importance of a final exam from a numerical standpoint, questions arise as to why teachers continued to use this form of assessment. While this will be discussed in greater detail in Chapter 5, part of the reason for this trend may be outlined in quotes from Duke and Joanna who spoke of perceived pressure to prepare students for post- secondary education. Duke stated "You know, the kids taking Bi 12 still go university so I gotta prepare 'em" while Joanna said "I still feel its important if students are academic and they're going to university, uh, they need to learn to write tests. Just, I feel obligated to teach them how to do that".

In addition to the slight de-emphasis on a course-ending exam, a theme emerged during interviews that shows teachers moderately reformed within-term assessment (the school district uses a semester system for their high schools with two terms within each semester. Teachers must produce a report card grade for students at the end of each of the two terms in both semesters). This alteration shows a slight de-emphasis on tests as a component of grading towards other forms of assessment such as assignments, labs, and projects.

Two teachers, Duke and Pat, stated they did not change the manner in which they assessed students within each term; the remaining seven indicated tests total a reduced portion of their assessment plan compared with the time of provincial exams. While each of the seven

assess students in a slightly different manner, teachers did offer insight into their grading schemes. Evan, Joanna, and Mackenzie all stated that when the provincial exam was in place 80% of the mark they assigned students was based on test scores, with 20% based upon various assignments. With no exam in place, both Evan and Joanna have altered their grading to 70% tests and 30% assignments, while Mackenzie stated she is now "roughly 60-70% tests and 30-40% assignments". Both Joe and RJ revealed that during the time of the provincial exam they assessed students based 90% on exams and 10% on assignments, while both indicated this changed to 80% tests and 20% assignments following the elimination of exams. Further, Gillian reduced tests from 70% to 60% of student grades and Duncan, while not specifying percentages, confessed he has "de-emphasized tests a bit".

To triangulate the evidence given in the preceding paragraph, teachers were asked if they could provide both current course outlines and ones used in the time of mandatory exams. Understandably, since exams were eliminated roughly three years ago, most teachers were unable to locate outlines used during the time of provincial exams. However, Joe, Duke, and Gillian were all able to provide outlines detailing their grading schemes during both pre and post exam elimination. These outlines confirm statements made in the previous paragraphs and are contained in *Appendix G*. Outlines from RJ and Joanna detailing their post-exam assessment programs are also contained in this appendix. Unfortunately, the outline provided by Duncan does not provide assessment particulars.

A reason for this shift in assessment may be found in statements made by four of the nine interviewees. These subjects intimated that during the time of exams they felt a pressure to have school/teacher-assigned marks closely align with the provincial exam mark students would achieve. Since the provincial exam was a "written test" these teachers felt that if their assessment

plan heavily emphasized written tests, there would be a balance between teacher assigned and provincial exam marks. Mackenzie stated “I just wanted to be sure… did their course mark align with their final exam mark?”. Further, Evan asserted he:

> Looked at what kids did and we looked at how they compared. I looked at how they compared with their school mark, because if my exam mark was way out of whack with my school mark… I didn’t have a big problem if my mark was a few percent above the average but I certainly didn’t want to be like I saw within some schools and districts where the percentage was 7 or 8% for their school mark inflated over top of the exam because then there’s something, I just didn’t think there was something quite right there.

In a similar vein, Joe stated:

> They used to publish the teacher-assigned mark and what the kids got on the provincial exam. I always thought that if there was too big a discrepancy between these, like the provincial exam mark being way lower than the school mark, that that meant I was doing a bad job preparing the kids.

While the changes to a decreased emphasis on testing as an assessment method have not been absolute–tests still made up the majority of student marks with all teachers interviewed–the movement, however slight, towards a decreased emphasis on tests and an increased emphasis on other forms of assessments seems to align with declarations in multiple Ministry of Education documents. For example, the Teacher Regulation Branch, which operates under the Ministry of Education, published standards of conduct all teachers in British Columbia are expected to abide by (British Columbia Ministry of Education, 2012b). Eight standards are listed, with standard #5 stating, in part, “educators implement effective practices in… assessment, evaluation and

reporting" (p. 4) and that "educators employ a variety of instructional and assessment strategies" (p. 4).

Further, the curriculum guides for all three subjects under investigation list the same recommendations for the manner in which students are to be assessed. These documents state, under the heading of Classroom Assessment and Evaluation:

> Assessment is the systematic gathering of information about what students know, are able to do, and are working toward. Assessment evidence can be collected using a wide variety of methods, such as
>
> - observation
> - student self-assessments and peer assessments
> - quizzes and tests (written, oral, practical)
> - samples of student work
> - projects and presentations
> - oral and written reports
> - journals and learning logs
> - performance reviews
> - portfolio assessments (British Columbia Ministry of Education, 2006a, p. 23; British Columbia Ministry of Education, 2006b, p. 23; British Columbia Ministry of Education 2006c, p. 21)

While a large volume of research discussed in the literature review and Emergent Theme #2 suggests teachers in standardized testing environments are prone to having classroom assessments mimic those of the exam their students will write, only one study was found speaking to how teachers in these conditions may alter the manner in which they determine

report card marks. A study conducted by Anderson, Muir, Bateson, Blackmore, and Rogers (1990) found following implementation of British Columbia Grade 12 provincial exams, for student report card grading, teachers increased the weighting assigned to class-based tests while decreasing the portion assigned to projects, assignments, and labs. It would appear the investigation conducted herein suggests the reverse may occur when exams are removed. The results of this investigation implies, with a reduction in importance of testing within terms and in final exams, teachers have, however incrementally, moved in the direction of a more holistic model of student assessment as suggested by Ministry edicts.

Emergent Theme #9 – Grade 12 Science Teachers Continue to Cover All Curricular Objectives in the Absence of a Provincial Exam

An Internet search of blogs and websites reveals many forums where large-scale testing is advocated as a lever to force teachers to adhere to prescribed curriculum. While the overwhelming majority of these writings do not quote research and seem to be more based on opinion, a small volume of peer-reviewed literature suggests that, for at least a portion of teachers, an exam serves as a catalyst to sharpen the focus of educators towards prescribed learning outcomes (Buck, Ritter, Jensen, & Rose, 2010; Gayler, 2005; Yeh, 2005). With these opinions and research findings taken into consideration, teachers were asked: *Overall, how has the removal of these exams affected your teaching practice?*

Conversations around this question morphed in a variety of directions. However, when the conversations in this area moved to curricular coverage every teacher interviewed confirmed, despite the elimination of the provincial exam, they still cover all prescribed learning outcomes in their courses. Mackenzie, who teaches all three of the senior science courses under investigation in this study, stated “I cover 100% of the prescribed learning outcomes” while

Joanna emphatically declared, “I teach everything very meticulously”. This finding seems to run counter to the popular discourse of exams being a necessity to ensure curricular coverage.

For the purposes of triangulating teacher statements regarding continued coverage of the entire curriculum in their courses, two pieces of evidence were examined. Firstly, the course outlines provided in *Appendix G* list the curricular topics teachers providing these outlines impart in their courses. A comparison of these outlines with the British Columbia curriculum guides for Biology 12, Chemistry 12, and Physics 12 show all topics from these guides are listed on the course outlines. Interestingly, for the three teachers who provided course outlines from both pre and post-exam elimination, the only changes made to the outlines are the manner in which students are evaluated, a topic discussed in Emergent Theme #8.

As a second source of triangulating evidence, some teachers provided copies of recent final exams they have given their students, displayed as *Appendix H*. The topics covered by the questions on these teacher-made exams were cross referenced with the prescribed curriculum and it was concluded each test provided covered the curriculum in a thorough manner. Both of these pieces of triangulating evidence lend support to teacher statements that they continued to cover all prescribed curriculum, despite the absence of a provincial exam.

Emergent Theme #10 – Class Time Formerly Allotted to Exam Preparation is now Being Used by Teachers to Explore a Greater Diversity of Learning and Pedagogical Avenues With Students

A very significant amount of research strongly suggests teachers working in high stakes testing environments allot a substantial amount of class time towards preparing students to write these exams (see pages 65-66). With this research taken into consideration, teachers were asked: *Did you spend time, either inside or outside of class, preparing students for how to write the*

provincial exam? If yes, can you estimate how much time was spent on this preparation? All teachers answered in the affirmative to this question and the results are discussed in the Emergent Theme #6 and #7 sections. When teachers answered in the affirmative, they were asked the follow-up question: *What are you now doing with your students in the time previously spent on exam preparation?*

Research suggests the presence of a large-scale assessment can significantly impact teacher practice. This may include a movement towards teacher-centred pedagogies, a decrease in student exposure to laboratory and "hands-on" experiences, and an emphasis on learning of facts over the development of other skills and competencies (see pages 75-79). Aside from these major findings, several other impacts of exams on teacher pedagogy are discussed in the final section of the literature review for this paper. Taking these findings into consideration, teachers were also asked: *Overall, how has the removal of these exams affected your teaching practice?*

While teacher answers to the questions written in the last sentences of the above two paragraphs varied greatly, two consistent themes emerged. The first was that in the absence of a provincial exam all teachers no longer engage in the time-consuming exam preparation addressed in Emergent Themes #6 and #7. Secondly, in part due to no longer allotting class time to exam preparation as well as a, in Joanna's words, "liberating" from the exam, all teachers spoke of changes made to how they deliver their courses. These alterations featured the implementation of a variety of new teaching and learning strategies, a shift in emphasis not only reflected in teacher descriptions in the following paragraphs, but in the post-exam assessment shift discussed in *Emergent Theme #8* to a slightly greater emphasis on assignments.

Pat, who has been teaching since the early 1980's, appeared to make the least alterations, stating the only changes he has made since exam elimination is "adding an extra lab or two". In

addition to Pat, six of the remaining eight interviewees discussed how the absence of in-class exam preparation allowed them to do extra labs with their students. Duke stated “there is a little extra time for doing, I do a couple labs. For example I now do a fitness test and we analyse that”. Gillian, who spent the greatest amount of class time on exam preparation, revealed she “added additional labs, um, that maybe before you just didn’t have time to add those labs. So, you know, you’d add at least one lab per chapter, um, in some chapters probably even more”.

Seven of the nine interviewees spoke of having time and freedom to do various student projects and assignments that were not done in the past. Joe stated that since exam elimination he has “added in a couple of assignments where the kids go to the computer room and research a topic of interest to them. I didn’t do that when the exam was in place”. Gillian spoke of undertaking a mentorship project where her class worked with a group from a nearby elementary school. She enthusiastically described how she has:

> Started doing in the past few years a, um, combined project/mentorship science fair extravaganza that takes approximately a week and a half in and of itself. So I paired my Grade 12’s with the Grade 1 class and they each had to each take a portion of the course, or a topic, not even a portion of the course, a topic in the course and in a hands-on laboratory setting present it to Grade 1’s. But they had to do it repeatedly, like in a 8 station cycle.

Evan, who admitted that during the time of mandatory exams he would often lecture for an entire 80 minute period, spoke of how, after the exam was removed:

> We looked at different ways of trying to get kids to be more familiar with all of the learning outcomes by perhaps doing fewer worksheets and other questions on review. And then we went to the, we went to presentations… I really quite like where kids choose

> topics within the human biology, the last half of the course, and they, they choose a topic related to one of the human biology areas...They have to take their learning outcomes, relate the learning outcomes specifically to the disorder, and kids will usually do, now they're using Prezi, they're using PowerPoint, and other cool things like that. I've had kids do all sorts of little documentaries, some kids have done games and songs around it, activities for the kids to do to understand concepts and we have just sort of a real simple marking rubric making sure that they thoroughly covered the concepts, they've got referencing along the way, they've got relationships to the learning outcomes, clarity of presentation, (inaudible) questions, and you know the kids do a wonderful job on it but, you know, they have, they can work in pairs when they do those, and you know, because some kids feel uncomfortable standing up in front of a class doing it so some kids will actually make movies at home and then send the movie clip in on their presentation.

Evan also described how his students now are tasked with creating their own journals and study guides instead of continuously relying on him to provide this information through lecture and notes. He glowingly talked of the "phenomenal" work his students created in this area and mentioned how he felt the quality was on par with commercially-produced materials.

RJ, who was the most senior of the interviewees having started teaching in 1979, also spoke of undertaking a similar presentation project to Evan's and admitted, in regards to such a project, that it "takes a lot of time, and in a finite semester where you have an external exam you might not have had that ability to do that". Similarly, Mackenzie eagerly spoke of moving towards project based learning that allows students to "go somewhere where they want to go instead of somewhere where I am forcing them to go", while also adding she is taking a more holistic approach by also adding activities such as student blogging.

Both Evan and Joe spoke of incorporating a greater deal of YouTube videos to compliment course concepts and building new assignments into their courses. Joe also spoke of an ability to now go with the teachable moment when it arises:

> I think I am more relaxed as a teacher too, like, um, I feel that if a topic or question arises that is a little off topic but still interesting I can spend some time on it whereas before I would just say to the kids something like 'that isn't on the exam so don't worry about it'. I guess I am saying I can go with teachable moments more than I could before. I am more relaxed and feel I can teach kids whereas when the provincial was on I just taught content at the expense of everything else.

Gillian, who spoke of an ability to now go through her course in a slower manner, also stated how she feels the course is more interesting for students due to all of the labs, projects and hands-on experiences that have been added since the exam was eliminated. Similarly in the vein of student centred approaches, Joanna indicated she felt more capable of placing a greater focus on building relationships with students and teaching with a greater responsiveness to individual student needs.

Further Joanna, who was one of four teachers who spoke of doing more teacher-centred lecture pedagogy during the time of the exam, talked of feeling more able to take risks and challenge students to be creative and problem solvers instead of relying on her "to be the expert". She said she does this in part by:

> Doing a collaborative project that integrates a lot of the sections so, um, or maybe have them each doing different projects to try to tie the whole thing together in presentations, you know, so the whole class is sort of teaching each other. Just change it up and make it more interesting and probably more, hopefully more, relevant to what science is about.

When asked in a follow-up question if she could have done this during the time of a mandatory government exam, she emphatically replied “no. I never would have taken that risk”.

Interestingly, these findings seem to suggest that one Ministry of Education edict, specifically the conducting of provincial exams in Grade 12 science classes, may have interfered with teacher implementation of other Ministry directives. For example, the Teacher Regulation Branch, which operates under the Ministry of Education, published standards of conduct all teachers in British Columbia are expected to abide by (British Columbia Ministry of Education, 2012b). Standard #5 states, in part, “educators implement effective practices in areas of classroom management, planning, instruction” (p. 4) and that “educators employ a variety of instructional and assessment strategies” (p. 4). Further, the curriculum guides for the three subject areas under investigation all state, on page 3, that their development “has been guided by the principles of learning: Learning requires the active participation of the student; People learn in a variety of ways and at different rates; Learning is both an individual and a group process” (British Columbia Ministry of Education, 2006a, 2006b, 2006c).

The findings discussed in this section that educators have moved away, in varying degrees, from an exam-focussed, teacher centred pedagogy towards a greater variety of instructional strategies suggests an environment without a high stakes exam better facilitates the Ministry guidelines discussed above.

Emergent Theme #11 – Teachers Spoke of Reduced Pressure in the Absence of an Exam

Literature discussed in Chapter 2 suggests teaching in standardized testing environments, especially those that may be labelled “high stakes”, causes teachers to feel a great deal of stress and pressure and may facilitate a decline in teacher morale (see pages 56-59). Specific to the British Columbia context, Anderson, Muir, Bateson, Blackmore, and Rogers (1990) reported

Grade 12 teachers experienced an increase in stress levels in the wake of the implementation of provincial exams in 1983. Further, Wideen, O'Shea, Pye, and Ivany (1997) investigated Grade 8, 10, and 12 science teachers in British Columbia during the time of mandatory Grade 12 provincial exams and concluded Grade 12 teachers experienced a greater deal of "psychological pressures" than their colleagues teaching Grades 8 and 10. These authors attributed these increased pressures felt by Grade 12 teachers to the presence of provincial exams.

While the interview questions used for this investigation (see *Appendix A*) did not contain any queries specifically addressing the issues of stress, pressure, or teacher morale, all but one of the interviewed subjects made mention of various pressures surrounding preparing students for the provincial exam. For example, Joe stated "there was a lot more pressure to drive the kids through the course at all costs" and how currently, in the absence of an exam, "there may be a more relaxed atmosphere in the class because of the less pressure to pass an exam". Duke echoed these feelings by declaring:

> You were driven by… I was always in the back of my mind, I don't want a kid to write this exam and get a question and go 'Oh, Mr. XXXXXX didn't cover that'. So I was always driven by, you know, I've gotta make sure I cross all my T's and dot all my I's and make sure I've covered the material up to the exam specs.

However, in the absence of an exam, Duke said "there's definitely less pressure there". Evan echoed this sentiment, saying how without a provincial exam "you're a little more relaxed. You don't have the pressure of a final to get them ready for".

Duncan spoke of how this decrease in pressure has rendered him "free-er" to try new things, while RJ spoke of a sense of greater autonomy in the absence of a provincial exam. It is perhaps this increased sense of freedom that led Pat to declare he is able to "do a couple of extra

things without the pressure of the exam coming up" and Joanna to reveal "that worry is gone. You know, it is more focussed on the relationship between me and them".

It is worth noting, as a reference to the literature cited at the beginning of this section, while 8 of 9 teachers did at least make mention of decreases in stress and/or pressure, no teachers spoke of any changes in their individual or staff morale following elimination of exams.

While no teachers specified the source(s) of pressure felt regarding provincial exams, issues surrounding the former Grade 12 provincial exam program may offer insights. Firstly, these exams counted for 40% of a student's overall mark in the Grade 12 science courses under investigation (Mussio, 2012). This potentially has large implications on a student's final mark and post-secondary admission. Further, to graduate from high school during the time of provincial exams students were required to complete a Grade 11 or 12 science course as well as 16 credits (four courses) at the Grade 12 level (British Columbia Ministry of Education, 2004). Moreover, the Ministry allocated scholarships to students based upon scores on provincial exams (British Columbia Ministry of Education, 2011b). In addition, school district achievement contracts often considered Grade 12 course marks and participation rates as indicators of school performance (e.g. School District #XX, 2007), while test results were made public in a widely-viewed school ranking system (e.g. Fraser Institute, 2010, 2011).

In relation to the 11 themes presented in this chapter, the purpose of this section was simply to reveal the findings of this investigation, not to engage in a deep level of analysis or commentary. The ensuing Chapter 5 will unpack the themes presented herein and analyse them through a critical theory lens.

Chapter 5 – A Critical Analysis of Findings

Critical Theory and Grade 12 Exams in British Columbia

The aim of any assessment program should be to improve the education and instruction that each child receives. However, research discussed previously in the literature review strongly suggests programs such as the former British Columbia Grade 12 science exams do the exact opposite, at least in part by limiting the role of the classroom teacher to implement what research reveals as sound educational practice. In addition, it would appear political and societal forces, with the aid of the media, have created a discourse and attitude in our society, which holds that exams are the ultimate tool for measuring virtually all facets of our education system. I do not agree with this viewpoint and challenge, through the use of critical theory in the analysis of my research findings, this dominant discourse and structures of our educational institutions in regards to exam programs. My research aims to "confront ignorance and misapprehensions" (Guba & Lincoln, 1994, p. 115) and facilitate change by helping individuals "develop greater insight into the existing state of affairs and… to act on it" (Guba & Lincoln, 1994, p. 115).

A critical theory approach to data analysis presents my research as the type of "advocacy" and "change agent" spoken of by Taylor (2013, para. 15), roles that will hopefully lead to improvements in our schools and the policy decisions that guide them by illuminating the oppressive nature high stakes exams have on the ability of teachers to design and implement diverse, meaningful, and rich educational experiences for their students. The findings of this research should help challenge the dominant social and political discourses regarding exams that permeate our society today. In the words of Habermans (as cited in Dash, 2005), my intention is to "transform the existing situation" (para. 12). I believe that a critical approach to data analysis is the best means to facilitate the achievement of this goal.

Grade 12 Science Exam Data Was Not Used as Promoted by Popular Discourse

As discussed in the literature review, many politicians, researchers, and members of the general public in British Columbia and beyond advocate for large-scale exams as a means of producing data that can be used to improve teaching and student learning. The results of this investigation suggest this was more popular discourse than lived practice in relation to the Grade 12 provincial science exams in the district examined.

Only two teachers in this investigation spoke of using Ministry-provided data reports (such as those shown in *Appendix D*) to make alterations to their teaching, and these teachers were only able to provide an at-best vague description as to how they used this data. Perhaps a large portion of this is because, like any year-ending standardized exam, after students completed provincial exams in Grade 12 they were no longer under the educational jurisdiction of their subject teachers, making it impractical, if not impossible, for educators to use this data to address perceived needs of individual students. This finding raises the question, what are the purposes of these data reports and the exams they are based upon?

It would appear, at least in the context of Grade 12 students in the district investigated, that these exams only served to produce data for accountability purposes with little to no bearing on actually improving the classroom experience of students. However, this data does serve a tremendous political value. As detailed in the literature review, since the 1970's there has been an erosion of public trust in internal professional accountability and regulation in the teaching profession. With this loss "a regime of neo-liberal corporate accountability has dominated the governance of education" (Ranson, 2003, p. 459) and parent choice in an education marketplace has become a dominant theme on the educational landscape of British Columbia.

Within this marketplace, to allow consumers to make choices they feel are best for their children, information is required. The markets and choice mantra is buttressed by the public provision by government of school and district exam scores. In regards to the Grade 12 exams, these scores were freely available on the British Columbia Ministry of Education website and were updated following the completion of each round of government exams. Such easily accessible data can be presented to the public and used to compare students, schools, and teachers, thereby providing education consumers with a source of information on which to base their decisions as they navigate the educational marketplace.

While this data is, on the surface, easy to understand and provides the public with what appears to be an accountable and competitive educational environment, the discourse that it also provides teachers information valuable to their practice appeared to be more fiction than fact. While quality assessment always has an educational purpose at the classroom and student levels, the data collected from Grade 12 provincial science assessments in British Columbia appeared to have little to no educational purpose for the teachers in this study.

In addition, the collection of such data may come at further hidden costs. The results of this investigation indicate production of this seemingly easy to interpret data negatively impacts classroom pedagogy, curricular coverage, assessment, development of student skills and attitudes, and teacher capacity to motivate students. In the race to deposit maximum information into students to produce favourable data for the political agenda of public accountability, policymakers may be sacrificing the quality of the education delivered to our children. The specifics of these statements will be discussed in subsequent sections.

Contrary To Popular Discourse, Externally-Imposed Exams Impede Curricular Coverage

The prevailing discourse discussed in the literature review proposes the presence of an externally-imposed exam serves to motivate teachers to cover the entire curriculum, lest their students be unable to answer items on the exam. The government-perceived importance of this curricular coverage is underlined on Page 15 of both the Chemistry 12 and Physics 12 curriculum guides, and Page 17 of the Biology document, for the province of British Columbia which state "schools have the responsibility to ensure that all prescribed learning outcomes in this curriculum are met" (British Columbia Ministry of Education, 2006a, 2006b, 2006c).

The discourse that teachers need the surveillance mechanism of an external exam to ensure the meeting of this mandate was shown to be not applicable to teachers interviewed for this investigation. One hundred percent of teachers interviewed for this study spoke to currently covering all aspects of the curriculum, despite provincial exams in their subjects being eliminated three years ago. This finding suggests there is no correlation between the "exams ensure curricular coverage" mantra and lived experience for teachers in this investigation. In fact, it will be argued in the following paragraphs that the curricula of the three Grade 12 science courses investigated are covered more thoroughly in the absence of an exam than they were during the presence of provincial exams.

Removal of provincial exams has led to expanded teacher pedagogy and fuller curricular coverage. As was discussed earlier in this chapter and in the literature review, proponents of large scale standardized assessments argue such tests lead to the collection of valuable data to be used for educational purposes as well as ensuring strict teacher adherence to curricular objectives. In this section I reveal how provincial exams actually impede full curricular coverage and limit pedagogical practices employed by teachers.

The findings of this study suggest improved teaching practice does not come through providing data regarding how students performed on a large scale standardized assessment, or using a test to ensure teachers cover all curricular objectives; it comes by freeing teachers from the shackles of these tests. It would appear not having to prepare students for an exam has led to an effect where teachers in this study feel a greater ability to teach students a wider variety of ideas and concepts using a greater diversity of pedagogical practices.

Pedagogy. As discussed in Chapter 4, teachers in this study revealed they feel less pressure since the elimination of provincial exams. Further, teachers expressed a greater sense of liberation and autonomy, which has led to an adoption by these teachers of a wider variety of pedagogical strategies and, subsequently, experiences for students post exam-elimination. In addition, teachers spoke of how time formerly spent on exam preparation has now been freed-up for other student experiences such as a movement away from predominantly teacher-centred practices towards more diverse pedagogies and greater curricular coverage.

As discussed in the literature review, a large volume of studies have shown a heavy emphasis on preparation for these tests can have negative impacts on the educational process. In terms of student learning, classrooms stressing exam preparation have been associated with students memorizing facts at the expense of meaningful understanding, creativity, critical thinking, and development in the areas of writing, analysis of data, and problem solving (Anderson, Muir, Bateson, Blackmore, & Rogers, 1990; Calder, 1990; Clarke, Shore, Rhoades, Abrams, Miao, & Li, 2003; Collins, Reiss, & Stobart, 2010; Cozart & Gerstl-Pepin, 2002; Crocco & Costigan 2007; Gayler, 2005; Higgins, Miller, & Wegmann, 2006; Hong & Youngs, 2008; Jones, Jones, Hardin, Chapman, Yarborough, & Davis, 1999; Massa & Pinhasi-Vittorio, 2009; McCarthey 2008; McClaskey, 2001; McGuire 2007; McNeil, 2000a; McNeil &

Valenzuela, 2000; Mitchell, 1997; Sacks, 2000; Scot, Callahan, & Urquhart, 2009; Toch 2006; Traub, 2002; Valli & Buese, 2007; Vogler 2005; Wenglinsky, 2005; Wideen, O'Shea, Pye, & Ivany, 1997). In the area of instruction, literature suggests teachers focussing on test preparation emphasize teacher-centred pedagogies such as lecture, note-taking, and whole-class instruction (Anagnostopoulos; 2006; Anderson, Muir, Bateson, Blackmore, & Rogers, 1990; Booher-Jennings, 2005; Crocco & Costigan, 2007; Diamond, 2007; Diamond & Spillane, 2004; Galton, 2007; Gayler, 2005; McNeil, 2000a; Moon, Brighton, & Callahan, 2003; Samiroden, 1990; Valenzuela, 2004; van Hover & Heinecke, 2005; Vogler, 2005; Wideen, O'Shea, Pye, & Ivany, 1997). A shift to these teacher-centred pedagogies in high-stakes testing environments is done at the expense of laboratory investigations, field trips, enrichment activities, student projects, inquiry work, laboratory research, group and co-operative learning, class discussions, and use of technology (Abrams, Pedulla, & Madaus, 2003; Anderson, Muir, Bateson, Blackmore, & Rogers, 1990; Collins, Reiss, & Stobart, 2010; Crocco & Costigan, 2007; Gayler, 2005; Kohn, 2000; Moon, Callahan, & Tomlinson, 2003; Pedulla, Abrams, Madaus, Russell, Ramos, & Miao 2003; Russell & Abrams, 2004; Samiroden, 1990; Smith, 1991; Taylor, Shepard, Kinner, & Rosenthal, 2003; Valli & Buese, 2007; Wideen, O'Shea, Pye, & Ivany, 1997). This shift has also been found to be associated with teachers moving through curricular material at an increased pace, more individual seatwork, decreased focus on the interest of students, amplified reliance on textbooks, intensified use of drill and practice activities, and a larger volume of homework (Anderson, Muir, Bateson, Blackmore, & Rogers, 1990; Gayler, 2005; Moon, Brighton, Jarvis, & Hall, 2007; Popham, 2000; Valli & Buese, 2007; Wideen, O'Shea, Pye, & Ivany, 1997).

Au (2011) spoke of standardized testing leading to a denial of teacher autonomy, creating a standardized mode of curricular delivery heavily centred on teacher-focussed pedagogies and

stated “teachers classroom practices are increasingly standardized by high-stakes testing” (p. 25). This standard, one-size fits all mode of curricular delivery also assumes a standard student, which does not exist in today’s classroom. As Scot, Callahan, and Urquhart (2009) stated “students are not all the same. They come from different backgrounds, learn at different paces, and have different learning styles and strengths in differing domains of intelligences” (p. 41). Therefore, today’s teachers must address this variety through use of a wide range of pedagogical strategies (Tomlinson, 1999; Tomlinson, Brighton, Hertberg, Callahan, Moon, & Brimijoin, 2004).

As specified in Chapter 4, the findings of this exploration indicate a movement in this direction following the elimination of provincial exams in Grade 12 science courses in British Columbia. Teachers in this investigation revealed that in the post-exam era they have moved towards practices that include less teacher-centred pedagogy and a larger number of laboratory-based experiments and hands-on activities, as well as extra individual, group, and collaborative projects. In addition, teachers revealed post-exam implementation of computer assignments, student mentorship programs, peer teaching, research assignments, oral reports, journals, blogging, greater use of computer technology and video by both teachers and students, as well as conducting courses at a slower pace. These changes show a greater diversity of teaching and learning options being offered students post-exam and suggest elimination of provincial exams has led teachers to implement a greater diversity of pedagogies appealing to a wider variety of student learning styles.

Post-exam movement away from the standardized, teacher centred practices towards the greater variety of strategies spoken of by teachers in this investigation will allow educators the opportunity to meet the broad variety of needs and learning styles found in their classrooms. It

would also appear eliminating Grade 12 provincial exams has made it easier for teachers to meet the Ministry of Education edict outlined on Page V in all of the Biology, Chemistry, and Physics 12 curriculum guides which state teachers must "plan their program delivery to meet the needs of all learners" (British Columbia Ministry of Education, 2006a, 2006b, 2006c).

Curricular coverage. Abrams and Madaus (2003) stated, "in every setting where a high-stakes test operates, the exam content eventually defines the curriculum" (p. 18). With this quote in mind, the previously discussed pedagogical changes implemented by teachers following exam elimination have also allowed teachers to cover in greater detail all aspects of the British Columbia curriculum, not less as would be feared by many exam advocates. Examples from each subject investigated will be discussed in the ensuing sections.

Biology. The Biology 12 curriculum guide states:

> Laboratory skills are essential to students of Biology 12. These skills are developed in lab activities that focus on the hypothetical as well as the practical. An emphasis on the processes of science is integral to the complete study of Biology 12. (British Columbia Ministry of Education, 2006a, p. 5)

Further, this guide provides a list of skills and attitudes students are to acquire through taking this course including:

- safe and correct lab technique (e.g., use of dissection and compound microscopes, dissection technique)
- applying the scientific method to design and carry out experiments
- making inferences and generalizations
- interpreting data from a variety of types of sources (e.g., electron micrographs)
- drawing conclusions

- communicating information and results (e.g., graphs, diagrams, models, formulae) (British Columbia Ministry of Education, 2006a, p. 44).

As discussed in Chapter 4, teachers stated the elimination of provincial exams has afforded them the opportunity to perform lab activities, and/or a greater variety of these activities, with their students. An increase in such activities naturally exposes students to greater opportunities to acquire the list of skills quoted above, allowing for greater coverage of the mandated curriculum in the post-exam era. In speaking of the exam-era times when he faced constraints around covering all the prescribed curriculum in his course, Biology teacher RJ told me that “the labs were the first thing to go. None of the lab skills were ever tested so cutting a lab never hurt kids on the exam”. This comment, and pedagogical changes spoken of previously, all suggest student exposure to opportunities to develop the skills discussed above has increased since the elimination of provincial exams.

Chemistry. The Chemistry 12 curriculum guide states "the provincial science curriculum promotes an activity-based program where students learn scientific knowledge and processes in a hands-on and ‘minds-on’ way” (B.C. Ministry of Education, 2006b, p. 3). Further, like the Biology 12 document, this guide lists a series of skills and attitudes students are expected to obtain through taking Chemistry 12 including:

- calculating reaction rates from experimental data (e.g., bleach decomposition, zinc in hydrochloric acid, iodine clock reaction)
- analysing reaction mechanisms
- graphically representing energy changes in reactions (British Columbia Ministry of Education, 2006b, p. 44).

Again, as with the Biology 12 course, the increased exposure to laboratory work following the elimination of provincial exams has led students taking Chemistry 12 in this district to have a greater exposure to, and opportunity to develop, the goals and laboratory skills spoken of above.

In addition, the Chemistry 12 curricular guide states "through participation in co-operative labs, independent research, and other classroom experiences, students acquire knowledge, skills, and attitudes that enable them to pursue further study and experience success in the workplace as informed decision makers and full participants" (British Columbia Ministry of Education, 2006b, p. 3). Research discussed previously suggests teachers working in high stakes testing environments focus on teacher-centred pedagogies and rote memorization (e.g. Clarke, Shore, Rhoades, Abrams, Miao, & Li, 2003; Collins, Reiss, & Stobart, 2010; Crocco & Costigan 2007; Gayler, 2005; McGuire 2007; McNeil, 2000a; McNeil & Valenzuela, 2000; McCarthey 2008; Sacks, 2000; Toch 2006; Vogler 2005). However, in addition to the post-exam era implementation of more labs, teachers also introduced additional individual, group, and collaborative projects, computer assignments, student mentorship programs, peer teaching, research assignments, oral reports, journals, blogging, and greater use of computer and video technology. These post-exam changes should foster student achievement of the quoted curricular objectives more so than previously relied upon lecture, notes, and rote memorization strategies.

Physics. Similar to the Biology and Chemistry documents, the Grade 12 Physics curriculum speaks to the importance of students acquiring laboratory skills and science attitudes. For example, the guide states students should develop the ability to:

- conduct appropriate experiments
- systematically gather and organize data from experiments

- use graphical methods to analyse results of experiments
- produce and interpret graphs (e.g., slope and intercept)
- verify relationships (e.g., linear, inverse, square, and inverse square) between variables
- use models (e.g., physics formulae, diagrams, graphs) to solve problems
- use appropriate units and metric prefixes (British Columbia Ministry of Education, 2006c, p. 49).

In addition, the Physics 12 guide states "when planning for instruction… teachers should provide opportunities for students to develop literacy in relation to information and communications technology sources, and to reflect critically on the role of these technologies in society" (British Columbia Ministry of Education, 2006c, p. 10). As discussed with the Biology and Chemistry sections, pedagogical changes following elimination of provincial exams should better facilitate the acquisition of these skills and attitudes by students in Physics 12.

The former Grade 12 provincial exams in British Columbia science courses in effect narrowed the pedagogies teachers implemented and curricular coverage. These issues affected the ability of teachers to address the learning needs and styles of all students and attend to curricular skills and attitudes that are important for not only a well-rounded science education, but for success in our rapidly changing world. These skills include critical thinking, problem solving, and analytical skills; these are skills that will better serve students in their futures than lower level cognitive skills such as rote memorization of soon to be forgotten facts for the purposes of attaining a successful exam score.

Further, Page 3 of all three curriculum guides states:

The science curriculum of British Columbia provides a foundation for the scientific literacy of citizens, for the development of a highly skilled and adaptable work force, and

> for the development of new technologies. It is a foundation on which teachers can develop a science program that provides a comprehensive set of knowledge, skills, and experiences related to science. (British Columbia Ministry of Education, 2006a, 2006b, 2006c)

The findings of this study suggest these and other previously discussed skills potentially learned through science courses are best fostered in an environment free of an externally imposed high stakes assessment such as the former British Columbia Grade 12 provincial exams. In regards to the discourse of exams fostering sound pedagogy and full coverage of curricular objectives discussed previously, Fullan (2000) seems to encapsulate the state of affairs accurately by stating "one policy works at cross-purposes with another one" (p. 12). The presence of Grade 12 provincial exams were oppressive in the sense that teachers spoke to how it narrowed their curricular and pedagogical options, which in turn narrowed the scope of knowledge and skills acquired by students.

Exam Scores Equals Quality Teaching: More Fiction Than Fact

All teachers in this study spoke of the various ways they prepared students for provincial exams. While methods were not uniform from teacher to teacher in terms of time spent and the type of "coaching" students received, the reality that all prepared students indicates teachers placed at least some value on how their students performed on these exams. Research, including this investigation, suggests this time and effort may come at the expense of deeper, and perhaps more meaningful, pedagogical experiences for students. Amrein and Berliner (2003) examined data from 28 states and concluded there was very little evidence supporting the discourse that high stakes testing leads to gains in student achievement and in fact stated the contrary, that "the implementation of high school graduation exams results in a decrease in academic achievement"

(p. 31). Similar results have been reported by Amrein and Berliner (2002), Klein, Hamilton, McCaffrey, and Stecher (2000), Linn (2000), and Haladyna, Nolen, and Haas (1991).

Research implies teachers are aware of this phenomenon. Abrams (2004) revealed that, according to a national survey in the United States, "40 percent of teachers surveyed nationally reported that they had found ways to raise state test scores without really improving learning" (p. 7). Similarly, Hoffman, Assaf, and Paris (2001) conveyed 50% of teachers surveyed in Texas did not agree that rising test scores on a standardized exam "reflected increased learning and high-quality teaching" (p. 488). Brown, Taggart, McCallum, and Gipps (1996) reported roughly half of the teachers in their investigation felt their focus on test-specific preparation had led to an increase in student test scores while Pedulla, Abrams, Madaus, Russell, Ramos, and Miao (2003) described teachers who communicated methods to improve test scores without, they felt, improving student learning. Not surprisingly, Burger and Krueger (2003) suggested the validity of standardized tests becomes compromised when such techniques of teaching to the test are implemented by teachers.

Examples of such preparation were spoken of by Sturman (2003), who detailed how teachers in her investigation focussed on exam preparation and:

> Exhorted their pupils to read questions carefully, to follow written instructions and to answer in sufficient detail. Almost all encouraged pupils to derive 'clues' about each test item from the number of mark boxes (to find out how many marks were available) and the size of the response space (to guide the level of detail required). It was also almost universal to give pupils either advice about or opportunities to practise the skills of timing and pace, ticking the required number of boxes in multiple-choice items, using scientific vocabulary, and reading and/or interpreting information from tables or graphs. (p. 265)

Such skills, while preparing students for how to write tests, seem to serve little in the way of preparing students for "real life" skills or learning that will serve them beyond the conclusion of their writing of an exam.

While teachers in this investigation did not speak specifically about improving test scores, during the time of exams there was a higher degree of lecture, notes, worksheets, practice tests, exam review, and rote memorization. Changes occurring following exam elimination suggest these practices were at the expense of more valuable forms of pedagogy and potential student learning discussed earlier in this chapter. Instead of spending class time on activities focussed only on improving test scores, following exam elimination teachers implemented practices that will improve the overall educational experience for students, changes that will better serve students than teaching them the best strategies for correctly filling in a bubble on an exam card.

In every interview for this investigation, when teachers spoke to preparing students for exams at no point was the word "learning" used, suggesting teachers may subtly be aware of the difference between test prep and actual meaningful learning. We need to question the purpose of education and challenge the discourses surrounding large scale test scores as an indicator of high quality teaching and meaningful learning. The findings of this investigation, reinforced by research, strongly suggests that to reflect reality the discourse in this area needs to shift away from the formula that high exam scores equals quality teaching; it is the exact opposite: Decreased focus on exam scores leads to improved teaching in science. With this in mind, we must confront the questions, *What, then, does an exam score indicate?* And, *Who is advantaged by this reduction of learning to an exam score?* The answers to both of these questions appear to lie in socio-economics and privilege.

Research suggests the poor and minority students perform well below the standards of Caucasian and high socioeconomic status students in high-stakes standardized testing environments, translating into higher grades and greater access to advanced education for students of privilege (Dee, 2003; Dee & Jacob, 2006; Glenn, 2006; Haney, 2000; Natriello & Pallas, 2001; Warren, Jenkins, & Kulick, 2006). While it is unlikely those in power implement a hidden conspiracy against minority and impoverished students; McLaren (1989) stated "I don't believe that they're *consciously* trying to reduce the competition for their sons at Harvard" (p. 152); the presence of such exams in our schools, with all their flaws noted herein, underline that "schools are not neutral institutions that prepare students equally for social and economic opportunities in the wider society" (Giroux, 1983, p. 207). McLaren (1989) espoused a similar viewpoint, stating:

> We claim to live in a meritocracy where social salvation is supposedly achieved through scholastic merit: every student will, more or less, reap the academic rewards of his or her own initiative, regardless of sex, religion, or family background. That all sounds fine on the surface, but in reality it's simply hollow rhetoric. Research has shown that one of the greatest predictors of academic success is socio-economic status. In other words, while we profess to believe in equal opportunity for rich and poor alike, the fact remains that an individual's social class and race at birth have a greater influence on social class later in life than do any other factors – including intelligence and merit. Put simply, each child appears to get as many chances for success in school as his or her family has dollars and privileged social status. (p. 151)

To re-inforce this point, data requests were submitted to both the British Columbia Ministry of Education and the district in which this investigation took place. These requests

solicited data surrounding course enrollment and student success trends for Biology 12, Chemistry 12, and Physics 12 in both the years preceding and following the elimination of provincial exams in August 2011. This request was made for the general student population as well as groups traditionally found to be negatively impacted by the presence of high-stakes exams, including students from low socioeconomic backgrounds, visible minorities (including students of Aboriginal ancestry), English as a second language, and those with special needs (Atkinson & Geiser, 2009; Bishop & Mane, 2001; Dee, 2003; Dee & Jacob, 2006; Education Trust, 2005; Gerald & Haycock, 2006; Giambo, 2010; Glenn, 2006; Haney, 2000; Jacob, 2001; Natriello & Pallas, 2001; Reardon, Atteberry, Arshan, & Kurlaender, 2009; Rogers, Holme, & Silver, 2005; Soares, 2007; Warren, Jenkins, & Kulick, 2006). The purpose of this request was to examine any effect(s) removal of provincial exams in the three subjects investigated may have had on student enrollment and/or success patterns for any of the groups identified in the previous sentence.

Unfortunately, such data was either never collected or ceased to be assembled following the elimination of Grade 12 provincial exams. However, district statistics were available for graduation rates for both special needs and Aboriginal students during this time period. From the 2009-10 to the completion of the 2012-13 school year Six Year Completion (graduation) rates increased 4.3% for the overall student population and 12.1% for students with special needs (School District #XX, 2014). Further, from 2009-10 to the conclusion of the 2013-14 school year, the same district completion rate for Aboriginal students rose by 21% (Anderson, 2015). A separate investigation would be required to fully examine to what extent the removal of provincial exams is responsible for these increases.

The Presence of Grade 12 Provincial Science Exams De-Skill Teachers in the Areas of Classroom Assessment and Student Motivation

Internalization of high-stakes assessment format. As a pre-requisite to participation in this study, all participants taught Chemistry 12, Biology 12, and/or Physics 12 during the time of provincial exams. McNeil (2000a) noted, when speaking of teachers who have worked within such testing environments, that educators:

> Assume outcomes testing to be a sad but 'inevitable' feature of schooling. The incremental normalizing of an accountability system and the casual use of its language in conversations about education can silence criticism and stifle the potential to pose counter models and to envision alternative possibilities. (p. 734)

Ranson (2003) suggested that strong regimes of public accountability such as the former Grade 12 provincial exams in British Columbia become so strengthened, engrained, and commonplace that they move to a position where they are no longer simply a component of the system, but become the system itself. Further, Avis (2005) suggested using large-scale exams and the numbers they generate for accountability practices fosters a "regime of truth that refuses other conceptualizations of good practice, which therefore become silenced and are denied legitimacy" (p. 211).

Several remarks made during the interview process suggest this may have come to pass with teachers in this study, teachers whose quotes underline the value and legitimacy they put on provincial exams. For example, Mackenzie stated "was my evaluation process, were they real? And I figured if they aligned with the final, if they were within a few percentage points, then I was doing pretty good, right?" and, "there was validity in those tests". Further, Duncan spoke of how he felt these tests let him know:

> Am I doing a good job? Am I requiring a level of expertise from the part of my students that allow them when they leave here to be able to compete with students coming from other areas when they get to university?
>
> Joe stated in regards to the exam that:
>
> They used to publish the teacher-assigned mark and what the kids got on the provincial exam. I always thought that if there was too big a discrepancy between these, like the provincial exam mark being way lower than the school mark, that that meant I was doing a bad job.

These quotes suggest a mentality subscribing to a reliance on an externally imposed paper and pencil test as a means of demonstrating to teachers not only their performance, but if students had learned to an appropriate standard.

Over the last 30-plus years social and political forces have served to create this mantra surrounding high stakes standardized exams, which essentially holds that these one-sitting paper and pencil assessments are beyond reproach: They are believed to be the best way to measure what our students have learned; they are the best way to collect data from large samples; they are the best way to measure the performance of teachers and schools; they are the best way to ensure schools are doing what they are supposed to. This discourse of exams being the "best way" to do all of these things has become so pervasive that high stakes standardized exams are, by many, seen as the "only way" to do all of these things. It would appear this discourse was in large part internalized by teachers in this study and, despite incremental movements towards the more varied forms of assessment detailed in Chapter 4, still held powerful sway over teacher assessment three years after mandatory exams were eliminated.

Critical theorists such as McLaren (1989), Giroux (1983), and Apple (1982) frequently

use the term “hegemony” in their works, a term that applies to the buy-in of teachers to the power of exams discussed in the previous paragraph. McLaren (1989) defined hegemony as:

> The maintenance of domination not by the sheer exercise of force *but primarily through consensual social practices, social forms, and social structures produced in specific sites such as the church, the state, the school, the mass media, the political system, and the family…* hegemony is a struggle in which the powerful win the consent of those who are oppressed, with the oppressed unknowingly participating in their own oppression. (p. 173)

Similarly, Apple (1982) spoke of hegemony as being a process where dominant classes and groups gain the consensus of those over whom they rule. It would appear that, despite the overwhelming evidence that high-stakes exams oppress teachers in many aspects of their work, educators in this investigation seem to subscribe to the pervasive neoliberal doctrine discussed earlier that exams are the ultimate measuring tool for assessing students.

This may help to explain why teachers in this study have, despite provincial assessments being eliminated three years ago, continued to use such instruments as past exam questions as a means to evaluate students, relied heavily upon paper and pencil assessments to account for a large portion of student grading, and still administer summative written final exams. Despite the many positive shifts in teacher pedagogy discussed earlier following exam elimination, teacher post-exam evaluation practices have not produced the changes seen in other pedagogical areas. Post-exam evaluation practices by teachers, while slightly de-emphasizing tests as a source of student assessment, appear to be a continuation of the practice and hegemony into which these teachers were indoctrinated into the teaching profession during the era of high stakes exams.

Teacher assessment de-skilling. Perhaps it is so that following years of working in a high-stakes testing environment emphasizing a one-size-fits-all evaluation system focussed on written tests that teachers in this study have so internalized the perceived "value" of paper and pencil assessments that they are struggling to conceive of alternative or supplemental ways to evaluate students. Is it that they are working under an ingrained assumption that only tests can be legitimately relied upon to assess any knowledge of real value? Maybe this continuance of a heavy reliance on written testing as the primary method of assessment is a reflection not only of perceived demands of parents and local authorities for "objective" evidence, but also teachers' own lack of confidence in their assessments following years of reliance on an external instrument?

The findings of this study reveal that provincial exams can lead to a de-skilling of teachers in the area of assessment. Firstly, the continued reliance on past-exam questions instead of teacher-made queries suggests a lack of teacher ability or confidence to create their own quality assessment tools specific to their classroom situation. Statements by teachers suggest this practice was likely born out of an exam-era desire to have classroom grades and marks students achieved on provincial exams closely align. However, with exams eliminated, continuation of this practice suggests this ritual has become ingrained as the best way to evaluate, and teachers may lack the skills, training, confidence, or initiative to explore other methods of gauging student learning.

Secondly, the continued reliance on paper and pencil exams as their predominant form of assessment suggests teachers have become indoctrinated into a system where such exams appear to be the most valid way to gauge student learning and progress. Exams forced teachers into a one size fits all system of student assessment, where student-centred practices were not used. Not

all students show what they know best on a paper and pencil test, yet these students continue to be punished and marginalized in these courses due to an overwhelming emphasis on paper and pencil assessments.

Thirdly, a reliance on paper and pencil assessments fails to capture many of the skills and attitudes students are required to develop in the Grade 12 science courses. Page 3 of the curricular guides for all three of the subjects under investigation states:

> The science curriculum of British Columbia provides a foundation for the scientific literacy of citizens, for the development of a highly skilled and adaptable work force, and for the development of new technologies. It is a foundation on which teachers can develop a science program that provides a comprehensive set of knowledge, skills, and experiences related to science. (British Columbia Ministry of Education, 2006a; British Columbia Ministry of Education, 2006b; British Columbia Ministry of Education, 2006c)

Further and more specifically, the Biology 12 guide speaks to the acquisition of laboratory skills including safety, microscope use, dissections, application of the scientific method, and communicating research results. This guide also speaks to developing scientifically literate students who are flexible and adaptable, can critically analyse and make informed, responsible decisions regarding scientific issues as they relate to themselves, society, and the environment, and encourage students to develop positive attitudes towards science (British Columbia Ministry of Education, 2006a). Similarly, the Chemistry guide supports the importance of similar lab skills in a program emphasizing a "hands-on, minds-on way" of knowledge acquisition (B.C. Ministry of Education, 2006b, p. 3). In addition, the Chemistry guide also speaks to students acquiring abilities such as use of experimental data to determine reaction rates, analysing mechanisms in a reaction, and graphically representing lab findings. Finally, the

Physics guide likewise addresses the importance of lab skills such as conducting experiments and gathering, analyzing, and graphically displaying data from said experiments (British Columbia Ministry of Education, 2006c). In addition, the Physics 12 guide speaks to the need for teachers to "provide opportunities for students to develop literacy in relation to information and communications technology sources, and to reflect critically on the role of these technologies in society" (British Columbia Ministry of Education, 2006c, p. 10).

Many of the skills and knowledge described in the preceding paragraphs are very difficult to measure on a single sitting paper and pencil test, the type of assessment tool teachers in this study began their careers teaching under and continue to emphasize as the major tool of their in-class assessment. These skills, deemed important by not only the curricular guides but likely the majority of citizens of our province in terms of a strong science education, are likely still going largely unassessed in favour of the recital of fact-based information that easily lends itself to being assessed on a paper and pencil test. Jones et al. (1999) discussed how such tests tend to "emphasize discreet facts and skills because they are easy to measure and avoid questions that require students to analyse and synthesis information at higher levels" (p. 200) while Pringle (2001) stated "tests measure only a narrow range of behaviors and very low level thinking" (p. 19).

While many areas of teacher pedagogy, discussed in a previous section of this chapter, have made strides towards more varied practices since the elimination of provincial Grade 12 science exams in 2011, it would appear changes in teachers' methods of assessment is an exception within this trend. Teachers appear to continue to focus student assessment on knowledge easily tested in the written form at the expense of a wide variety of "hands-on" lab skills, critical thinking, and non-written test expressions of learning.

Considering the narrow range of student skills and abilities a paper and pencil test can determine, a wider variety of measures and formats of assessment should be implemented in order for teachers to better ascertain the true abilities of their students in relation to the goals of their courses. This movement would shift teachers more toward the British Columbia Teacher Regulation Branch standards that state "educators implement effective practices in areas of… assessment, evaluation and reporting" and that "educators employ a variety of instructional and assessment strategies" (British Columbia Ministry of Education, 2012b, p. 4). This sentiment is echoed by the British Columbia Ministry of Education (2015), which states in documents surrounding the proposed new K-9 provincial Science curriculum that "classroom assessments should include a wide variety of opportunities for students to demonstrate their learning" (para. 14).

Will assessment changes continue to evolve to a more holistic model as teachers learn, develop, and implement new skills and strategies over time? Is an influx of new teachers whose entry to the profession will not include the weight and discourse of a high stakes provincial exam needed to spur this change? How the small changes observed in this study play out over the long term would be a task for a longitudinal study. However, as a legacy of the exam era it would appear, in terms of assessment, that teachers in this investigation are still experiencing "compliance when compliance silences professional expertise" (McNeil, 2000a, p. 734). Freire (1989) spoke of such actions occurring out of an internalization and fear of freedom, stating that, "the oppressed, having internalized the image of the oppressor and adopted his guidelines, are fearful of freedom. Freedom would require them to eject this image and replace it with autonomy and responsibility" (p. 31).

Teacher motivation of students. The Grade 12 provincial exams in science courses were implemented in 1983 (Mussio, 2012) and ran until August of 2011 (British Columbia Ministry of Education, 2011). As mentioned previously, all teachers who were interviewed for this study began their careers during a time when both they and their students were faced with a course-ending exam comprising 40% of a student's grade. In fact, all but one of the interviewed teachers spent a significant number of years instructing under the provincial exams. Speaking to educators through the course of conducting this study, I concluded that the presence of these high-stakes exams may have served to de-skill many teachers in terms of their ability to motivate students; essentially, years of reliance on an external source (the exam) to motivate students has potentially left teachers "out of practice" in this area.

Many interviewees spoke to a perceived decrease in the overall "quality" of students taking their courses since the provincial exam was eliminated. Seven of the nine teachers spoke of how they have noticed "more weaker/less academic kids" in their classes, "less effort" and "attendance issues" among students that they feel were not seen in the time of the provincial exam. Duke summed up the sentiment of many interviewees when he stated, in regards to his students, "it just may be they know there isn't a provincial exam that's 40% of their mark so they're not putting as much effort".

Teachers also seemed to speak fondly of the "structure" the exam gave to the course. Duncan stated "the provincial exam I thought was just really good because, um, the kids need to know that there is a standard". These findings are not surprising in light of the findings by Anderson, Muir, Bateson, Blackmore, and Rogers (1990) who found British Columbia Grade 12 teachers during the time of provincial exams praised these exams for their structuring of the curriculum and providing teachers and students with academic goals.

These and similar statements by seven of the nine interviewees regarding exams serving as a motivational tool that gave rigour to their courses seem to suggest teachers may be subtly arguing for an exam and the supposed motivational and structural powers it brings. This is not startling when examined through the lens of critical theorists such as Freire and Apple. Perhaps it is so that after decades of having what teachers seem to feel was a motivational tool imposed upon them by an external body, and subsequently internalizing the perceived powers of this instrument, that teachers are at a loss in terms of how to motivate students in the absence of a government-imposed exam. Freire (1989) stated, "the internalization of the oppressor by the dominated consciousness… explains their fear and their inefficiency" (p. 116). Their fondly recalling the motivational clout of the exam seems to suggest teachers have perhaps become reduced in their abilities to impose their own standards and implement effective, non-exam centred motivational practices in their classrooms. Apple (1982) stated:

> Skills that teachers used to need, that were deemed essential to the craft of working with children – such as curriculum deliberation and planning, designing teaching and curricular strategies for specific groups and individuals based on intimate knowledge of these people – are no longer as necessary. With the large-scale influx of prepackaged material… what were previously considered valuable skills slowly atrophy because they are less often required. (p.146)

While this finding is important, a word of caution is noted. Annual trends in student motivation, quality, and work habits are very much a matter of opinion and not something teachers have accurately tracked from year to year. A true measure of whether the removal of provincial exams affected student motivation would likely have required a longitudinal study examining students in the time of exams and in the time following exam elimination. Such an

investigation is beyond the scope of this study. Therefore, deciding whether teachers are simply remembering past students in a fond light in comparison to current students, or if the motivational phenomenon spoken of is real, is impossible to ascertain at this point.

However, if this phenomenon is indeed real and a major concern to teachers, supports may need to be put into place that allow teachers to develop ways to inspire students in the absence of a high stakes exam. Teachers must ask tough questions in this area and seek to remediate their own practices in the area of motivation. This may also in part require a generation of new teachers who have not taught in the time of exams, and were never reliant upon this external motivator, to bring fresh ideas in this area.

This brings about a very important contradiction. On one hand teachers speak to less pressure with no exams, which has freed them up to implement new and pedagogically exciting practices that have allowed them to appeal to a broader range of learning styles and cover a greater extent of the curriculum. On the other hand, they also seem to be yearning for the motivational and structural aspects of an exam. While teachers appeared ready for many of the pedagogical changes no exam has provided, there still appears to be lingering effects from the exam era in the area of student motivation and assessment.

Conclusion and Implications

Through the findings of this research and examination of relevant literature, the elimination of Grade 12 provincial science exams was, from the perspective of educating students in the district investigated, a positive move by the British Columbia Ministry of Education. The results of this study suggest three of the main political justifications for such exams are more discourse than lived practice.

First, the argument that large scale exams provide data valuable to improving educational programs was found to have little to no basis in fact in the circumstances surrounding this investigation. Secondly, the hypothesis that exams ensure a full curricular coverage by teachers was also found to be false. In fact, it was argued herein that elimination of Grade 12 science provincial exams in British Columbia has actually led to a more comprehensive coverage of the provincial curriculum. Research quoted herein suggests this investigation is not alone in this finding. Finally, the discourse that exam data provides valuable insight into the quality of teaching and learning was argued against. The measures teachers go to to produce "good exam scores" both in this study and other investigations quoted suggests education quality is compromised, not enriched, when there is a heavy emphasis on the production of said exam scores.

Aside from debunking these discourses, the findings of this study also suggest positive pedagogical changes occurred when exams were eliminated. It was found that during the time of exams teachers, like educators in a large volume of other investigations cited, worked within a narrow pedagogical framework which often consisted of teacher-focused activities that appealed to a narrow range of learning styles and developed a limited assortment of student skills. Elimination of exams in August of 2011 has led to a steady expansion of the pedagogical strategies employed by teachers, strategies that should lead to better student knowledge and skill development and which are better suited to meeting the needs of a more diverse set of learners and learning styles than the teacher-centred pedagogies employed during the time of exams.

Further, it was declared a prolonged period of teaching in a situation where a single paper and pencil exam accounted for such a high portion of student grades served to erode teacher skills in the areas of student assessment and motivation. It was noted that during the time of

exams teachers relied heavily on tests that closely mirrored the format of the exam to make up the bulk of their grading scheme. While changes towards a more holistic assessment system have been made in this area since exam elimination, these changes have been small and somewhat incremental. Will these incremental changes continue towards a more holistic assessment format in the future as the exam era fades further into the past? In addition, what will be the influence on assessment of new teachers entering the profession who did not teach under the exams? A longitudinal study examining how teacher assessment practices change over time may be beneficial in answering these questions.

Finally, the issue of teachers being "de-skilled" in terms of their ability to motivate students in the absence of an exam appears to be a problematic legacy of the exam era. As with the issue of assessment spoken of above, perhaps a future study after the passage of a greater amount of time since exam elimination would serve to shed a more complete light on how teachers will deal with this issue moving forward. However, to remediate these issues in the near term, two recommendations should be considered. Firstly, a focus on professional development training should be offered to teachers in the areas of holistic assessment and how to motivate students in the absence of a high-stakes exam. Secondly, it is recommended that university teacher-training programs in British Columbia make the development of these skills a high priority in the development of future educators.

It is clear from this investigation and literature quoted herein that skills and pedagogies valued in 21st century learning, such as those described in the British Columbia Education Plan (British Columbia Ministry of Education, 2012c), a Ministry document charting the future of BC education, are not compatible with a high stakes testing environment. This plan emphasizes a "personalized approach to learning" (p.2), declaring students will "have more freedom to pursue

their individual interests and passions within a particular topic" (p. 3) and that "there will be more emphasis on… self-reliance, critical thinking, inquiry, creativity, problem solving, innovation, teamwork and collaboration, cross cultural understanding" (p. 4). However, on the same page this document asserts that, "students' progress will continue to be monitored through rigorous province-wide assessments" (p. 4). This and other research makes it perfectly clear that the policy of "rigorous province-wide assessments" will make it very difficult to achieve development of the 21st century skills and attributes quoted above.

The elimination of Grade 12 provincial science exams has led to an enormous amount of educationally positive outcomes that far outweigh any potential negatives, negatives that can likely be dealt with through the aforementioned teacher professional development and exposure to new ideas. Policy makers need to take heed of these findings as it is likely future public outcries regarding "falling standards" and "failing schools" will, much like the early 1980's, lead to calls for the re-implementation of Grade 12 testing as a means to rectify all that is wrong with the school system.

Perhaps the beginnings of this pressure are already upon us. An Ipsos Reid (2012) poll reported 86% of Canadians acknowledged they were worried about the performance of Canadian students in reading, writing, and math. Further to this, nationally 75% of poll respondents indicated standardized testing is a good way to measure and compare students (support in BC was at 72%). *Further indications of burgeoning discontent specific to the Grade 12 program in our province was underlined in a move made in the fall of 2012 by the University of British Columbia, the province's largest post-secondary institution. UBC instituted a policy for incoming applicants that specified if there was a 20% or greater difference between the school-assigned mark and the student's English 12 provincial exam score, the university would*

disregard the school-assigned mark and count the exam score as the student's entrance application grade (University of British Columbia, 2013). This is a strong statement as to how this influential institution feels regarding teacher-assigned grades compared to standardized test scores.

Therefore, it is not beyond the realm of possibility that in the near future education policy makers in British Columbia will find themselves facing a strong push from various factions for the re-implementation of Grade 12 science exams. When this day comes, our political leaders will need to ask themselves some hard questions. Do we want to produce exam data to satiate the citizenry and public institutions, or do we want best teaching practices? Do we want to numerically measure all students, teachers, and schools to fulfil a political agenda, or do we want to develop science students who have a wide variety of skills, attitudes, and abilities? Do we want teachers to devote time to exam preparation in order to produce skilled test-takers, or do we want actual meaningful student learning that may develop an array of skills applicable to post-school life, a life where the ability to perform well on a standardized test will serve little to no purpose? The findings of this investigation and the supporting research quoted suggest that for each of these questions we cannot have the latter if the former is in place.

The reality that an accountability program "provides politicians with a highly visible symbol of action" (Mazzeo, 2001, p. 390) makes it very unlikely government measures of accountability in education will disappear anytime soon. However, to truly foster positive, long-term changes in the way we educate our students, for both economic and democratic purposes, governments must become creative and develop new systems of accountability, systems that capture a more holistic measure of school quality beyond the current sole reliance on exam scores. In the words of Pringle and Martin (2005) "in the end, educators, politicians and the

public who push standardised high-stakes testing as a means to uphold high national standards are accomplishing quite the opposite" (p. 349).

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Appendices

Appendix A – Interview Questions

TEACHER INTERVIEW QUESTIONS

BACKGROUND INFO

1) From Biology 12, Chemistry 12, and Physics 12, which of these courses do you teach?
2) How long have you taught each course?

QUESTIONS SPECIFIC TO MY STUDY

3) When the provincial exam was in place how, if at all, did it affect the way you taught your course? Can you give specific examples?
    a. Did you ever use data from exam results to change your teaching?
    b. During the time when exams were required, what resources did you allocate to exam preparation (such as, purchasing test preparation materials, photocopying practice exams, etc.)?
    c. Did you spend time, either inside or outside of class, preparing students for how to write the provincial exam? If yes, can you estimate how much time was spent on this preparation? Also, if yes was answered, what are you now doing with your students in the time previously spent on exam preparation?
4) What effects, if any, has the removal of provincial exams had on the way you taught your course? Can you give specific examples?
    a. How are you using any time previously allotted to exam preparation?
    b. Have you noticed any differences in your professional relationships with your fellow science-teaching colleagues since the cancellation of exams? If yes, please give examples.
    c. Have you noticed any differences in students' responses to your course(s) now that there no longer is a mandatory government final exam?
    d. Overall, how has the removal of these exams affected your teaching practice?

Appendix B – Participant Consent Form

Department of Curriculum & Instruction
Faculty of Education
PO Box 1700 STN CSC
Victoria British Columbia V8W 2Y2 Canada
Tel (250) 721-7886 Fax (250) 721-7598
E-mail cichair@uvic.ca
Web: www.uvic.ca/education/curriculum

Participant Consent Form

Effects on Teachers of the Elimination of Grade 12 Provincial Exams in Chemistry, Biology, and Physics in a British Columbia School District

You are invited to participate in a study entitled *Effects on Teachers of the Elimination of Grade 12 Provincial Exams in Chemistry, Biology, and Physics in a British Columbia School District* that is being conducted by Brian Heese.

Brian Heese is a doctoral student in the department of Curriculum and Instruction at the University of Victoria and you may contact him if you have further questions by e-mail (bheese@shaw.ca) or phone (250-585-7068).

As a graduate student, I am required to conduct research as part of the requirements for a degree in Doctorate of Science Education. It is being conducted under the supervision of Dr. David Blades. You may contact Dr. Blades at 250-721-7775 if you have any questions or concerns.

Purpose and Objectives

A substantial body of research details effects high stakes exams have on teachers and their practices. These include constricting curriculum to tested areas, allotting resources to test preparation, and spending curricular time teaching students to write tests. Further research noted these exams greatly hinder teacher attempts to integrate pedagogical reforms. Finally, it has been found exams lead to little reflection or dialogue between colleagues, a decline in morale, and a sense of disempowerment among teachers.

In 2011, British Columbia eliminated provincial exams for Grade 12 subjects including Physics, Chemistry, and Biology. To my knowledge, there has been no research conducted in situations such as this, where teachers of science courses concluding with a high stakes exam have had said exam removed.

Therefore, my question is what effect has the removal of provincial exams in Grade 12 science courses had on teachers of these courses? My attached interview questions will elaborate on the questions I wish to pursue.

Importance of this Research

Research of this type will provide important information about the effects of standardized testing, and its removal, on teaching practices. It is hoped the findings will add to the body of knowledge surrounding how to create environments that foster best teaching practices, and subsequently maximal student learning.

Participant Selection

You are being asked to participate in this study because like all school districts in the province, provincial exams for all Grade 12 science subjects were removed in School District #68 August of 2011. Past research indicates similar exams have had a large, and in some way negative, impact on teachers. It is my intention to uncover how removal of these exams in the Grade 12 courses of biology, chemistry, and physics has affected teacher practices and pedagogy. As someone who is teaching/has taught one of Biology 12, Chemistry 12, and/or Physics 12, I am seeking your input into this study.

What is Involved?

If you consent to voluntarily participate in this research, your participation will involve a 30-45 minute one on one interview to be conducted at a location of your convenience at a time outside of your work responsibilities.

Audio-tapes/and-written notes, observations/ will be taken. A transcription will be made.

Inconvenience

The only anticipated inconvenience to you as a participant is the time you will donate to be a part of this study.

Risks

There are no known or anticipated risks to you by participating in this research.

Benefits

I feel through participating in this study you will have an opportunity to reflect on your own practice. I also feel the findings of this study will benefit the field of education through contributing to the knowledge base surrounding teaching practices and standardized exams. It is hoped the knowledge gained from this research will allow for research-based educational policies and practices that will ultimately result in improved student learning.

Compensation

There will be no monetary of material compensation given for participation in this study.

Voluntary Participation

Your participation in this research must be completely voluntary. If you do decide to participate, you may withdraw at any time without any consequences or any explanation. If you do withdraw from the study I will honour your wishes by destroying any data I have collected from you and not use this data in my analysis.

Researcher's Relationship with Participants

I am currently on leave from my past position as a high school science teacher in School District #68. I was at one time a colleague with three of the potential participants. Further, of the potential participant pool of roughly 35 teachers, I am casual acquaintances with five others and have little to no relationship with the remaining potential participants.

Anonymity

In terms of protecting your anonymity, pseudonyms will be used for each participant should they be quoted in the final written form of this investigation. In addition, school names and the identity of School District #68 will not be revealed in the written form of my paper. Despite these safeguards, it needs to be noted that there is a chance someone very familiar with both this study and School District #68 may be able to identify a person based on a quote if they read the final copy of my paper.

Confidentiality

Your confidentiality and that of data collected from you will be protected. Only you and I will know that you were interviewed for this study. Any verbal data collected during the interview process will be stored on a password-protected recording device that will be kept in a locked filing cabinet in my home. Any written data, notes, etc. collected will be stored in a locked filing cabinet in my home. Data will be stored until the completion of the study, at which time it will

be destroyed. Verbal data stored on electronic devices will be deleted. Data in the paper/document format will be shredded.

Dissemination of Results

My main focus for dissemination of the results of this study will be for the purposes of a doctoral thesis/dissertation. In addition, I will make available a copy of my final report to my participants and the administration of School District #68. At this point it is too early to say with any finality, but it may be a possibility that my findings will be presented at scholarly meetings and may be submitted for publication in a journal.

Disposal of Data

Any verbal data collected during the interview process will be stored on a password-protected recording device that will be kept in a locked filing cabinet in my home. Any written data, notes, etc. collected will be stored in a locked filing cabinet in my home. Data will be stored until the completion of the study, at which time it will be destroyed. Verbal data stored on electronic devices will be deleted. Data in the paper/document format will be shredded.

Contacts

Individuals that may be contacted regarding this study include my University of Victoria supervisor Dr. David Blades 250-721-7775.

In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or ethics@uvic.ca).

Your signature below indicates that you understand the above conditions of participation in this study, that you have had the opportunity to have your questions answered by the researchers, and that you consent to participate in this research project.

_____	_____	_____
Name of Participant	*Signature*	*Date*

A copy of this consent will be left with you, and a copy will be taken by the researcher.

Appendix C – Participant Invitation Letter

Brian Heese
5686 Oceanview Terrace,
Nanaimo, BC
V9V 0A8
250-585-7068
bheese@shaw.ca

Dear Sir or Madame,

My name is Brian Heese. I have been a high school science teacher in School District #68 for the past 19 years. I am currently working on a doctorate degree in Science Education from the University of Victoria and am engaging in a research project as partial fulfilment of the requirements for this degree. I am sending this e-mail to invite you to be a participant in my research project.

My study will focus on the effects the removal of mandatory provincial exams has had on Grade 12 teachers in School District #68. Specifically, I wish to investigate the effects this removal has had on science teachers. Therefore, this e-mail is directed at educators who have taught Biology 12, Chemistry 12, and/or Physics 12 both in the time of mandatory provincial exams and in the time since exams were removed in August of 2011.

Your participation will require a verbal interview, either done in person or over the phone, where I will ask you a series of questions regarding practices associated with your teaching and how these may or may not have changed following the elimination of Grade 12 provincial exams. I have attached the questions I plan to ask for your perusal.

It is anticipated our conversation will take roughly 30-45 minutes. The information obtained through this interview will be used as data to help complete my doctoral thesis study. Your identity will remain completely confidential through this entire process.

If you wish to participate in this study, please respond to me via e-mail at bheese@shaw.ca

Thank-you for your time.

Sincerely,

Brian Heese

Appendix D – Data Report Examples

BRITISH COLUMBIA Ministry of Education

DATA MANAGEMENT AND STUDENT CERTIFICATION BRANCH
PARLIAMENT BUILDINGS
VICTORIA BC V8W 9H1

Report: TRAX1274E

Grade 12 Examinations and Transcripts
DISTRIBUTION OF LETTER GRADES BY COURSE AND PUBLIC SCHOOL
2000/01 SESSION

Date: 2000/02/28

Jan. 2000
Biology 12

BIOLOGY 12

		Number Counted	Average Score	Standard Deviation	Proportion of Students Achieving Letter Grades A	B	C+	C	C-	F
SCHOOL MARK	SCHOOL	20	69.25	15.06	10.00	30.00	25.00	.00	25.00	10.00
	DISTRICT	209	73.44	14.24	23.44	30.14	14.83	11.96	17.22	2.39
	ALL PUBLIC	4843	72.48	16.95	24.05	31.46	13.60	12.61	12.07	6.17
	PROVINCE	5085	72.70	16.97	24.85	31.09	13.39	12.60	11.93	6.11
EXAM MARK	SCHOOL	19	72.15	13.20	15.78	26.31	26.31	21.05	5.26	5.26
	DISTRICT	206	68.21	16.99	18.44	26.21	12.13	11.16	16.99	15.04
	ALL PUBLIC	4781	65.57	18.09	15.54	23.82	10.81	12.34	16.00	21.48
	PROVINCE	5027	65.88	18.25	16.31	23.81	10.70	12.15	15.81	21.20
FINAL MARK	SCHOOL	19	70.36	13.86	15.78	26.31	21.05	15.78	15.78	5.26
	DISTRICT	206	71.52	14.72	20.87	30.09	10.67	13.59	20.38	4.36
	ALL PUBLIC	4685	70.18	15.61	18.71	28.72	12.61	14.45	18.01	7.47
	PROVINCE	4920	70.45	15.70	19.55	28.51	12.41	14.36	17.72	7.41

Explanations:

Note: The numbers in this report may differ slightly from previous reports due to the data being updated since the previous reports were created.

1. All school marks and exam marks relate ONLY to the specific session(s) shown at top of report.
2. Final marks may relate to earlier exam sessions since final marks are based on 'best' school and exam marks.
3. Does not include Aegrotats, Deferrals or Challenges.
4. Number Counted for School marks includes all school percents which were submitted by the school.
5. Number Counted for Exam marks includes all exams written during this session.
6. Number Counted for Final marks includes every occurence of both a school % and exam mark for a student during the same session in the selected period.
7. The District total includes only public schools in the district.
8. The Province totals include all schools - both public and independent.

BRITISH COLUMBIA Ministry of Education

EVALUATION AND ACCOUNTABILITY
PARLIAMENT BUILDINGS
VICTORIA B.C.
V8W 9H1

2000 FEB 28 MINISTRY OF EDUCATION - Grade 12 Transcripts and Examinations System Page 1707

PROGRAM TRAX1270B2 Student Marks and Scholarship Scores by Subject

JANUARY 2000 - BIOLOGY 12

STUDENT NUMBER	LOCAL ID	NAME	SCHOOL PERCENT	BEST SCHOOL %	EXAM PERCENT	BEST EXAM %	FINAL PERCENT	LTR GRADE	SCHOL SMS
			58	58	65	65	61	C	N/A
			57	57	74	74	64	C	412
			82	82	68	68	76	B	N/A
			67	67	68	68	67	C+	N/A
			75	75	61	61	69	C+	N/A
			81	81	79	79	80	B	467
			84	84	95	95	88	A	646
			96	96	93	93	95	A	617
			73	73	77	77	75	B	448
			45	45	42	42	44	F	N/A
			57	57	59	59	58	C-	N/A
			69	69	DNW	---	---	---	N/A
			56	56	62	62	58	C-	N/A
			96	96	92	92	94	A	604
			70	70	70	70	70	C+	298
			72	72	78	78	74	B	458
			54	54	69	69	60	C	N/A
			81	81	85	85	83	B	532
			42	42	62	62	50	C-	N/A
			70	70	72	72	71	C+	374

Student ID Blocked

BRITISH COLUMBIA Ministry of Education

DATA MANAGEMENT AND STUDENT CERTIFICATION BRANCH
PARLIAMENT BUILDINGS
VICTORIA BC V8W 9H1

Report: TRAX1274E

Grade 12 Examinations and Transcripts
DISTRIBUTION OF LETTER GRADES BY COURSE AND PUBLIC SCHOOL
2000/01 SESSION

CHEMISTRY 12

		Number Counted	Average Score	Standard Deviation	Proportion of Students Achieving Letter Grades A	B	C+	C	C-	F
SCHOOL MARK	SCHOOL	15	77.60	10.11	20.00	60.00	6.66	6.66	6.66	.00
	DISTRICT	155	77.90	12.59	34.19	35.48	11.61	10.32	5.80	2.58
	ALL PUBLIC	3544	73.59	17.34	26.01	34.56	13.03	10.41	9.17	6.80
	PROVINCE	3695	73.39	17.58	25.89	34.34	12.85	10.47	9.28	7.14
EXAM MARK	SCHOOL	15	69.46	16.73	20.00	20.00	6.66	20.00	20.00	13.33
	DISTRICT	155	70.77	17.65	25.80	23.87	10.96	11.61	14.83	12.90
	ALL PUBLIC	3512	68.52	18.01	21.15	24.57	8.82	15.11	14.83	15.48
	PROVINCE	3654	68.31	18.16	20.93	24.54	8.75	15.05	14.75	15.95
FINAL MARK	SCHOOL	15	74.33	12.08	20.00	33.33	20.00	13.33	13.33	.00
	DISTRICT	155	75.02	14.25	29.03	30.96	9.67	13.54	12.25	4.51
	ALL PUBLIC	3404	72.25	15.37	21.62	31.69	13.54	12.72	13.77	6.63
	PROVINCE	3536	72.14	15.44	21.57	31.47	13.43	12.89	13.74	6.87

Jan 2000
Chemistry 12

Explanations:

Note: The numbers in this report may differ slightly from previous reports due to the data being updated since the previous reports were created.

1. All school marks and exam marks relate ONLY to the specific session(s) shown at top of report.
2. Final marks may relate to earlier exam sessions since final marks are based on 'best' school and exam marks.
3. Does not include Aegrotats, Deferrals or Challenges.
4. Number Counted for School marks includes all school percents which were submitted by the school.
5. Number Counted for Exam marks includes all exams written during this session.
6. Number Counted for Final marks includes every occurence of both a school % and exam mark for a student during the same session in the selected period.
7. The District total includes only public schools in the district.
8. The Province totals include all schools - both public and independent.

BRITISH COLUMBIA Ministry of Education

EVALUATION AND ACCOUNTABILITY
PARLIAMENT BUILDINGS
VICTORIA B.C.
V8W 9H1

2000 FEB 28 MINISTRY OF EDUCATION - Grade 12 Transcripts and Examinations System Page 1708

PROGRAM TRAX1270B2 Student Marks and Scholarship Scores by Subject

JANUARY 2000 - CHEMISTRY 12

STUDENT NUMBER	LOCAL ID	NAME	SCHOOL PERCENT	BEST SCHOOL %	EXAM PERCENT	BEST EXAM %	FINAL PERCENT	LTR GRADE	SCHOL SMS
			79	79	62	62	72	C+	N/A
			78	78	65	65	73	B	N/A
			82	82	84	84	83	B	502
			89	89	85	85	87	A	514
			60	60	49	49	56	C-	N/A
			73	73	84	84	77	B	502
			80	80	88	88	83	B	549
			80	80	58	58	71	C+	N/A
			71	71	59	59	66	C	N/A
			73	73	53	53	65	C	N/A
			92	92	95	95	93	A	637
			80	80	67	67	75	B	N/A
			77	77	61	61	71	C+	N/A
			93	93	90	90	92	A	574
			57	57	42	42	51	C-	N/A

Student ID Blocked.

BRITISH COLUMBIA Ministry of Education

DATA MANAGEMENT AND STUDENT CERTIF. ION BRANCH
PARLIAMENT BUILDINGS
VICTORIA BC V8W 9H1

Report: TRAX1274E

Grade 12 Examinations and Transcripts
DISTRIBUTION OF LETTER GRADES BY COURSE AND PUBLIC SCHOOL
2000/06 SESSION

Date: 2000/07/22

June 2000
Biology 12

BIOLOGY 12

		Number Counted	Average Score	Standard Deviation	Proportion of Students Achieving Letter Grades A	B	C+	C	C-	F
SCHOOL MARK	SCHOOL	14	78.78	9.25	28.57	28.57	42.85	.00	.00	.00
	DISTRICT	175	75.46	14.37	29.14	30.28	14.85	10.85	12.00	2.85
	ALL PUBLIC	10171	73.57	14.69	25.26	31.37	13.25	13.02	11.92	5.15
	PROVINCE	11401	73.78	14.50	25.53	31.82	13.16	12.99	11.63	4.85
EXAM MARK	SCHOOL	14	78.64	11.20	21.42	64.28	.00	.00	14.28	.00
	DISTRICT	178	67.63	17.74	19.10	25.28	10.67	8.42	17.97	18.53
	ALL PUBLIC	10173	65.32	18.11	15.61	23.05	12.40	10.16	18.34	20.41
	PROVINCE	11423	65.65	18.02	15.89	23.40	12.61	10.15	18.11	19.81
FINAL MARK	SCHOOL	14	78.85	9.37	28.57	50.00	14.28	7.14	.00	.00
	DISTRICT	172	72.60	14.85	23.25	29.06	11.62	13.95	16.27	5.81
	ALL PUBLIC	9854	70.86	14.67	19.49	28.66	12.81	14.75	17.79	6.46
	PROVINCE	11069	71.08	14.55	19.61	29.19	12.96	14.75	17.24	6.22

Explanations:

Note: The numbers in this report may differ slightly from previous reports due to the data being updated since the previous reports were created.

1. All school marks and exam marks relate ONLY to the specific session(s) shown at top of report.
2. Final marks may relate to earlier exam sessions since final marks are based on 'best' school and exam marks.
3. Does not include Aegrotats, Deferrals or Challenges.
4. Number Counted for School marks includes all school percents which were submitted by the school.
5. Number Counted for Exam marks includes all exams written during this session.
6. Number Counted for Final marks includes every occurence of both a school % and exam mark for a student during the same session in the selected period.
7. The District total includes only public schools in the district.
8. The Province totals include all schools - both public and independent.

BRITISH COLUMBIA Ministry of Education

EVALUATION AND ACCOUNTABILITY
PARLIAMENT BUILDINGS
VICTORIA B.C.
V8W 9H1

2000 JUL 22 MINISTRY OF EDUCATION - Grade 12 Transcripts and Examinations System Page 3754

PROGRAM TRAX1270B2 Student Marks and Scholarship Scores by Subject

JUNE 2000 - BIOLOGY 12

STUDENT NUMBER	LOCAL ID	NAME	SCHOOL PERCENT	BEST SCHOOL %	EXAM PERCENT	BEST EXAM %	FINAL PERCENT	LTR GRADE	SCHOL SMS
			72	72	59	59	67	C+	N/A
			78	78	77	77	78	B	456
			72	72	57	57	66	C	N/A
			96	96	98	98	97	A	733
			91	91	96	96	93	A	698
			72	72	77	77	74	B	456
			72	72	79	79	75	B	478
			92	92	84	84	89	A	526
			77	77	77	77	77	B	456
			67	67	80	80	72	C+	489
			89	89	86	86	88	A	547
			78	78	77	77	78	B	456
			72	72	76	76	74	B	447
			75	75	78	78	76	B	467

Student ID Blocked.

BRITISH COLUMBIA Ministry of Education

DATA MANAGEMENT AND STUDENT CERTIFICATION BRANCH
PARLIAMENT BUILDINGS
VICTORIA BC V8W 9H1

Report: TRAX1274E

Grade 12 Examinations and Transcripts
DISTRIBUTION OF LETTER GRADES BY COURSE AND PUBLIC SCHOOL
2000/06 SESSION

Date: 2000/07/22

June 2000
Chem 12

CHEMISTRY 12

		Number Counted	Average Score	Standard Deviation	Proportion of Students Achieving Letter Grades A	B	C+	C	C-	F
SCHOOL MARK	SCHOOL	23	71.00	12.48	13.04	30.43	21.73	13.04	21.73	.00
	DISTRICT	120	76.94	12.71	29.16	35.83	11.66	13.33	10.00	.00
	ALL PUBLIC	8310	75.18	14.56	28.24	34.96	12.10	10.44	9.13	5.10
	PROVINCE	9243	75.31	14.39	28.27	35.31	12.08	10.39	9.07	4.85
EXAM MARK	SCHOOL	23	55.26	16.12	4.34	8.69	4.34	21.73	21.73	39.13
	DISTRICT	128	63.97	16.15	8.59	21.87	14.06	19.53	16.40	19.53
	ALL PUBLIC	8228	67.60	17.75	18.21	25.61	11.72	12.77	14.76	16.89
	PROVINCE	9206	67.70	17.68	18.16	25.90	11.81	12.78	14.76	16.56
FINAL MARK	SCHOOL	23	64.69	13.47	8.69	17.39	17.39	17.39	30.43	8.69
	DISTRICT	120	71.66	13.61	19.16	30.83	12.50	17.50	15.83	4.16
	ALL PUBLIC	7960	72.88	14.15	21.68	33.16	13.51	12.92	13.73	4.97
	PROVINCE	8873	72.94	14.06	21.59	33.43	13.62	12.91	13.54	4.87

Explanations:

Note: The numbers in this report may differ slightly from previous reports due to the data being updated since the previous reports were created.

1. All school marks and exam marks relate ONLY to the specific session(s) shown at top of report.
2. Final marks may relate to earlier exam sessions since final marks are based on 'best' school and exam marks.
3. Does not include Aegrotats, Deferrals or Challenges.
4. Number Counted for School marks includes all school percents which were submitted by the school.
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BRITISH COLUMBIA Ministry of Education

EVALUATION AND ACCOUNTABILITY
PARLIAMENT BUILDINGS
VICTORIA B.C.
V8W 9H1

JUNE 2000 - CHEMISTRY 12

STUDENT NUMBER	LOCAL ID	NAME	SCHOOL PERCENT	BEST SCHOOL %	EXAM PERCENT	BEST EXAM %	FINAL PERCENT	LTR GRADE	SCHOL SMS
			85	85	58	58	74	B	N/A
			94	94	94	94	94	A	647
			70	70	45	45	60	C	N/A
			86	86	75	75	82	B	421
			74	74	59	59	68	C+	N/A
			85	85	62	62	76	B	N/A
			60	60	41	41	52	C-	N/A
			55	55	42	42	50	C-	N/A
			92	92	85	85	89	A	526
			85	85	69	69	79	B	N/A
			58	58	60	60	59	C-	N/A
			69	69	50	50	61	C	N/A
			72	72	65	65	69	C+	N/A
			72	72	58	58	66	C	N/A
			52	52	30	30	43	F	N/A
			76	76	65	65	72	C+	N/A
			55	55	50	50	53	C-	N/A
			73	73	60	60	68	C+	N/A
			62	62	45	45	55	C-	N/A
			54	54	29	29	44	F	N/A
			67	67	39	39	56	C-	N/A
			73	73	45	45	62	C	N/A
			64	64	45	45	56	C-	N/A

Student ID Blocked.

BRITISH COLUMBIA Ministry of Education

DATA MANAGEMENT AND STUDENT CERTIF_ .TION BRANCH
PARLIAMENT BUILDINGS
VICTORIA BC V8W 9H1

Report: TRAX1274E

Grade 12 Examinations and Transcripts
DISTRIBUTION OF LETTER GRADES BY COURSE AND PUBLIC SCHOOL
2000/06 SESSION

Date: 2000/07/22

JUNE 2000
Physics B

PHYSICS 12

		Number Counted	Average Score	Standard Deviation	Proportion of Students Achieving Letter Grades A	B	C+	C	C-	F
SCHOOL MARK	SCHOOL	13	81.84	9.63	46.15	38.46	7.69	.00	7.69	.00
	DISTRICT	110	78.52	14.05	40.00	29.09	11.81	6.36	10.00	2.72
	ALL PUBLIC	5852	75.08	15.82	30.84	31.88	11.55	10.47	9.39	5.84
	PROVINCE	6567	75.49	15.60	31.88	31.84	11.49	10.14	9.16	5.46
EXAM MARK	SCHOOL	13	80.53	15.56	53.84	15.38	15.38	7.69	.00	7.69
	DISTRICT	107	72.78	18.49	33.64	21.49	9.34	10.28	15.88	9.34
	ALL PUBLIC	5779	71.60	18.46	28.79	24.45	12.56	9.24	11.42	13.53
	PROVINCE	6484	71.76	18.42	29.07	24.53	12.58	9.23	11.18	13.38
FINAL MARK	SCHOOL	13	81.23	11.61	46.15	38.46	7.69	.00	7.69	.00
	DISTRICT	107	76.27	14.90	36.44	25.23	13.08	13.08	5.60	6.54
	ALL PUBLIC	5563	74.62	14.59	27.91	31.09	12.78	11.98	11.34	4.87
	PROVINCE	6257	74.89	14.49	28.40	31.46	12.67	11.79	10.97	4.68

Explanations:

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BRITISH COLUMBIA Ministry of Education

EVALUATION AND ACCOUNTABILITY
PARLIAMENT BUILDINGS
VICTORIA B.C.
V8W 9H1

2000 JUL 22 MINISTRY OF EDUCATION - Grade 12 Transcripts and Examinations System Page 3760

PROGRAM TRAX1270B2 Student Marks and Scholarship Scores by Subject

JUNE 2000 - PHYSICS 12

STUDENT NUMBER	LOCAL ID	NAME	SCHOOL PERCENT	BEST SCHOOL %	EXAM PERCENT	BEST EXAM %	FINAL PERCENT	LTR GRADE	SCHOL SMS
			79	79	79	79	79	B	450
			71	71	64	64	68	C+	N/A
			80	80	70	70	76	B	298
			88	88	94	94	90	A	615
			82	82	90	90	85	B	561
			86	86	86	86	86	A	509
			88	88	86	86	87	A	509
			56	56	42	42	50	C-	N/A
			91	91	96	96	93	A	650
			83	83	92	92	87	A	587
			91	91	94	94	92	A	615
			80	80	85	85	82	B	501
			89	89	69	69	81	B	N/A

Student ID Blocked

BRITISH COLUMBIA Ministry of Education

DATA MANAGEMENT AND STUDENT CERTIFICATION BRANCH
PARLIAMENT BUILDINGS
VICTORIA BC V8W 9H1

Report: TRAX1274E

Grade 12 Examinations and Transcripts
DISTRIBUTION OF LETTER GRADES BY COURSE AND PUBLIC SCHOOL
2003/06 SESSION

Date: 2003/07/19

BIOLOGY 12

		Number Counted	Average Score	Standard Deviation	Proportion of Students Achieving Letter Grades A	B	C+	C	C-	F
SCHOOL MARK	SCHOOL	24	73.95	12.95	25.00	33.33	16.66	4.16	20.83	.00
	DISTRICT	166	72.66	13.73	21.68	33.73	11.44	13.85	15.06	4.21
	ALL PUBLIC	11391	74.28	14.67	27.40	31.26	12.42	12.31	11.52	5.06
	PROVINCE	12974	74.67	14.52	28.27	31.46	12.44	11.87	11.19	4.74
EXAM MARK	SCHOOL	24	70.45	16.37	25.00	16.66	12.50	16.66	20.83	8.33
	DISTRICT	179	60.68	17.80	11.17	14.52	9.49	12.29	26.81	25.69
	ALL PUBLIC	11365	64.18	19.08	17.00	19.43	9.87	11.78	19.12	22.77
	PROVINCE	12957	64.58	18.99	17.47	19.73	9.90	11.78	18.95	22.14
FINAL MARK	SCHOOL	24	72.62	13.93	20.83	29.16	12.50	12.50	20.83	4.16
	DISTRICT	162	68.14	14.41	15.43	19.75	16.04	21.60	17.90	9.25
	ALL PUBLIC	10847	70.91	15.07	20.96	27.16	12.67	14.57	17.54	7.07
	PROVINCE	12397	71.27	14.99	21.55	27.54	12.71	14.40	17.08	6.69

June '03

Biology 12.

Explanations:

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BIOLOGY 12 - JUNE 2003

TOPIC AREA	OUT OF	SCHOOL				DISTRICT/AUTHORITY				PROVINCE			
		STUDENTS	MEAN	STD DEV	AVG%	STUDENTS	MEAN	STD DEV	AVG%	STUDENTS	MEAN	STD DEV	AVG%
CELL BIOLOGY	16.0	24	11.13	2.92	69.53	179	9.92	3.12	61.9	12,946	10.42	3.38	65.1
CELL PROCESSES AND APPLICATION	21.0	24	14.92	3.75	71.03	179	13.40	4.24	63.8	12,954	14.23	4.32	67.7
HUMAN BIOLOGY	63.0	24	42.92	11.42	68.12	179	35.45	12.12	56.2	12,957	38.22	12.82	60.6

COGNITIVE LEVEL	OUT OF	SCHOOL				DISTRICT/AUTHORITY				PROVINCE			
		STUDENTS	MEAN	STD DEV	AVG%	STUDENTS	MEAN	STD DEV	AVG%	STUDENTS	MEAN	STD DEV	AVG%
HIGHER MENTAL PROCESSES	18.0	24	11.25	3.96	62.50	178	9.64	3.60	53.5	12,951	10.36	3.79	57.5
KNOWLEDGE	23.0	24	17.92	3.51	77.90	179	15.87	4.19	68.9	12,956	16.51	4.44	71.7
UNDERSTANDING/APPLICATION	59.0	24	39.79	10.46	67.44	179	33.32	11.54	56.4	12,957	35.98	12.15	60.9

BRITISH COLUMBIA Ministry of Education

EVALUATION AND ACCOUNTABILITY
PARLIAMENT BUILDINGS
VICTORIA B.C.
V8W 9H1

2003 JUL 19 MINISTRY OF EDUCATION - Grade 12 Transcripts and Examinations System Page 3986

PROGRAM TRAX1270B2 Student Marks and Scholarship Scores by Subject

JUNE 2003 - BIOLOGY 12

STUDENT NUMBER	LOCAL ID	NAME	SCHOOL PERCENT	BEST SCHOOL %	EXAM PERCENT	BEST EXAM %	FINAL PERCENT	LTR GRADE	SCHOL SMS
			73	73	71	71	72	C+	344
			75	75	69	69	73	B	N/A
			51	51	36	36	45	F	N/A
			68	68	64	64	66	C	N/A
			55	55	57	57	56	C-	N/A
			82	82	86	86	84	B	528
			69	69	57	57	64	C	N/A
			56	56	48	48	53	C-	N/A
			88	88	91	91	89	A	594
			58	58	61	61	59	C-	N/A
			87	87	90	90	88	A	577
			74	74	76	76	75	B	435
			86	86	81	81	84	B	479
			62	62	51	51	58	C-	N/A
			71	71	58	58	66	C	N/A
			89	89	96	96	92	A	668
			90	90	95	95	92	A	651
			93	93	92	92	93	A	606
			82	82	80	80	81	B	470
			78	78	62	62	72	C+	N/A
			82	82	82	82	82	B	488
			83	83	69	69	77	B	N/A
			51	51	58	58	54	C-	N/A
			72	72	61	61	68	C+	N/A

Student ID Blacked

BRITISH COLUMBIA Ministry of Education

DATA MANAGEMENT AND STUDENT CERTIFICATION BRANCH
PARLIAMENT BUILDINGS
VICTORIA BC V8W 9H1

Report: TRAX1274E

Grade 12 Examinations and Transcripts
DISTRIBUTION OF LETTER GRADES BY COURSE AND PUBLIC SCHOOL
2003/06 SESSION

Page: 2317
Date: 2003/07/19

CHEMISTRY 12

		Number Counted	Average Score	Standard Deviation	Proportion of Students Achieving Letter Grades A	B	C+	C	C-	F
SCHOOL MARK	SCHOOL	30	76.90	11.72	23.33	43.33	10.00	16.66	6.66	.00
	DISTRICT	165	75.73	12.45	23.63	40.00	13.33	13.93	7.87	1.21
	ALL PUBLIC	8898	76.55	14.28	32.02	34.59	11.58	9.14	8.18	4.46
	PROVINCE	10049	76.78	14.01	32.24	35.09	11.67	9.05	7.84	4.08
EXAM MARK	SCHOOL	30	72.13	15.45	26.66	30.00	.00	16.66	23.33	3.33
	DISTRICT	165	69.62	16.53	18.78	26.06	18.18	10.30	13.93	12.72
	ALL PUBLIC	8834	72.51	17.59	27.76	27.09	12.83	8.13	12.71	11.44
	PROVINCE	10027	72.82	17.42	28.04	27.34	13.14	8.07	12.38	11.00
FINAL MARK	SCHOOL	30	75.06	12.86	30.00	33.33	3.33	23.33	6.66	3.33
	DISTRICT	163	73.49	13.45	21.47	34.35	12.88	14.72	14.11	2.45
	ALL PUBLIC	8586	75.49	14.25	28.41	33.76	12.22	10.52	10.93	4.12
	PROVINCE	9727	75.72	14.06	28.54	34.38	12.36	10.34	10.47	3.87

June 2003
Chemistry
12

Explanations:

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BRITISH COLUMBIA Ministry of Education

EVALUATION AND ACCOUNTABILITY
PARLIAMENT BUILDINGS
VICTORIA B.C.
V8W 9H1

2003 JUL 19 MINISTRY OF EDUCATION - Grade 12 Transcripts and Examinations System Page 3987

PROGRAM TRAX1270B2 Student Marks and Scholarship Scores by Subject

JUNE 2003 - CHEMISTRY 12

STUDENT NUMBER	LOCAL ID	NAME	SCHOOL PERCENT	BEST SCHOOL %	EXAM PERCENT	BEST EXAM %	FINAL PERCENT	LTR GRADE	SCHOL SMS
			92	92	89	89	91	A	546
			81	81	75	75	79	B	409
			82	82	81	81	82	B	471
			62	62	54	54	59	C-	N/A
			63	63	57	57	61	C	N/A
			68	68	53	53	62	C	N/A
			83	83	65	65	76	B	N/A
			54	54	33	33	46	F	N/A
			79	79	76	76	78	B	421
			92	92	86	86	90	A	517
			95	95	91	91	93	A	568
			93	93	88	88	91	A	537
			74	74	76	76	75	B	421
			89	89	89	89	89	A	546
			55	55	50	50	53	C-	N/A
			79	79	66	66	74	B	N/A
			83	83	78	78	81	B	442
			69	69	60	60	65	C	N/A
			79	79	83	83	81	B	489
			89	89	82	82	86	A	481
			85	85	88	88	86	A	537
			64	64	65	65	64	C	N/A
			83	83	79	79	81	B	452
			75	75	83	83	78	B	489
			63	63	64	64	63	C	N/A
			83	83	90	90	86	A	556
			74	74	58	58	68	C+	N/A
			89	89	93	93	91	A	592
			67	67	57	57	63	C	N/A
			63	63	55	55	60	C	N/A

Student ID Blocked.

BRITISH COLUMBIA Ministry of Education

DATA MANAGEMENT AND STUDENT CERTIFICATION BRANCH
PARLIAMENT BUILDINGS
VICTORIA BC V8W 9H1

Report: TRAX1274E

Grade 12 Examinations and Transcripts
DISTRIBUTION OF LETTER GRADES BY COURSE AND PUBLIC SCHOOL
2003/06 SESSION

Date: 2003/07/19

PHYSICS 12

		Number Counted	Average Score	Standard Deviation	Proportion of Students Achieving Letter Grades A	B	C+	C	C-	F
SCHOOL MARK	SCHOOL	14	77.50	11.80	21.42	42.85	21.42	7.14	7.14	.00
	DISTRICT	81	74.96	15.04	25.92	37.03	12.34	8.64	11.11	4.93
	ALL PUBLIC	5837	76.83	15.30	34.81	32.63	9.97	9.25	8.32	5.00
	PROVINCE	6619	77.30	14.99	35.68	33.13	9.75	9.03	7.82	4.56
EXAM MARK	SCHOOL	14	69.42	19.17	21.42	28.57	14.28	7.14	7.14	21.42
	DISTRICT	82	65.52	18.00	18.29	15.85	14.63	8.53	28.04	14.63
	ALL PUBLIC	5835	69.21	19.02	24.76	22.62	10.33	10.48	16.33	15.45
	PROVINCE	6629	69.62	18.84	25.20	23.11	10.27	10.52	16.12	14.75
FINAL MARK	SCHOOL	14	74.28	14.47	21.42	35.71	14.28	7.14	21.42	.00
	DISTRICT	79	71.40	15.07	21.51	29.11	15.18	16.45	10.12	7.59
	ALL PUBLIC	5554	74.42	14.95	27.90	30.37	11.93	12.13	12.38	5.25
	PROVINCE	6324	74.84	14.76	28.58	30.99	11.87	11.89	11.79	4.85

June 2003
Physics 12

Explanations:

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BRITISH COLUMBIA Ministry of Education

EVALUATION AND ACCOUNTABILITY
PARLIAMENT BUILDINGS
VICTORIA B.C.
V8W 9H1

2003 JUL 19 MINISTRY OF EDUCATION - Grade 12 Transcripts and Examinations System Page 3992

PROGRAM TRAX1270B2 Student Marks and Scholarship Scores by Subject

JUNE 2003 - PHYSICS 12

STUDENT NUMBER	LOCAL ID	NAME	SCHOOL PERCENT	BEST SCHOOL %	EXAM PERCENT	BEST EXAM %	FINAL PERCENT	LTR GRADE	SCHOL SMS
			93	93	96	96	94	A	648
			71	71	72	72	71	C+	353
			69	69	45	45	59	C-	N/A
			55	55	44	44	51	C-	N/A
			92	92	86	86	90	A	511
			96	96	95	95	96	A	626
			78	78	67	67	74	B	N/A
			83	83	81	81	82	B	467
			75	75	62	62	70	C+	N/A
			61	61	33	33	50	C-	N/A
			80	80	78	78	79	B	441
			82	82	78	78	80	B	441
			70	70	57	57	65	C	N/A
			80	80	78	78	79	B	441

Student ID Blocked.

BRITISH COLUMBIA *Ministry of Education*

Report: TRAX1274E

Provincial Examinations and Transcripts
DISTRIBUTION OF LETTER GRADES BY COURSE AND PUBLIC SCHOOL
2006/06 SESSION

Page: 1
Date: 2006/08/06

BIOLOGY 12

			Number Counted	Average Score	Standard Deviation	Proportion of Students Achieving Letter Grades A	B	C+	C	C-	F	
SCHOOL MARK		SCHOOL	28	73.46	11.32	17.85	28.57	28.57	17.85	7.14	.00	
		DISTRICT	216	76.30	13.89	30.55	32.40	13.88	12.03	7.87	3.24	
		ALL PUBLIC	10989	74.55	15.05	28.57	31.59	11.63	11.60	11.36	5.22	
		PROVINCE	12607	75.09	14.76	29.61	32.14	11.43	11.27	10.87	4.65	
EXAM	MARK	SCHOOL	28	70.78	13.12	17.85	17.85	32.14	10.71	14.28	7.14	N/A
		DISTRICT	220	66.15	17.79	17.27	18.63	17.72	14.09	12.27	20.00	
		ALL PUBLIC	10743	67.64	17.74	20.01	23.18	12.65	12.32	14.18	17.63	
		PROVINCE	12372	68.24	17.62	20.93	23.75	12.72	12.17	13.65	16.74	
FINAL	MARK	SCHOOL	28	72.42	11.68	21.42	25.00	21.42	17.85	14.28	.00	
		DISTRICT	214	72.28	14.84	22.89	31.77	12.14	13.55	13.08	6.54	
		ALL PUBLIC	10432	72.52	14.60	23.30	29.91	12.50	12.95	15.91	5.41	
		PROVINCE	12024	73.04	14.40	24.11	30.57	12.54	12.66	15.16	4.93	

Bld. D
June '06

Explanations:

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BRITISH COLUMBIA *Ministry of Education*

2006 AUG 06 MINISTRY OF EDUCATION - Transcripts and Examinations System

PROGRAM TRAX1270B2 Student Marks and Scholarship Scores by Subject

JUNE 2006 - BIOLOGY 12

STUDENT NUMBER	LOCAL ID	NAME	SCHOOL PERCENT	BEST SCHOOL %	EXAM PERCENT	BEST EXAM %	FINAL PERCENT	LTR GRADE	SCHOL SMS
			71	71	60	60	67	C+	N/A
			77	77	72	72	75	B	374
			67	67	71	71	69	C+	345
			86	86	84	84	85	B	510
			52	52	54	54	53	C-	N/A
			82	82	74	74	79	B	410
			63	63	48	48	57	C-	N/A
			64	64	61	61	63	C	N/A
			87	87	84	84	86	A	510
			61	61	57	57	59	C-	N/A
			88	88	89	89	88	A	N/A
			88	88	90	90	89	A	585
			69	69	70	70	69	C+	294
			67	67	67	67	67	C+	N/A
			71	71	68	68	70	C+	N/A
			75	75	71	71	73	B	345
			61	61	69	69	64	C	N/A
			90	90	85	85	88	A	518
			51	51	49	49	50	C-	N/A
			85	85	89	89	87	A	572
			71	71	61	61	67	C+	N/A
			83	83	72	72	79	B	374
			60	60	68	68	63	C	N/A
			70	70	54	54	64	C	N/A
			68	68	56	56	63	C	N/A
			84	84	83	83	84	B	501
			83	83	86	86	84	B	530
			83	83	90	90	86	A	585

Student ID Blocked.

BRITISH COLUMBIA *Ministry of Education*

Report: TRAX1274E

Provincial Examinations and Transcripts
DISTRIBUTION OF LETTER GRADES BY COURSE AND PUBLIC SCHOOL
2006/06 SESSION

Date: 2006/08/06

CHEMISTRY 12

		Number Counted	Average Score	Standard Deviation	Proportion of Students Achieving Letter Grades A	B	C+	C	C-	F	
SCHOOL MARK	SCHOOL	33	77.48	9.73	33. 3	30.30	27.27	9.09	.00	.00	
	DISTRICT	153	80.36	10.70	39.86	36.60	13.72	6.53	3.26	.00	
	ALL PUBLIC	8511	77.08	14.24	33.80	34.27	10.79	9.56	7.55	4.00	
	PROVINCE	10009	77.42	13.84	33.97	35.21	10.92	9.18	7.16	3.53	
EXAM MARK	SCHOOL	32	65.03	15.09	9.37	25.00	18.75	9.37	25.00	12.50	N/A
	DISTRICT	154	66.17	15.96	13.63	20.12	13.63	18.18	20.77	13.63	
	ALL PUBLIC	8448	71.29	15.65	23.42	24.01	14.39	15.82	14.47	7.85	
	PROVINCE	9994	71.34	15.55	23.31	24.20	14.64	15.95	14.10	7.76	
FINAL MARK	SCHOOL	32	72.25	11.30	15.62	31.25	18.75	15.62	18.75	.00	
	DISTRICT	152	74.63	12.03	21.71	34.21	18.42	13.15	10.52	1.97	
	ALL PUBLIC	8164	75.37	13.27	26.62	33.68	14.00	12.43	10.61	2.63	
	PROVINCE	9639	75.55	13.05	26.44	34.51	14.30	12.08	10.25	2.39	

Chem 12
June '06

Explanations:

Note: The numbers in this report may differ slightly from previous reports due to the data being updated since the previous reports were created.

1. All school marks and exam marks relate ONLY to the specific session(s) shown at top of report.
2. Final marks may relate to earlier exam sessions since final marks are based on 'best' school and exam marks.
3. Does not include Aegrotats, Deferrals or Challenges.
4. Number Counted for School marks includes all school percents which were submitted by the school.
5. Number Counted for Exam marks includes all exams written during this session.
6. Number Counted for Final marks includes every occurence of both a school % and exam mark for a student during the same session in the selected period.
7. The District total includes only public schools in the district.
8. The Province totals include all schools - both public and independent.

BRITISH COLUMBIA *Ministry of Education*

2006 AUG 06 MINISTRY OF EDUCATION - Transcripts and Examinations System Page 2

PROGRAM TRAX1270B2 Student Marks and Scholarship Scores by Subject

JUNE 2006 - CHEMISTRY 12

STUDENT NUMBER	LOCAL ID	NAME	SCHOOL PERCENT	BEST SCHOOL %	EXAM PERCENT	BEST EXAM %	FINAL PERCENT	LTR GRADE	SCHOL SMS
[redacted]	[redacted]	[redacted]	71	71	67	67	69	C+	N/A
			70	70	70	70	70	C+	297
			86	86	71	71	80	B	348
			69	69	58	58	65	C	N/A
			83	83	73	73	79	B	399
			86	86	77	77	82	B	447
			73	73	57	57	67	C+	N/A
			73	73	66	66	70	C+	N/A
			60	60	38	38	51	C-	N/A
			87	87	DNW	---	---	---	N/A
			67	67	46	46	59	C-	N/A
			67	67	37	37	55	C-	N/A
			86	86	77	77	82	B	447
			63	63	51	51	58	C-	N/A
			73	73	50	50	64	C	N/A
			93	93	89	89	91	A	560
			86	86	71	71	80	B	348
			91	91	86	86	89	A	524
			91	91	81	81	87	A	483
			74	74	63	63	70	C+	N/A
			73	73	54	54	65	C	N/A
			81	81	73	73	78	B	399
			70	70	59	59	66	C	N/A
			61	61	53	53	58	C-	N/A
			72	72	78	78	74	B	456
			81	81	62	62	73	B	N/A
			72	72	33	33	56	C-	N/A
			93	93	89	89	91	A	560
			91	91	85	85	89	A	515
			84	84	77	77	81	B	447
			74	74	70	70	72	C+	297
			70	70	51	51	62	C	N/A
			86	86	69	69	79	B	N/A

Student ID Blocked.

BRITISH COLUMBIA *Ministry of Education*

Report: TRAX1274E

Provincial Examinations and Transcripts
DISTRIBUTION OF LETTER GRADES BY COURSE AND PUBLIC SCHOOL
2006/06 SESSION

Date: 2006/08/06

PHYSICS 12

		Number Counted	Average Score	Standard Deviation	Proportion of Students Achieving Letter Grades A	B	C+	C	C-	F	
SCHOOL MARK	SCHOOL	18	79.16	9.43	33.33	38.88	22.22	5.55	.00	.00	
	DISTRICT	108	80.43	12.60	43.51	33.33	11.11	7.40	2.77	1.85	
	ALL PUBLIC	5776	77.20	14.78	35.63	33.01	10.11	8.84	7.96	4.43	
	PROVINCE	6694	77.73	14.48	36.97	33.14	9.81	8.64	7.42	3.98	
EXAM MARK	SCHOOL	16	71.50	12.56	18.75	31.25	.00	37.50	6.25	6.25	N/A
	DISTRICT	106	69.49	13.02	12.26	30.18	15.09	24.52	8.49	9.43	
	ALL PUBLIC	5709	73.89	15.11	25.83	28.67	16.30	14.50	8.11	6.56	
	PROVINCE	6605	74.10	15.06	26.29	28.99	15.86	14.51	8.00	6.31	
FINAL MARK	SCHOOL	16	76.18	10.79	31.25	31.25	12.50	18.75	6.25	.00	
	DISTRICT	104	76.18	10.95	23.07	44.23	13.46	11.53	6.73	.96	
	ALL PUBLIC	5534	76.45	13.38	29.25	35.61	12.82	10.42	9.14	2.72	
	PROVINCE	6419	76.82	13.20	29.97	36.01	12.72	10.11	8.66	2.50	

Physics 12
June 06

Explanations:

Note: The numbers in this report may differ slightly from previous reports due to the data being updated since the previous reports were created.

1. All school marks and exam marks relate ONLY to the specific session(s) shown at top of report.
2. Final marks may relate to earlier exam sessions since final marks are based on 'best' school and exam marks.
3. Does not include Aegrotats, Deferrals or Challenges.
4. Number Counted for School marks includes all school percents which were submitted by the school.
5. Number Counted for Exam marks includes all exams written during this session.
6. Number Counted for Final marks includes every occurence of both a school % and exam mark for a student during the same session in the selected period.
7. The District total includes only public schools in the district.
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BRITISH COLUMBIA *Ministry of Education*

2006 AUG 06 MINISTRY OF EDUCATION - Transcripts and Examinations System Page 9

PROGRAM TRAX1270B2 Student Marks and Scholarship Scores by Subject

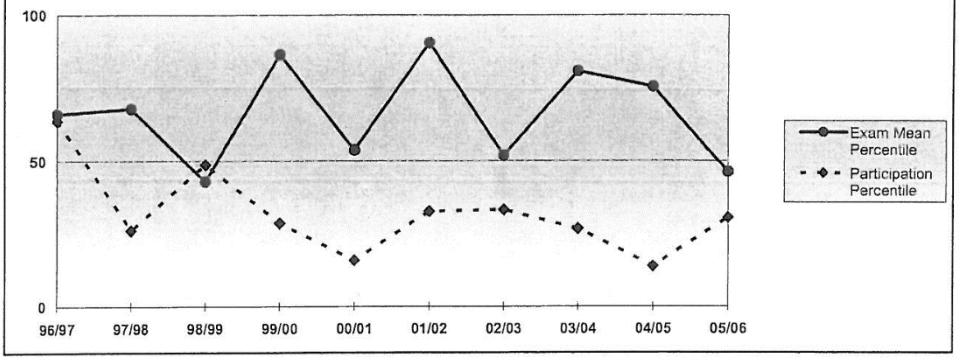
JUNE 2006 - PHYSICS 12

STUDENT NUMBER	LOCAL ID	NAME	SCHOOL PERCENT	BEST SCHOOL %	EXAM PERCENT	BEST EXAM %	FINAL PERCENT	LTR GRADE	SCHOL SMS
			63	63	63	63	63	C	N/A
			74	74	75	75	74	B	420
			82	82	DNW	---	---	---	N/A
			89	89	88	88	89	A	548
			80	80	64	64	74	B	N/A
			68	68	46	46	59	C-	N/A
			90	90	82	82	87	A	488
			89	89	88	88	89	A	548
			76	76	DNW	---	---	---	N/A
			68	68	64	64	66	C	N/A
			88	88	78	78	84	B	452
			69	69	62	62	66	C	N/A
			79	79	73	73	77	B	396
			95	95	90	90	93	A	570
			91	91	83	83	88	A	498
			77	77	66	66	73	B	N/A
			72	72	59	59	67	C+	N/A
			75	75	63	63	70	C+	N/A

Student ID Blocked

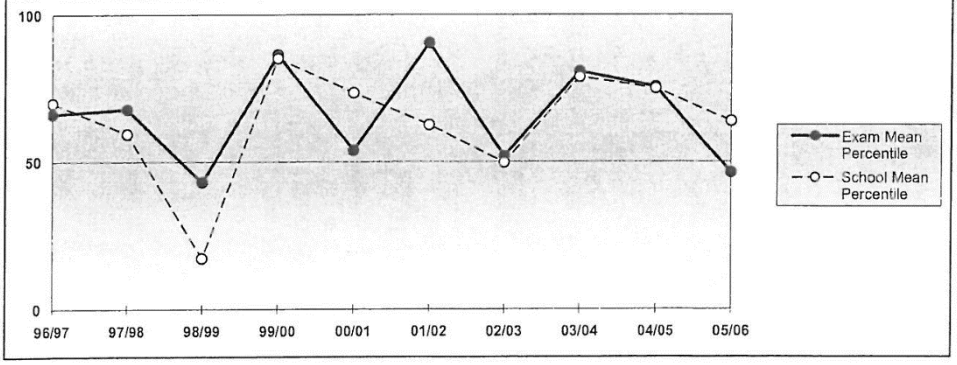
Physics 12

EXAM MEAN SCORE AND PARTICIPATION RATE* *Expressed as Percentiles*



	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Exam Mean Score (%)	72%	73%	69%	81%	71%	79%	69%	75%	76%	72%
Exam Mean Percentile	**66**	**68**	**43**	**86**	**54**	**90**	**52**	**81**	**75**	**46**
Participation Rate (%)	17%	8%	15%	10%	5%	11%	11%	10%	6%	11%
Participation Percentile	**64**	**26**	**49**	**29**	**16**	**33**	**33**	**27**	**14**	**31**
Number of students writing exam (all grade levels)	17	10	19	13	7	16	14	15	9	16
No. of schools used (standard public schools)	214	218	223	228	225	228	227	225	224	229

EXAM MEAN SCORE AND SCHOOL MEAN SCORE* *Expressed as Percentiles*



	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Exam Mean Score (%)	72%	73%	69%	81%	71%	79%	69%	75%	76%	72%
Exam Mean Percentile	**66**	**68**	**43**	**86**	**54**	**90**	**52**	**81**	**75**	**46**
School Mean Score (%)	79%	78%	70%	82%	80%	78%	78%	82%	82%	79%
School Mean Percentile	**70**	**59**	**17**	**85**	**73**	**63**	**50**	**79**	**75**	**64**
Number of students writing exam (all grade levels)	17	10	19	13	7	16	14	15	9	16
No. of schools used (standard public schools)	214	218	223	228	225	228	227	225	224	229

* *See Tab 1 for definitions of terms.*
The percentiles shown above assume the data are from a normal distribution ('bell' curve) of Standard Public school scores.

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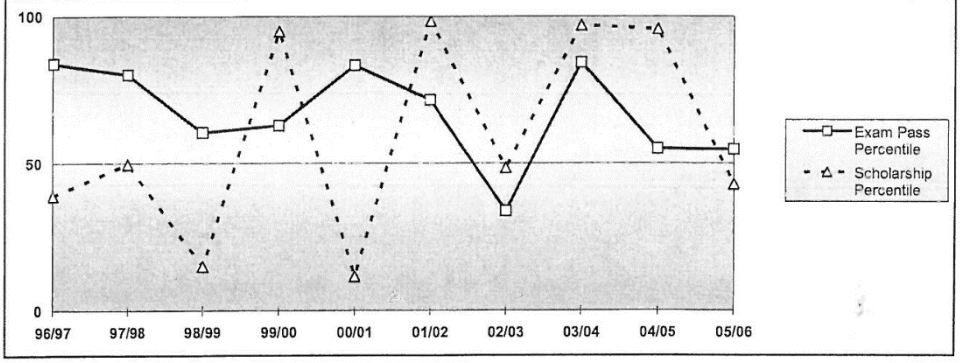
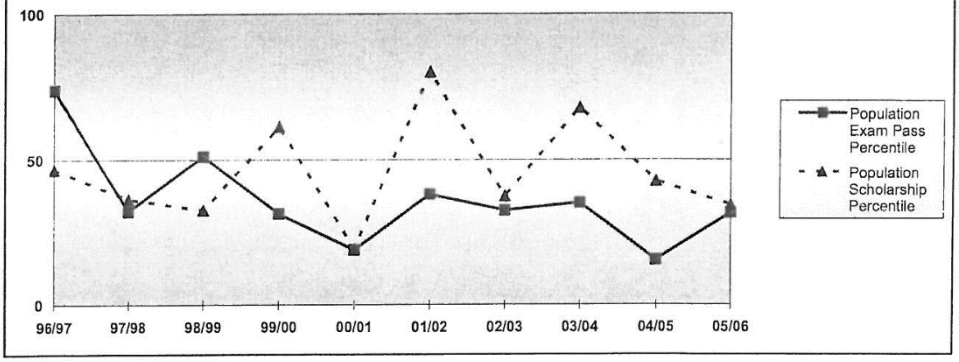
Physics 12

EXAM PASS RATE AND SCHOLARSHIP (A) RATE* *Expressed as Percentiles*



	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Exam Pass Rate (%)	100%	100%	89%	92%	100%	94%	79%	100%	89%	94%
Exam Pass Percentile	**84**	**80**	**60**	**63**	**83**	**72**	**34**	**84**	**55**	**55**
Exam Scholarship (A) Rate (%)	18%	20%	5%	54%	0%	50%	21%	47%	44%	19%
Exam Scholarship Percentile	**39**	**50**	**15**	**95**	**12**	**98**	**49**	**97**	**96**	**43**
Number of students writing exam (all grade levels)	17	10	19	13	7	16	14	15	9	16
No. of schools used (standard public schools)	214	218	223	228	225	228	227	225	224	229

POPULATION EXAM PASS RATE AND SCHOLARSHIP (A) RATE* *Expressed as Percentiles*



	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Population Exam Pass Rate (%)	17%	8%	13%	9%	5%	11%	9%	10%	5%	10%
Population Exam Pass Percentile	**74**	**32**	**51**	**31**	**19**	**38**	**33**	**35**	**15**	**32**
Population Exam Scholarship (A) Rate (%)	3.1%	1.6%	0.8%	5.3%	0.0%	5.7%	2.3%	4.6%	2.6%	2.0%
Population Exam Scholarship Percentile	**47**	**36**	**33**	**61**	**19**	**80**	**37**	**68**	**43**	**34**
Number of students writing exam (all grade levels)	17	10	19	13	7	16	14	15	9	16
No. of schools used (standard public schools)	214	218	223	228	225	228	227	225	224	229

** See Tab 1 for definitions of terms.*
The percentiles shown above assume the data are from a normal distribution ("bell" curve) of Standard Public school scores.

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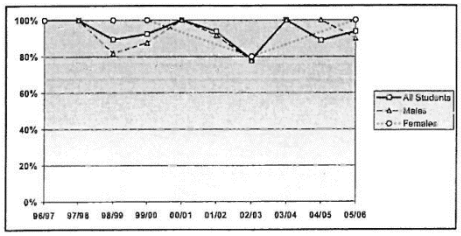
Physics 12

EXAM PASS RATE AND PARTICIPATION RATE

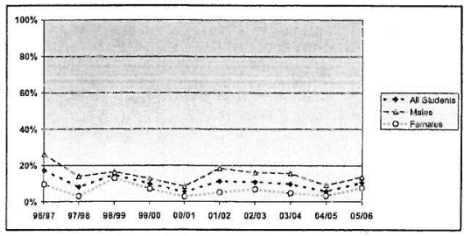
Selected Groups of Students Expressed as Percentages

GENDER

Pass Rate



Participation Rate



Pass Rate		96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Percentages for school	All Students	100%	100%	89%	92%	100%	94%	79%	100%	89%	94%
	Males	100%	100%	82%	86%	100%	92%	78%	100%	100%	90%
	Females	100%	Mask	100%	100%	Mask	Mask	80%	Mask	Mask	100%
Writers in all grades	Males	12	8	11	8	5	12	9	11	6	10
	Females	5	2	8	5	2	4	5	4	3	6
B.C. Rates (public only)	All Students	84%	87%	86%	88%	88%	87%	88%	86%	90%	94%
	Males	84%	88%	85%	87%	87%	85%	86%	84%	90%	94%
	Females	86%	85%	89%	91%	89%	89%	91%	89%	91%	95%

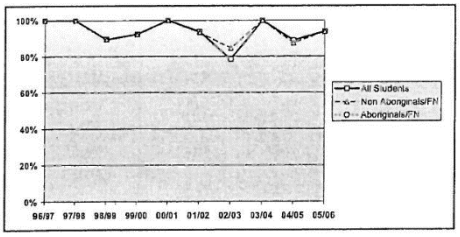
Pass Rate is the percentage of all students writing the exam awarded a Pass (C-) or higher.

Participation Rate		96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Percentages for school	All Students	17%	8%	15%	10%	5%	11%	11%	10%	6%	11%
	Males	26%	14%	16%	13%	8%	18%	16%	16%	9%	14%
	Females	10%	3%	13%	7%	3%	5%	7%	5%	3%	8%
Enrolment in Grade 12	Males	46	57	87	82	59	65	56	70	66	73
	Females	52	65	61	69	69	75	72	83	89	78
B.C. Rates (public only)	All Students	14%	14%	15%	15%	15%	15%	15%	15%	15%	15%
	Males	19%	19%	20%	20%	20%	20%	20%	20%	20%	21%
	Females	8%	8%	9%	9%	9%	9%	9%	10%	9%	9%

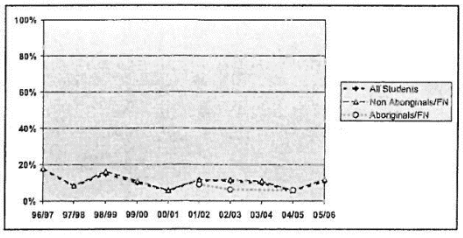
Participation Rate is the number of Grade 12 students writing the exam divided by Grade 12 enrolment.

ABORIGINAL/FIRST NATIONS STATUS

Pass Rate



Participation Rate



Pass Rate		96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Percentages for school	All Students	100%	100%	89%	92%	100%	94%	79%	100%	89%	94%
	Non Aboriginals/FN	100%	100%	89%	92%	100%	93%	85%	100%	86%	94%
	Aboriginals/FN	N/A	N/A	N/A	N/A	N/A	Mask	Mask	N/A	Mask	N/A
Writers in all grades	Non Aboriginals/FN	17	10	19	13	7	15	13	15	8	16
	Aboriginals/FN	0	0	0	0	0	1	1	0	1	0
B.C. Rates (public only)	All Students	84%	87%	86%	88%	88%	87%	88%	86%	90%	94%
	Non Aboriginals/FN	84%	87%	86%	88%	88%	87%	88%	86%	91%	94%
	Aboriginals/FN	80%	93%	76%	86%	86%	84%	75%	82%	86%	90%

Pass Rate is the percentage of all students writing the exam awarded a Pass (C-) or higher.

Participation Rate		96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Percentages for school	All Students	17%	8%	15%	10%	5%	11%	11%	10%	6%	11%
	Non Aboriginals/FN	18%	8%	16%	11%	6%	12%	12%	11%	6%	12%
	Aboriginals/FN	Mask	Mask	0%	0%	0%	9%	6%	0%	6%	0%
Enrolment in Grade 12	Non Aboriginals/FN	95	120	118	120	121	130	112	139	138	135
	Aboriginals/FN	3	2	10	11	7	11	16	14	17	16
B.C. Rates (public only)	All Students	14%	14%	15%	15%	15%	15%	15%	15%	15%	15%
	Non Aboriginals/FN	14%	14%	15%	15%	16%	16%	16%	16%	16%	16%
	Aboriginals/FN	3%	2%	3%	3%	3%	3%	3%	3%	4%	3%

Participation Rate is the number of Grade 12 students writing the exam divided by Grade 12 enrolment.

NOTES.
In the tables above, 'N/A' indicates that either no students were involved or no data are currently available. 'Mask' indicates that results have been suppressed (masked) to comply with the Freedom of Information and Protection of Privacy Act. This applies if there is less than 5 students writing the exam (Pass Rates) or less than 5 enrolled in Grade 12 (Participation Rates).
All data refer to Standard schools only. Continuing Education, Distance Education, Alternate schools, Electronic Schooling, etc. are excluded.

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Physics 12

DIAGNOSTICS TABLE*

Compulsory exam for this subject

			1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06
Number of students in Grade 12 (grade level enrolment of Subject)		School	98	122	128	131	128	141	128	153	155	151
		District	1,090	1,125	1,229	1,278	1,218	1,406	1,296	1,340	1,417	1,312
		All Public	43,857	45,957	46,317	47,763	47,406	48,493	47,962	46,022	46,463	47,650
Number of students writing the exam (Grade 12 only)		School	17	10	19	13	7	16	14	15	9	16
		District	120	111	123	139	116	160	108	128	123	121
		All Public	5,930	6,315	6,861	7,093	7,076	7,294	7,213	7,048	6,879	7,312
Exam Participation Rate (% of Subject grade level enrolment)		School	17.3%	8.2%	14.8%	9.9%	5.5%	11.3%	10.9%	9.8%	5.8%	10.6%
		District	11.0%	9.9%	10.0%	10.9%	9.5%	11.4%	8.3%	9.6%	8.7%	9.2%
		All Public	13.5%	13.7%	14.8%	14.9%	14.9%	15.0%	15.0%	15.3%	14.8%	15.3%
Exam Mark (all grades)	Exam Mean Score (%) (average for the year)	School	72.3%	73.2%	68.8%	80.5%	70.9%	78.9%	69.4%	75.4%	75.8%	71.5%
		District	67.9%	67.3%	67.1%	73.3%	70.0%	67.5%	67.2%	67.4%	72.7%	70.3%
		All Public	70.4%	70.2%	71.7%	72.6%	70.8%	70.3%	70.6%	70.1%	72.5%	74.9%
	Exam Pass Rate (%)	School	100.0%	100.0%	89.5%	92.3%	100.0%	93.8%	78.6%	100.0%	88.9%	93.8%
		District	81.3%	86.0%	79.7%	92.1%	90.6%	86.9%	87.2%	85.2%	92.7%	90.9%
		All Public	84.3%	86.8%	86.1%	87.9%	87.6%	86.5%	87.6%	85.7%	90.5%	94.4%
	Exam 'A' Rate (%) (Scholarship Rate)	School	17.6%	20.0%	5.3%	53.8%	0.0%	50.0%	21.4%	46.7%	44.4%	18.8%
		District	22.0%	14.9%	19.5%	32.4%	12.0%	15.0%	21.1%	20.3%	27.4%	15.7%
		All Public	26.4%	22.5%	27.4%	29.9%	24.3%	23.4%	26.0%	23.4%	24.8%	27.7%
School Mark (all grades)	School Mean Score (%) (average for the year)	School	79.1%	77.8%	70.2%	81.8%	80.4%	78.1%	77.5%	82.1%	81.6%	79.2%
		District	77.4%	74.0%	74.0%	77.7%	79.6%	77.2%	76.8%	78.4%	80.5%	80.9%
		All Public	76.1%	76.5%	76.1%	76.3%	77.0%	76.8%	77.9%	78.2%	78.4%	78.1%
	School Pass Rate (%)	School	100.0%	100.0%	89.5%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		District	97.6%	96.5%	95.9%	97.9%	99.1%	97.5%	96.4%	96.9%	99.2%	98.4%
		All Public	94.7%	95.1%	94.8%	95.0%	95.4%	95.2%	95.8%	96.2%	96.3%	96.1%
	School 'A' Rate (%)	School	17.6%	30.0%	26.3%	46.2%	28.6%	43.8%	21.4%	46.7%	44.4%	33.3%
		District	36.5%	25.4%	28.5%	37.1%	38.5%	33.1%	31.8%	37.5%	48.3%	44.0%
		All Public	32.3%	33.1%	32.9%	33.6%	34.5%	35.2%	37.3%	38.6%	39.0%	38.3%
Final Mark (blended)	Final Mean Score (%) (average for the year)	School	76.4%	75.9%	69.7%	81.2%	76.9%	78.4%	74.3%	79.4%	79.3%	76.2%
		District	74.4%	71.4%	71.2%	76.0%	75.8%	73.5%	73.3%	74.0%	77.3%	76.9%
		All Public	74.4%	74.5%	74.9%	75.5%	75.1%	74.8%	75.5%	75.4%	76.5%	77.3%
	Final Pass Rate (%)	School	100.0%	100.0%	89.5%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		District	95.1%	94.7%	91.9%	95.7%	99.1%	96.9%	93.6%	95.3%	100.0%	99.2%
		All Public	95.0%	96.0%	95.1%	95.9%	96.0%	95.3%	95.9%	96.2%	97.3%	97.6%
	Final 'A' Rate (%)	School	17.6%	20.0%	10.5%	46.2%	28.6%	43.8%	21.4%	40.0%	44.4%	31.3%
		District	28.7%	16.7%	22.0%	33.1%	23.9%	21.4%	26.6%	28.1%	36.7%	25.6%
		All Public	29.2%	25.3%	28.7%	30.1%	27.0%	27.1%	30.1%	29.4%	30.7%	31.5%
Population Exam Pass Rate (Participation Rate X Exam Pass Rate)		School	17.3%	8.2%	13.3%	9.2%	5.5%	10.6%	8.6%	9.8%	5.2%	9.9%
		District	9.0%	8.5%	8.0%	10.0%	8.6%	9.9%	7.3%	8.1%	8.1%	8.4%
		All Public	11.4%	11.9%	12.8%	13.1%	13.1%	13.0%	13.2%	13.1%	13.4%	14.5%
Population Exam 'A' Rate (Participation Rate X Exam 'A' Rate)		School	3.1%	1.6%	0.8%	5.3%	0.0%	5.7%	2.3%	4.6%	2.6%	2.0%
		District	2.4%	1.5%	2.0%	3.5%	1.1%	1.7%	1.8%	1.9%	2.4%	1.4%
		All Public	3.6%	3.1%	4.1%	4.4%	3.6%	3.5%	3.9%	3.6%	3.7%	4.2%
Grade Point Average (GPA) of this Subject (A = 4; B = 3; C+ = 2.5; C = 2; C- = 1) **NOTE EXCLUSION OF 'F'**		School	2.97	2.75	2.59	3.27	3.14	3.03	2.64	3.13	3.11	2.94
		District	2.90	2.59	2.64	2.95	2.85	2.73	2.87	2.81	2.98	2.94
		All Public	2.90	2.82	2.88	2.91	2.86	2.85	2.89	2.88	2.94	2.99
Three year moving average of Final Mean Score		School	N/A	72.3%	73.5%	74.8%	74.8%	79.1%	76.6%	77.5%	77.5%	78.1%
		District	N/A	72.5%	72.3%	73.1%	74.4%	75.0%	74.1%	73.6%	74.9%	76.0%
		All Public	N/A	74.3%	74.6%	75.0%	75.2%	75.1%	75.1%	75.2%	75.8%	76.4%

NOTES

1. See Tab 1 for definitions of terms.

* District and All Public statistics include only Standard Public Schools. Excluded are Continuing Education, Distance Education, Alternate Schools, Youth custody/residential attendance centres, Provincial Resource Programs, Electronic Education and independent schools.

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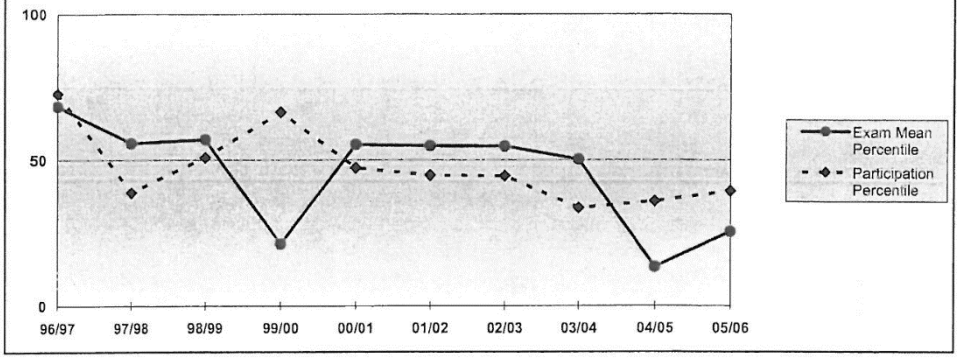
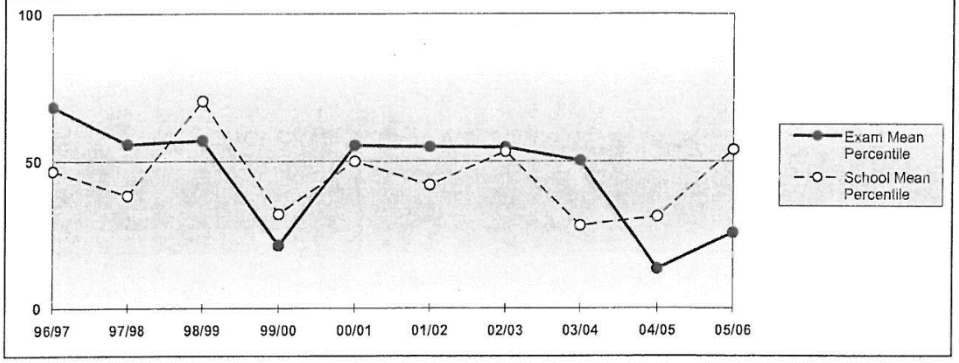
Chemistry 12

EXAM MEAN SCORE AND PARTICIPATION RATE* *Expressed as Percentiles*



	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Exam Mean Score (%)	72%	70%	68%	61%	73%	73%	72%	69%	60%	65%
Exam Mean Percentile	**68**	**56**	**57**	**21**	**55**	**55**	**55**	**50**	**13**	**26**
Participation Rate (%)	32%	20%	25%	29%	23%	22%	23%	19%	21%	21%
Participation Percentile	**73**	**39**	**51**	**66**	**47**	**45**	**45**	**34**	**36**	**39**
Number of students writing exam (all grade levels)	31	24	32	38	30	31	30	30	32	32
No. of schools used (standard public schools)	223	226	235	236	240	235	242	234	237	242

EXAM MEAN SCORE AND SCHOOL MEAN SCORE* *Expressed as Percentiles*



	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Exam Mean Score (%)	72%	70%	68%	61%	73%	73%	72%	69%	60%	65%
Exam Mean Percentile	**68**	**56**	**57**	**21**	**55**	**55**	**55**	**50**	**13**	**26**
School Mean Score (%)	75%	73%	78%	74%	76%	75%	77%	74%	74%	77%
School Mean Percentile	**47**	**38**	**70**	**32**	**50**	**42**	**53**	**28**	**31**	**54**
Number of students writing exam (all grade levels)	31	24	32	38	30	31	30	30	32	32
No. of schools used (standard public schools)	223	226	235	236	240	235	242	234	237	242

** See Tab 1 for definitions of terms.*
The percentiles shown above assume the data are from a normal distribution ('bell' curve) of Standard Public school scores.

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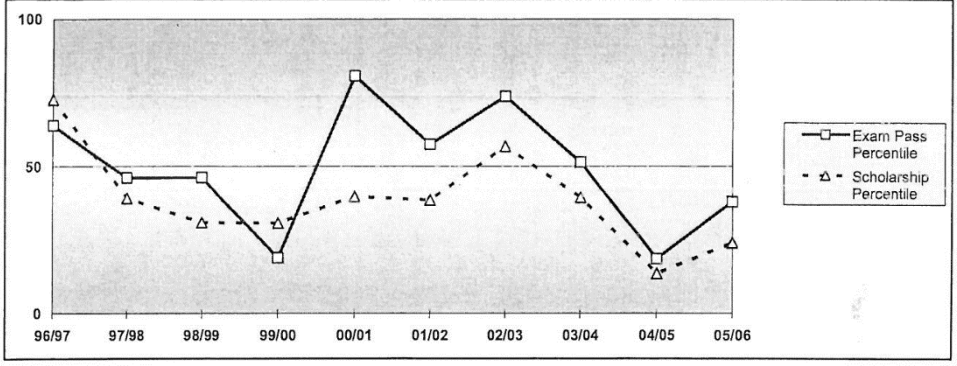
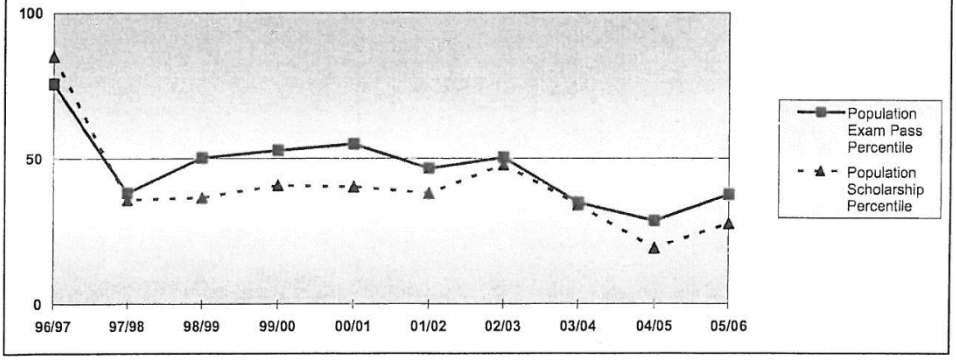
Chemistry 12

EXAM PASS RATE AND SCHOLARSHIP (A) RATE* ***Expressed as Percentiles***



	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Exam Pass Rate (%)	90%	83%	81%	71%	100%	90%	97%	87%	75%	88%
Exam Pass Percentile	**64**	**46**	**46**	**19**	**81**	**57**	**74**	**51**	**19**	**38**
Exam Scholarship (A) Rate (%)	29%	17%	13%	11%	20%	23%	27%	17%	3%	9%
Exam Scholarship Percentile	**73**	**39**	**31**	**31**	**40**	**39**	**57**	**39**	**14**	**24**
Number of students writing exam (all grade levels)	31	24	32	38	30	31	30	30	32	32
No. of schools used (standard public schools)	223	226	235	236	240	235	242	234	237	242

POPULATION EXAM PASS RATE AND SCHOLARSHIP (A) RATE* ***Expressed as Percentiles***



	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Population Exam Pass Rate (%)	29%	16%	20%	21%	23%	20%	23%	16%	15%	19%
Population Exam Pass Percentile	**76**	**38**	**50**	**53**	**55**	**47**	**50**	**35**	**29**	**38**
Population Exam Scholarship (A) Rate (%)	9.2%	3.3%	3.1%	3.1%	4.7%	5.0%	6.3%	3.2%	0.6%	2.0%
Population Exam Scholarship Percentile	**85**	**36**	**37**	**41**	**40**	**38**	**48**	**34**	**19**	**28**
Number of students writing exam (all grade levels)	31	24	32	38	30	31	30	30	32	32
No. of schools used (standard public schools)	223	226	235	236	240	235	242	234	237	242

** See Tab 1 for definitions of terms.*
The percentiles shown above assume the data are from a normal distribution ('bell' curve) of Standard Public school scores.

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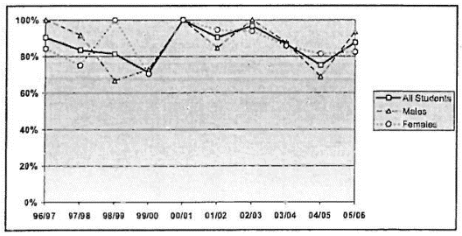
Chemistry 12

EXAM PASS RATE AND PARTICIPATION RATE

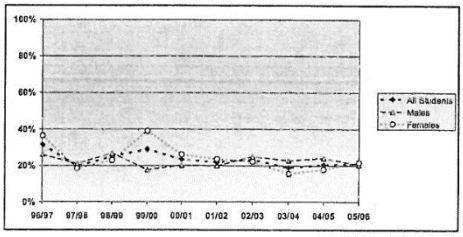
Selected Groups of Students Expressed as Percentages

GENDER

Pass Rate



Participation Rate



Pass Rate		96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Percentages for school	All Students	90%	83%	81%	71%	100%	90%	97%	87%	75%	88%
	Males	100%	92%	87%	73%	100%	85%	100%	88%	69%	93%
	Females	84%	75%	100%	70%	100%	94%	94%	86%	81%	82%
Writers in all grades	Males	12	12	16	11	12	13	14	16	16	15
	Females	19	12	14	27	16	16	16	14	16	17
B.C. Rates (public only)	All Students	86%	88%	85%	85%	91%	89%	90%	88%	90%	92%
	Males	85%	88%	85%	84%	90%	89%	89%	89%	89%	92%
	Females	86%	88%	86%	85%	91%	90%	90%	88%	90%	92%

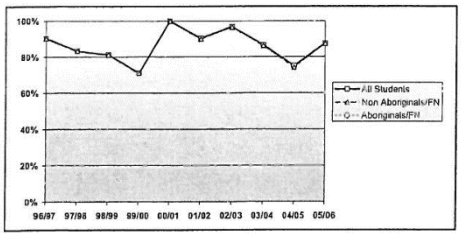
Pass Rate is the percentage of all students writing the exam awarded a Pass (C-) or higher.

Participation Rate		96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Percentages for school	All Students	32%	20%	25%	29%	23%	22%	23%	19%	21%	21%
	Males	26%	21%	27%	18%	20%	20%	25%	23%	24%	21%
	Females	37%	18%	23%	39%	26%	24%	22%	16%	18%	22%
Enrolment in Grade 12	Males	46	57	67	62	59	65	56	70	66	73
	Females	52	65	91	69	69	79	72	93	89	78
B.C. Rates (public only)	All Students	24%	24%	24%	24%	24%	24%	25%	25%	26%	25%
	Males	23%	23%	24%	24%	23%	23%	24%	25%	25%	25%
	Females	24%	25%	25%	24%	25%	24%	27%	26%	26%	26%

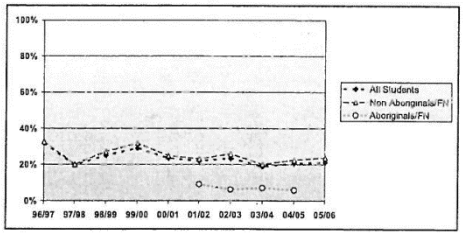
Participation Rate is the number of Grade 12 students writing the exam divided by Grade 12 enrolment.

ABORIGINAL/FIRST NATIONS STATUS

Pass Rate



Participation Rate



Pass Rate		96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Percentages for school	All Students	90%	83%	81%	71%	100%	90%	97%	87%	75%	88%
	Non Aboriginals/FN	90%	83%	81%	71%	100%	90%	97%	86%	74%	88%
	Aboriginals/FN	N/A	N/A	N/A	N/A	N/A	Mask	Mask	Mask	Mask	N/A
Writers in all grades	Non Aboriginals/FN	31	24	32	38	30	30	29	29	31	32
	Aboriginals/FN	0	0	0	0	0	1	1	1	1	0
B.C. Rates (public only)	All Students	86%	88%	85%	85%	91%	89%	90%	88%	90%	92%
	Non Aboriginals/FN	86%	88%	86%	85%	91%	89%	90%	89%	90%	92%
	Aboriginals/FN	82%	73%	69%	71%	78%	77%	79%	76%	81%	89%

Pass Rate is the percentage of all students writing the exam awarded a Pass (C-) or higher.

Participation Rate		96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Percentages for school	All Students	32%	20%	25%	29%	23%	22%	23%	19%	21%	21%
	Non Aboriginals/FN	33%	20%	27%	32%	25%	23%	26%	20%	22%	24%
	Aboriginals/FN	Mask	Mask	0%	0%	0%	9%	6%	7%	6%	0%
Enrolment in Grade 12	Non Aboriginals/FN	95	120	118	120	121	130	112	139	138	135
	Aboriginals/FN	3	2	10	11	7	11	16	14	17	16
B.C. Rates (public only)	All Students	24%	24%	24%	24%	24%	24%	25%	25%	26%	25%
	Non Aboriginals/FN	24%	25%	25%	25%	26%	25%	26%	26%	27%	27%
	Aboriginals/FN	6%	6%	6%	5%	6%	6%	7%	7%	7%	6%

Participation Rate is the number of Grade 12 students writing the exam divided by Grade 12 enrolment.

NOTES.
In the tables above, 'N/A' indicates that either no students were involved or no data are currently available. 'Mask' indicates that results have been suppressed (masked) to comply with the Freedom of Information and Protection of Privacy Act. This applies if there is less than 5 students writing the exam (Pass Rates) or less than 5 enrolled in Grade 12 (Participation Rates).
All data refer to Standard schools only. Continuing Education, Distance Education, Alternate schools, Electronic Schooling, etc. are excluded.

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Chemistry 12

DIAGNOSTICS TABLE*

Compulsory exam for this subject

			1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06
Number of students in Grade 12 (grade level enrolment of Subject)		School	98	122	128	131	128	141	128	153	155	151
		District	1,090	1,125	1,229	1,278	1,218	1,406	1,296	1,340	1,417	1,312
		All Public	43,857	45,957	46,317	47,763	47,406	48,493	47,962	46,022	46,463	47,650
Number of students writing the exam (Grade 12 only)		School	31	24	32	38	30	31	30	29	32	32
		District	199	209	225	274	246	257	253	238	287	254
		All Public	10,323	10,960	11,344	11,511	11,339	11,454	12,188	11,682	11,952	11,987
Exam Participation Rate (% of Subject grade level enrolment)		School	31.6%	19.7%	25.0%	29.0%	23.4%	22.0%	23.4%	19.0%	20.6%	21.2%
		District	18.3%	18.6%	18.3%	21.4%	20.2%	18.3%	19.5%	17.8%	20.3%	19.4%
		All Public	23.5%	23.8%	24.5%	24.1%	23.9%	23.6%	25.4%	25.4%	25.7%	25.2%
Exam Mark (all grades)	Exam Mean Score (%) (average for the year)	School	71.7%	70.5%	68.1%	61.1%	72.6%	72.5%	72.1%	69.0%	60.3%	65.0%
		District	69.7%	68.3%	67.2%	68.1%	69.3%	71.2%	71.1%	67.4%	68.4%	67.7%
		All Public	69.1%	71.4%	68.8%	68.8%	73.4%	73.7%	73.2%	70.9%	71.0%	72.0%
	Exam Pass Rate (%)	School	90.3%	83.3%	81.3%	71.1%	100.0%	90.3%	96.7%	86.7%	75.0%	87.5%
		District	87.3%	85.3%	84.4%	84.7%	87.4%	90.0%	91.0%	86.6%	86.8%	88.2%
		All Public	85.9%	88.0%	85.4%	84.8%	90.8%	89.2%	89.6%	88.3%	89.7%	92.2%
	Exam 'A' Rate (%) (Scholarship Rate)	School	29.0%	16.7%	12.5%	10.5%	20.0%	22.6%	26.7%	16.7%	3.1%	9.4%
		District	23.0%	14.7%	19.6%	18.5%	19.0%	23.9%	22.4%	15.5%	16.0%	15.0%
		All Public	22.6%	25.5%	22.6%	21.0%	28.2%	32.1%	28.7%	23.4%	23.6%	24.8%
School Mark (all grades)	School Mean Score (%) (average for the year)	School	75.0%	73.1%	78.1%	73.6%	75.9%	75.1%	76.9%	74.4%	74.5%	77.5%
		District	77.1%	77.3%	75.3%	77.6%	75.5%	77.8%	76.6%	77.1%	77.4%	80.8%
		All Public	75.5%	75.6%	75.6%	75.8%	76.2%	76.5%	77.2%	77.6%	77.8%	77.6%
	School Pass Rate (%)	School	96.8%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		District	96.1%	100.0%	95.2%	98.5%	96.8%	97.3%	98.1%	98.7%	98.3%	99.6%
		All Public	95.5%	95.4%	95.4%	95.5%	95.8%	95.8%	96.3%	96.5%	96.5%	96.2%
	School 'A' Rate (%)	School	32.3%	20.8%	31.3%	15.8%	16.7%	19.4%	23.3%	20.0%	25.0%	33.3%
		District	31.1%	30.7%	32.2%	32.2%	27.0%	30.5%	27.6%	28.0%	33.9%	43.5%
		All Public	28.2%	28.9%	29.2%	29.2%	30.1%	32.3%	33.6%	35.8%	35.5%	35.0%
Final Mark (blended)	Final Mean Score (%) (average for the year)	School	73.8%	72.0%	74.1%	68.6%	74.5%	74.1%	75.1%	72.2%	68.8%	72.3%
		District	74.3%	73.7%	72.7%	73.8%	73.1%	75.3%	74.5%	73.3%	73.9%	75.6%
		All Public	73.3%	74.4%	73.4%	73.5%	75.5%	75.8%	76.1%	75.3%	75.5%	75.8%
	Final Pass Rate (%)	School	96.8%	100.0%	100.0%	94.7%	100.0%	93.5%	96.7%	100.0%	96.9%	100.0%
		District	97.1%	98.1%	96.4%	95.6%	97.2%	95.0%	97.3%	97.1%	96.5%	98.0%
		All Public	95.2%	95.8%	95.3%	95.4%	96.8%	96.3%	96.6%	96.5%	97.1%	97.3%
	Final 'A' Rate (%)	School	32.3%	20.8%	18.8%	13.2%	16.7%	19.4%	30.0%	20.0%	9.4%	15.6%
		District	28.9%	19.0%	22.7%	24.9%	20.6%	27.1%	25.5%	19.2%	20.4%	25.2%
		All Public	25.1%	25.6%	23.8%	23.5%	27.8%	30.8%	29.8%	28.5%	26.9%	27.9%
Population Exam Pass Rate (Participation Rate X Exam Pass Rate)		School	28.6%	16.4%	20.3%	20.6%	23.4%	19.9%	22.7%	16.4% *	15.5%	18.5%
		District	15.9%	15.8%	15.5%	18.2%	17.7%	16.4%	17.8%	15.4%	17.6%	17.1%
		All Public	20.2%	21.0%	20.9%	20.4%	21.7%	21.1%	22.8%	22.4%	23.1%	23.2%
Population Exam 'A' Rate (Participation Rate X Exam 'A' Rate)		School	9.2%	3.3%	3.1%	3.1%	4.7%	5.0%	6.3%	3.2%	0.6%	2.0%
		District	4.2%	2.7%	3.6%	4.0%	3.8%	4.4%	4.4%	2.7%	3.2%	2.9%
		All Public	5.3%	6.1%	5.5%	5.1%	6.7%	7.6%	7.3%	5.9%	6.1%	6.2%
Grade Point Average (GPA) of this Subject (A = 4; B = 3; C+ = 2.5; C = 2; C- = 1) **NOTE EXCLUSION OF 'F'**		School	2.95	2.54	2.66	2.39	2.73	2.91	2.91	2.57	2.35	2.53
		District	2.87	2.70	2.66	2.78	2.67	2.93	2.81	2.70	2.74	2.85
		All Public	2.82	2.82	2.76	2.77	2.88	2.91	2.92	2.86	2.87	2.89
Three year moving average of Final Mean Score		School	N/A	72.9%	73.4%	71.3%	72.1%	72.1%	74.6%	73.8%	72.0%	71.1%
		District	N/A	74.2%	73.5%	73.4%	73.3%	74.1%	74.3%	74.4%	73.9%	74.3%
		All Public	N/A	74.0%	73.7%	73.8%	74.1%	75.0%	75.8%	75.7%	75.6%	75.5%

NOTES

1. See Tab 1 for definitions of terms.

* District and All Public statistics include only Standard Public Schools. Excluded are Continuing Education, Distance Education, Alternate Schools, Youth custody/residential attendance centres, Provincial Resource Programs, Electronic Education and independent schools.

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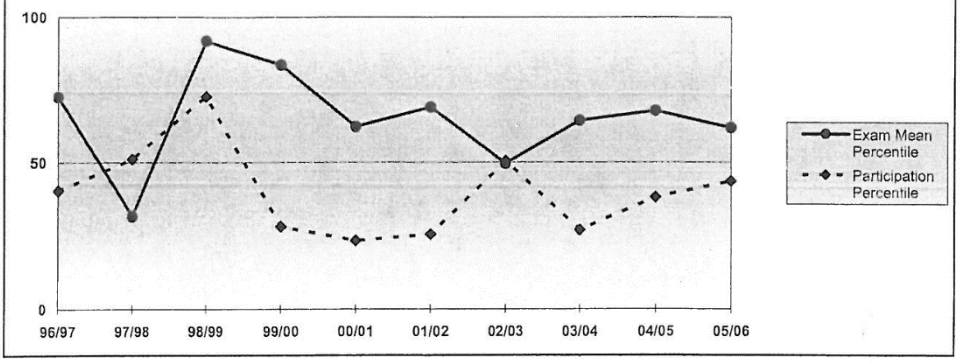
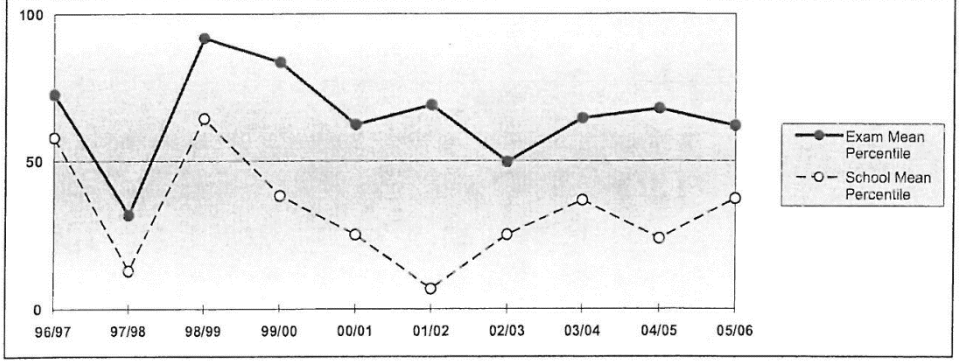
Biology 12

EXAM MEAN SCORE AND PARTICIPATION RATE* ***Expressed as Percentiles***



	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Exam Mean Score (%)	70%	60%	77%	74%	67%	69%	64%	69%	70%	70%
Exam Mean Percentile	**73**	**32**	**92**	**84**	**62**	**69**	**50**	**64**	**68**	**62**
Participation Rate (%)	28%	31%	38%	24%	23%	25%	35%	27%	31%	33%
Participation Percentile	**40**	**51**	**73**	**28**	**23**	**25**	**51**	**27**	**38**	**44**
Number of students writing exam (all grade levels)	27	38	49	33	29	35	46	41	48	51
No. of schools used (standard public schools)	235	238	243	247	247	251	245	244	247	258

EXAM MEAN SCORE AND SCHOOL MEAN SCORE* ***Expressed as Percentiles***



	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Exam Mean Score (%)	70%	60%	77%	74%	67%	69%	64%	69%	70%	70%
Exam Mean Percentile	**73**	**32**	**92**	**84**	**62**	**69**	**50**	**64**	**68**	**62**
School Mean Score (%)	74%	68%	76%	73%	71%	66%	70%	72%	71%	72%
School Mean Percentile	**58**	**13**	**64**	**38**	**25**	**7**	**25**	**37**	**24**	**37**
Number of students writing exam (all grade levels)	27	38	49	33	29	35	46	41	48	51
No. of schools used (standard public schools)	235	238	243	247	247	251	245	244	247	258

** See Tab 1 for definitions of terms.*
The percentiles shown above assume the data are from a normal distribution ('bell' curve) of Standard Public school scores.

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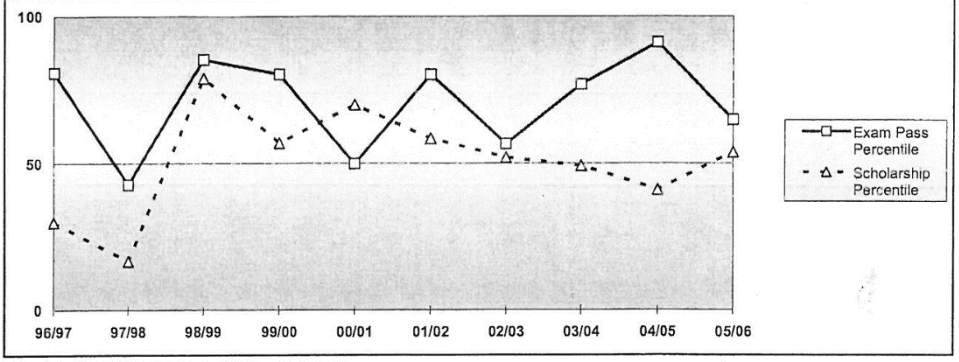
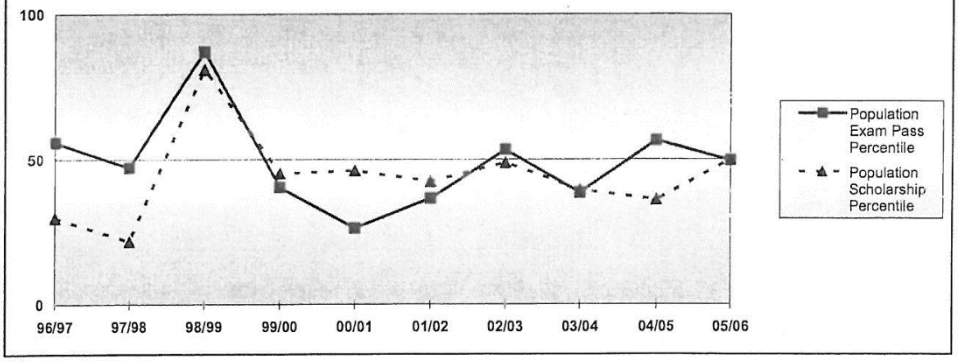
Biology 12

EXAM PASS RATE AND SCHOLARSHIP (A) RATE* *Expressed as Percentiles*



	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Exam Pass Rate (%)	96%	76%	98%	94%	76%	94%	80%	93%	100%	88%
Exam Pass Percentile	**81**	**43**	**85**	**80**	**50**	**80**	**57**	**77**	**91**	**65**
Exam Scholarship (A) Rate (%)	7%	3%	29%	18%	21%	20%	17%	20%	19%	22%
Exam Scholarship Percentile	**30**	**17**	**79**	**57**	**70**	**59**	**52**	**49**	**41**	**54**
Number of students writing exam (all grade levels)	27	38	49	33	29	35	46	41	48	51
No. of schools used (standard public schools)	235	238	243	247	247	251	245	244	247	258

POPULATION EXAM PASS RATE AND SCHOLARSHIP (A) RATE* *Expressed as Percentiles*



	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Population Exam Pass Rate (%)	27%	24%	37%	23%	17%	23%	28%	25%	31%	29%
Population Exam Pass Percentile	**56**	**47**	**87**	**40**	**26**	**36**	**53**	**38**	**57**	**50**
Population Exam Scholarship (A) Rate (%)	2.0%	0.8%	10.9%	4.4%	4.7%	5.0%	6.1%	5.2%	5.8%	7.1%
Population Exam Scholarship Percentile	**30**	**22**	**81**	**45**	**46**	**42**	**49**	**40**	**36**	**50**
Number of students writing exam (all grade levels)	27	38	49	33	29	35	46	41	48	51
No. of schools used (standard public schools)	235	238	243	247	247	251	245	244	247	258

** See Tab 1 for definitions of terms.*
The percentiles shown above assume the data are from a normal distribution ('bell' curve) of Standard Public school scores.

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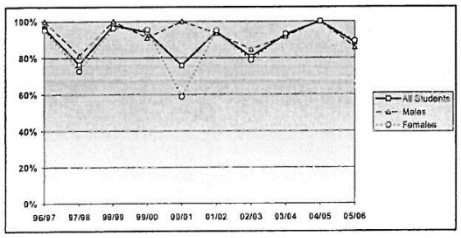
Biology 12

EXAM PASS RATE AND PARTICIPATION RATE

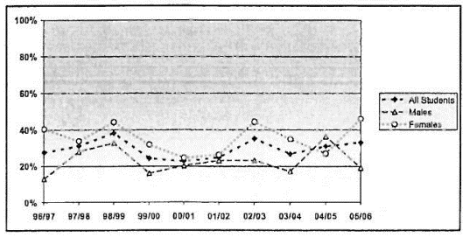
Selected Groups of Students Expressed as Percentages

GENDER

Pass Rate



Participation Rate



Pass Rate		96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Percentages for school	All Students	96%	76%	98%	94%	76%	94%	80%	93%	100%	88%
	Males	100%	81%	100%	91%	100%	93%	85%	92%	100%	86%
	Females	95%	73%	96%	95%	59%	95%	79%	93%	100%	89%
Writers in all grades	Males	8	16	22	11	12	15	13	12	24	14
	Females	21	22	27	22	17	20	33	29	24	37
B.C. Rates (public only)	All Students	83%	80%	79%	86%	77%	81%	79%	83%	83%	85%
	Males	84%	79%	79%	81%	78%	82%	79%	84%	83%	85%
	Females	83%	80%	80%	86%	77%	81%	79%	82%	83%	84%

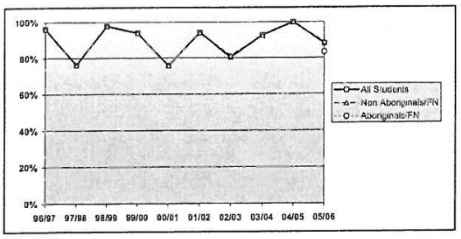
Pass Rate is the percentage of all students writing the exam awarded a Pass (C-) or higher.

Participation Rate		96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Percentages for school	All Students	28%	31%	38%	24%	23%	25%	35%	27%	31%	33%
	Males	13%	28%	33%	16%	20%	23%	23%	17%	36%	19%
	Females	40%	34%	44%	32%	25%	26%	44%	35%	27%	46%
Enrolment in Grade 12	Males	46	57	67	62	59	65	56	70	66	73
	Females	52	65	61	69	69	76	72	83	89	78
B.C. Rates (public only)	All Students	28%	29%	29%	30%	31%	32%	35%	34%	35%	34%
	Males	20%	20%	20%	21%	21%	21%	23%	23%	24%	24%
	Females	37%	38%	39%	40%	42%	44%	45%	45%	46%	45%

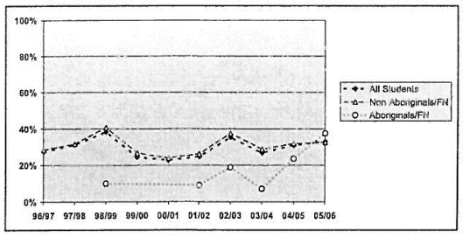
Participation Rate is the number of Grade 12 students writing the exam divided by Grade 12 enrolment.

ABORIGINAL/FIRST NATIONS STATUS

Pass Rate



Participation Rate



Pass Rate		96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Percentages for school	All Students	96%	76%	98%	94%	76%	94%	80%	93%	100%	88%
	Non Aboriginals/FN	96%	76%	98%	94%	76%	94%	81%	93%	100%	89%
	Aboriginals/FN	N/A	N/A	Mask	N/A	N/A	Mask	Mask	Mask	Mask	63%
Writers in all grades	Non Aboriginals/FN	27	38	48	33	29	34	43	40	44	45
	Aboriginals/FN	0	0	1	0	0	1	3	1	4	6
B.C. Rates (public only)	All Students	83%	80%	79%	86%	77%	81%	79%	83%	83%	85%
	Non Aboriginals/FN	83%	80%	80%	81%	78%	82%	79%	83%	83%	85%
	Aboriginals/FN	74%	65%	69%	72%	62%	69%	70%	70%	78%	74%

Pass Rate is the percentage of all students writing the exam awarded a Pass (C-) or higher.

Participation Rate		96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Percentages for school	All Students	28%	31%	38%	24%	23%	25%	35%	27%	31%	33%
	Non Aboriginals/FN	28%	32%	41%	27%	24%	26%	38%	29%	32%	33%
	Aboriginals/FN	Mask	Mask	10%	0%	8%	9%	19%	7%	24%	38%
Enrolment in Grade 12	Non Aboriginals/FN	95	120	118	120	121	130	112	139	138	135
	Aboriginals/FN	3	2	10	11	7	11	16	14	17	16
B.C. Rates (public only)	All Students	28%	29%	29%	30%	31%	32%	35%	34%	35%	34%
	Non Aboriginals/FN	29%	30%	30%	31%	32%	33%	36%	35%	35%	36%
	Aboriginals/FN	14%	14%	14%	14%	14%	15%	16%	16%	16%	16%

Participation Rate is the number of Grade 12 students writing the exam divided by Grade 12 enrolment.

NOTES.
In the tables above, 'N/A' indicates that either no students were involved or no data are currently available. 'Mask' indicates that results have been suppressed (masked) to comply with the Freedom of Information and Protection of Privacy Act. This applies if there is less than 5 students writing the exam (Pass Rates) or less than 5 enrolled in Grade 12 (Participation Rates).
All data refer to Standard schools only. Continuing Education, Distance Education, Alternate schools, Electronic Schooling, etc. are excluded.

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Biology 12

DIAGNOSTICS TABLE*

Compulsory exam for this subject

			1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06
Number of students in Grade 12 (grade level enrolment of Subject)		School	98	122	128	131	128	141	128	153	155	151
		District	1,090	1,125	1,229	1,278	1,218	1,406	1,296	1,340	1,417	1,312
		All Public	43,857	45,957	46,317	47,763	47,406	48,493	47,962	46,022	46,463	47,650
Number of students writing the exam (Grade 12 only)		School	27	38	49	32	29	35	45	41	48	50
		District	304	310	398	372	405	424	378	406	453	403
		All Public	12,404	13,296	13,614	14,446	14,736	15,744	16,600	15,496	16,107	16,340
Exam Participation Rate (% of Subject grade level enrolment)		School	27.6%	31.1%	38.3%	24.4%	22.7%	24.8%	35.2%	26.8%	31.0%	33.1%
		District	27.9%	27.6%	32.4%	29.1%	33.3%	30.2%	29.2%	30.3%	32.0%	30.7%
		All Public	28.3%	28.9%	29.4%	30.2%	31.1%	32.5%	34.6%	33.7%	34.7%	34.3%
Exam Mark (all grades)	Exam Mean Score (%) (average for the year)	School	69.5%	60.1%	77.1%	73.7%	66.7%	69.3%	64.3%	68.9%	70.4%	70.0%
		District	65.5%	65.2%	66.1%	67.8%	59.7%	63.0%	62.0%	64.4%	67.1%	65.9%
		All Public	65.6%	65.1%	65.6%	66.2%	65.1%	66.3%	65.3%	67.6%	68.2%	68.8%
	Exam Pass Rate (%)	School	96.3%	76.3%	98.0%	93.9%	75.9%	94.3%	80.4%	92.7%	100.0%	88.2%
		District	83.8%	83.3%	81.4%	83.0%	67.2%	73.6%	75.8%	79.6%	84.1%	80.0%
		All Public	83.2%	79.8%	79.5%	80.4%	77.2%	81.3%	78.9%	82.8%	82.9%	84.5%
	Exam 'A' Rate (%) (Scholarship Rate)	School	7.4%	2.6%	28.6%	18.2%	20.7%	20.0%	17.4%	19.5%	18.8%	21.6%
		District	13.3%	13.2%	17.6%	18.8%	11.7%	12.9%	14.1%	14.3%	21.8%	18.6%
		All Public	14.7%	16.2%	17.5%	16.6%	17.1%	18.7%	18.7%	22.7%	24.8%	22.2%
School Mark (all grades)	School Mean Score (%) (average for the year)	School	73.9%	67.6%	75.9%	72.8%	70.6%	66.2%	69.9%	72.3%	71.3%	72.2%
		District	73.3%	73.6%	73.3%	74.5%	71.8%	73.8%	73.0%	73.5%	75.1%	75.6%
		All Public	73.3%	73.6%	73.8%	74.1%	73.9%	74.0%	74.8%	75.3%	75.4%	75.0%
	School Pass Rate (%)	School	96.3%	94.7%	98.0%	93.9%	96.7%	86.1%	95.7%	97.6%	94.2%	96.0%
		District	93.7%	95.9%	95.2%	97.4%	93.6%	95.1%	95.6%	94.4%	95.9%	95.8%
		All Public	94.8%	95.0%	95.2%	95.6%	94.9%	94.7%	95.6%	95.9%	95.6%	95.4%
	School 'A' Rate (%)	School	14.8%	10.5%	18.4%	18.2%	26.7%	8.3%	15.2%	12.2%	17.3%	16.0%
		District	26.5%	25.7%	23.6%	26.2%	25.8%	29.9%	23.2%	24.3%	30.0%	29.2%
		All Public	24.2%	24.9%	24.9%	25.9%	26.2%	26.3%	28.0%	29.3%	29.6%	29.4%
Final Mark (blended)	Final Mean Score (%) (average for the year)	School	72.0%	64.7%	76.4%	73.2%	68.7%	67.9%	67.4%	71.0%	72.0%	71.5%
		District	70.7%	70.4%	70.4%	72.0%	67.3%	69.7%	68.7%	70.4%	72.4%	72.0%
		All Public	70.6%	70.6%	70.9%	71.3%	70.8%	71.4%	71.3%	72.6%	72.9%	73.0%
	Final Pass Rate (%)	School	96.3%	92.1%	100.0%	97.0%	96.6%	94.3%	91.1%	97.6%	100.0%	96.0%
		District	94.8%	93.9%	92.2%	94.9%	89.0%	92.3%	91.6%	93.1%	94.0%	94.3%
		All Public	95.0%	93.2%	93.9%	94.0%	93.1%	94.1%	93.6%	95.0%	94.9%	95.3%
	Final 'A' Rate (%)	School	14.8%	7.9%	22.4%	21.2%	20.7%	14.3%	13.3%	14.6%	12.5%	22.0%
		District	20.5%	16.4%	19.1%	21.8%	18.3%	19.9%	17.2%	16.1%	23.5%	22.6%
		All Public	19.8%	18.9%	19.8%	20.2%	20.1%	21.2%	22.0%	24.3%	25.7%	24.5%
Population Exam Pass Rate (Participation Rate X Exam Pass Rate)		School	26.5%	23.8%	37.5%	22.9%	17.2%	23.4%	28.3%	24.8%	31.0%	29.2%
		District	23.4%	22.9%	26.4%	24.2%	22.3%	22.2%	22.1%	24.1%	26.9%	24.6%
		All Public	23.5%	23.1%	23.4%	24.3%	24.0%	26.4%	27.3%	27.9%	28.7%	29.0%
Population Exam 'A' Rate (Participation Rate X Exam 'A' Rate)		School	2.0%	0.8%	10.9%	4.4%	4.7%	5.0%	6.1%	5.2%	5.8%	7.1%
		District	3.7%	3.6%	5.7%	5.5%	3.9%	3.9%	4.1%	4.3%	7.0%	5.7%
		All Public	4.2%	4.7%	5.2%	5.0%	5.3%	6.1%	6.5%	7.6%	8.6%	7.6%
Grade Point Average (GPA) of this Subject (A = 4; B = 3; C+ = 2.5; C = 2; C- = 1) **NOTE EXCLUSION OF 'F'**		School	2.75	2.10	2.89	2.75	2.39	2.32	2.28	2.50	2.52	2.65
		District	2.62	2.52	2.59	2.64	2.44	2.53	2.46	2.53	2.69	2.69
		All Public	2.61	2.58	2.59	2.62	2.60	2.62	2.63	2.69	2.72	2.73
Three year moving average of Final Mean Score		School	N/A	67.8%	71.5%	71.8%	73.5%	69.9%	67.9%	68.7%	70.1%	71.5%
		District	N/A	70.7%	70.5%	70.9%	69.9%	69.6%	68.6%	69.6%	70.6%	71.6%
		All Public	N/A	70.8%	70.7%	70.9%	71.0%	71.1%	71.2%	71.7%	72.3%	72.8%

NOTES

1 See Tab 1 for definitions of terms

* District and All Public statistics include only Standard Public Schools. Excluded are Continuing Education, Distance Education, Alternate Schools, Youth custody/residential attendance centres, Provincial Resource Programs, Electronic Education and independent schools.

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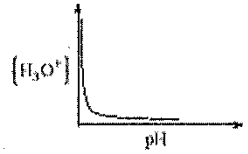
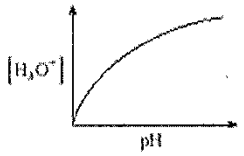
Appendix E – Teacher-Made Tests and Quizzes

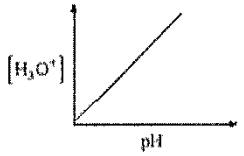
Chem 12
Dec 20/2013.

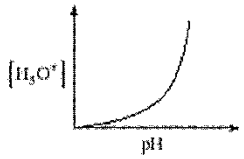
ACIDS, BASES AND SALTS CHAPTER TEST

1.) Which of the following graphs describes the relationship between $[H_3O^+]$and pH?

A.) 

B.) 

C.) 

D.) 

2.) When the $[H_3O^+]$ in a solution is increased to twice the original concentration, the change in pH could be from

A.) 5.0 to 2.5

B.) 1.7 to 1.4

C.) 8.5 to 6.5

D.) 2.0 to 4.0

3.) Consider the acid-base equilibrium shown. In the equilibrium,

$$H_2C_6H_5O_7^- + HPO_4^{2-} \rightleftarrows HC_6H_5O_7^{2-} + H_2PO_4^-$$

A.) products are favoured because $H_2PO_4^-$ is the weaker acid.

B.) reactants are favoured because $H_2C_6H_5O_7^-$ is the weaker acid.

C.) reactants are favoured because HPO_4^{2-} is the weaker acid.

D.) products are favoured because $HC_6H_5O_7^{2-}$ is the weaker acid.

4.) A sample of an unknown solution is tested with the indicator chlorophenol red. The solution turns yellow on the addition of this indicator. The solution could be

A.) 1.0 M NaCl

B.) 1.0 M Li_2SO_4

C.) 1.0 M KF

D.) 1.0 M NH_3NO_3

5.) Which of the following represents the reaction between MgO and H_2O?

A.) $2MgO + H_2O \rightarrow 2MgOH + \frac{1}{2}O_2$

B.) $MgO + H_2O \rightarrow Mg + H_2O_2$

C.) $MgO + H_2O \rightarrow MgH_2 + O_2$

D.) $MgO + H_2O \rightarrow Mg(OH)_2$

6.) What is the concentration of $Sr(OH)_2$ in a solution with a pH=11.00?

A.) 5.0×10^{-4} M

B.) 1.0×10^{-11} M

C.) 2.0×10^{-11} M

D.) 1.0×10^{-3} M

7.) The relationship shown is the

$$\frac{[H_2P_2O_7^{2-}][H_3O^+]}{[H_3P_2O_7^-]}$$

A.) K_a for $H_2P_2O_7^-$

B.) K_b for $H_3P_2O_7^-$

C.) K_a for $H_3P_2O_7^-$

D.) K_b for $H_2P_2O_7^-$

8.) Addition of HCl to water causes

A.) $[H_3O^+]$to decrease and $[OH^-]$to decrease.

B.) both $[H_3O^+]$and $[OH^-]$ to decrease.

C.) $[H_3O^+]$to increase and $[OH^-]$to decrease.

D.) both $[H_3O^+]$and $[OH^-]$ to increase.

9.) The net ionic equation for the hydrolysis of NH_4ClO_4 is

A.) $NH_4^+{}_{(aq)} + ClO_4^-{}_{(aq)} \rightleftarrows NH_{3(aq)} + HClO_{4(aq)}$

B.) $ClO_4^-{}_{(aq)} + H_2O_{(l)} \rightleftarrows HClO_{4(aq)} + OH^-{}_{(aq)}$

C.) $NH_4^+{}_{(aq)} + H_2O_{(l)} \rightleftarrows NH_{3(aq)} + H_3O^+{}_{(aq)}$

D.) $NH_4ClO_{4(s)} \rightleftarrows NH_4^+{}_{(aq)} + ClO_4^-{}_{(aq)}$

10.) What is the approximate K_a value for the indicator chlorophenol red?

A.) 1×10^{-8}

B.) 1×10^{-6}

C.) 1×10^{-14}

D.) 1×10^{-3}

11.) Which of the following represents the predominant reaction between HCO_3^- and water?

A.) $2HCO_3^- + H_2O \rightarrow H_3O^+ + CO_3^{2-} + OH^- + CO_2$

B.) $HCO_3^- + H_2O \rightarrow H_2CO_3 + OH^-$

C.) $HCO_3^- + H_2O \rightarrow H_3O^+ + CO_3^{2-}$

D.) $2HCO_3^- \rightarrow H_2O + 2CO_2$

12.) What is the pH of a 0.10 M $Sr(OH)_2$ solution?

A.) 0.70

B.) 13.00

C.) 13.30

D.) 1.00

13.) Which of the below is/are present in a reagent bottle labelled 1.0M H_2SO_4?

I.	H_2SO_4
II.	HSO_4^-
III.	SO_4^{2-}

A.) II and III only

B.) I, II and III

C.) I only

D.) I and II only

14.) The order of Bronsted-Lowry acids and bases in the reaction is

$$HC_2O_4^- + HSO_4^- \rightleftarrows H_2C_2O_4 + SO_4^{2-}$$

A.) acid, base, acid, base.

B.) base, acid, base, acid.

C.) base, acid, acid, base.

D.) acid, base, base, acid.

15.) The value of K_b for HCO_3^- is

A.) 4.3×10^{-7}

B.) 2.3×10^{-8}

C.) 5.6×10^{-11}

D.) 1.8×10^{-4}

16.) What will cause the value of K_w to change?

A.) adding OH^-

B.) adding a catalyst

C.) increasing the temperature

D.) decreasing the pH

17.) The equation representing the predominant reaction of sodium ethanoate, $NaCH_3COO$, with water is

A.) $CH_3COOH + H_2O \rightleftarrows CH_3COOH_2^+ + OH^-$

B.) $CH_3COO^- + H_2O \rightleftarrows H_3O^+ + CH_2COO^{2-}$

C.) $CH_3COO^- + H_2O \rightleftarrows CH_3COOH + OH^-$

D.) $CH_3COOH + H_2O \rightleftarrows H_3O^+ + CH_3COO^-$

18.) Which of the following 1.0M solutions would have a pH greater than 7.00?

A.) HCN

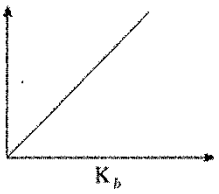
B.) KNO_3

C.) $NaCH_3COO$

D.) NH_4Cl

19.) Which of the following graphs describes the relationship between K_a and K_b for all conjugate pairs?

A.)



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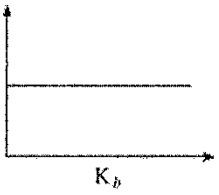

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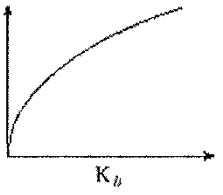
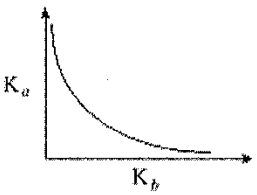


D.) 

20.) In order to change the pH of a solution from 2.0 to 4.0 to the $[H_3^+]$ must

A.) decrease by a factor of 2.

B.) decrease by a factor of 100.

C.) increase by a factor of 2.

D.) increase by a factor of 100.

21.) Identify the indicator that has a K_a of 1.6×10^{-7}?

A.) thymol blue

B.) methyl red

C.) bromthymol blue

D.) phenolphthalein

22.) What is the $[H_3O^+]$ at the transition point for an indicator with a K_a of 3.9×10^{-8}

A.) 2.6×10^{-7} M

B.) 3.9×10^{-8} M

C.) 1.0×10^{-7} M

D.) 1.0×10^{-14} M

23.) The conjugate acid of $HAsO_4^{2-}$ is

A.) H_3O^+

B.) H_3AsO_4

C.) $H_2AsO_4^-$

D.) AsO_4^{3-}

24.) The value of K_b for HPO_4^{2-} is

A.) 6.2×10^{-8}

B.) 1.6×10^{-7}

C.) 4.5×10^{-2}

D.) 2.2×10^{-13}

25.) The pH of normal rainwater is a result of the presence of dissolved

A.) NO_2

B.) SO_2

C.) CO_2

D.) ClO_2

26.) A buffer solution is formed by adding which of the following to water?

A.) NaBr and NaOH

B.) HCN and RbCN

C.) HNO_3 and $LiNO_3$

D.) HCl and KOH

27.) A buffer solution may contain equal moles of

A.) strong acid and its conjugate base.

B.) weak acid and its conjugate base.

C.) strong acid and strong base.

D.) weak acid and strong base.

28.) The relationship shown is the expression for

$$\frac{[H_3BO_3][OH^-]}{[H_2BO_3^-]}$$

A.) K_b for $H_2BO_3^-$

B.) K_a for H_3BO_3

C.) K_b for H_3BO_3

D.) K_a for $H_2BO_3^-$

29.) The predominant acid-base reaction between H_2O_22 and H_2O is

A.) $H_2O_22 + H_2O \rightarrow H_3O_2^+ + OH^-$

B.) $H_2O_22 + H_2O \rightarrow H_3O^+ + HO_2^-$

C.) $H_2O_22 + H_2O \rightarrow 3OH^- + H^+$

D.) $H_2O_22 + H_2O \rightarrow 2H_2O + O^{2-}$

30.) The value of K_b for HSO_3^- is

A.) 1.5×10^{-2}

B.) 1.5×10^{-13}

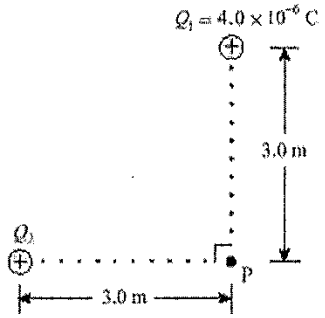
C.) 6.7×10^{-13}

D.) 1.0×10^{-7}

Physics 12
Feb 21/2014

ELECTROSTATICS QUIZ

1.) The magnitude of the net electric field at P in the diagram below is 5.0×10^3 N/C. Find the magnitude of charge Q_2.



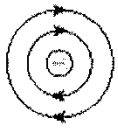
A.) 6.4×10^{-6} C
B.) 3.0×10^{-6} C
C.) 1.0×10^{-5} C
D.) 1.0×10^{-6} C

2.) Which pair of values will cause the greatest deflection of an electron beam in a cathod ray tube?

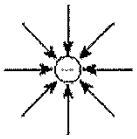
A.) 400 V Accelerating; 40 V Deflection (Plate)
B.) 800 V Accelerating; 20 V Deflection (Plate)
C.) 800 V Accelerating; 40 V Deflection (Plate)
D.) 400 V Accelerating; 20 V Deflection (Plate)

3.) Which diagram shows the electric field near a negative point charge?

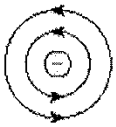
A.)

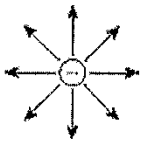


B.)



C.)



D.) 

4.) Which of the following best describes how electric potential varies with distance in the region around a point charge?

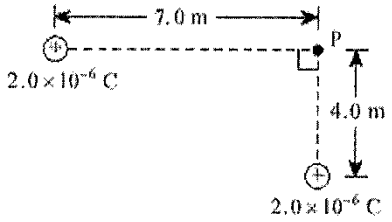
A.) $V \propto \frac{1}{r}$

B.) $V \propto r^2$

C.) $V \propto r$

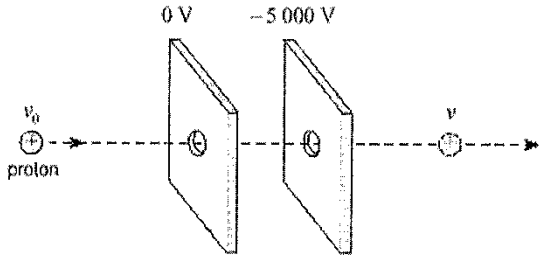
D.) $V \propto \frac{1}{r^2}$

5.) What is the electric potential at point P due to the two fixed charges as shown?



A.) 7 100 V
B.) 5 200 V
C.) 1 200 V
D.) 1 500 V

6.) A moving proton has 6.4 x 10^{-16} J of kinetic energy. The proton is accelerated by a potential difference of 5 000 V between parallel plates. The proton emerges from the parallel plates with what speed?



A.) 1.3 x 10^6 m/s
B.) 8.8 x 10^5 m/s

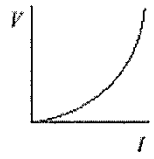
C.) 9.8×10^5 m/s

D.) 1.8×10^6 m/s

7.) Which of the following graphs illustrates Ohm's law?

A.)

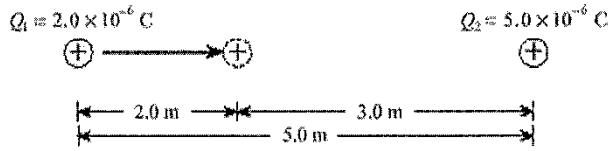
B.)



C.)

D.)

8.) Charge Q_1 is located 5.0 m from charge Q_2 as shown. How much work must be done to move charge Q_1 2.0 m closer to charge Q_2?



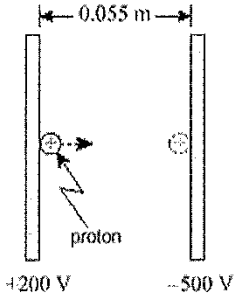
A.) 1.1×10^{-2} J

B.) 2.0×10^{-2} J

C.) 7.2×10^{-3} J

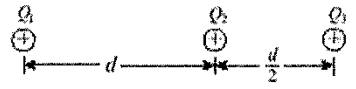
D.) 1.2×10^{-2} J

9.) A proton initially at rest is accelerated between parallel plates through a potential difference of 700 V. What is the maximum speed reached by the proton?



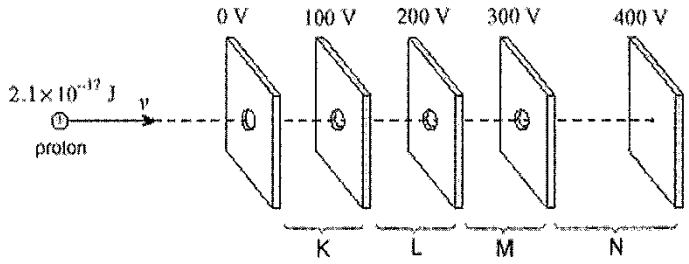
A.) 3.1 x 10^5 m/s
B.) 8.6 x 10^4 m/s
C.) 1.6 x 10^6 m/s
D.) 3.7 x 10^5 m/s

10.) Three identical positive electric charges are fixed as shown in the diagram. What is the direction of the net electric force on Q_2 due to Q_1 and Q_3?



A.) the net force is zero
B.) cannot be determined
C.) to the left
D.) to the right

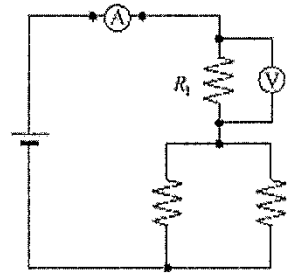
11.) A proton with kinetic energy of 2.1 x 10^{-17} J is moving into a region of charged parallel plates. The proton will be stopped momentarily in what region?



A.) Region K
B.) Region N
C.) Region L
D.) Region M

12.) Which one of the following shows the correct placement of an ammeter and a voltmeter to determine the power output of resistor R_1?

A.)



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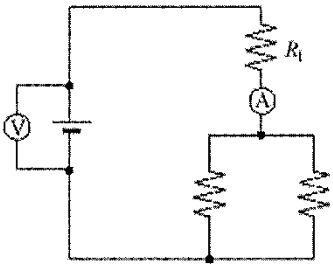
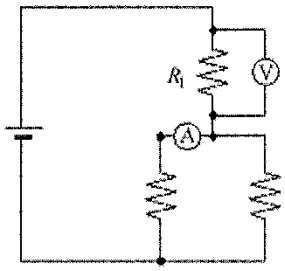
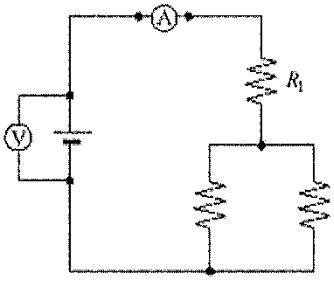


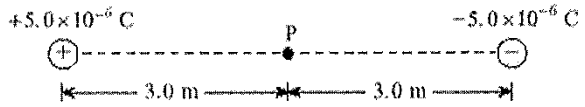
C.)



D.)



13.) What are the magnitudes of the electric field and the electric potential at point *P* midway between the two fixed charges?

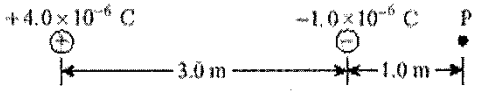


A.) Field: 10 000 N/C; Potential: 0 V
B.) Field: 0 N/C; Potential: 30 000 V
C.) Field: 0 N/C; Potential: 0 V
D.) Field: 10 000 N/C; Potential: 30 000 V

14.) In a cathode ray tube

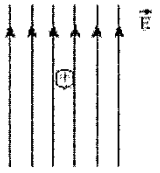
A.) protons are accelerated from anode (positive) to cathode (negative).
B.) electrons are accelerated from cathode (negative) to anode (positive).
C.) electrons are accelerated from anode (positive) to cathode (negative).
D.) protons are accelerated from cathode (negative) to anode (positive).

15.) What is the magnitude and direction of the electric field at point P due to the two fixed charges?



A.) Magnitude: 11 000 N/C; Direction: left
B.) Magnitude: 6 800 N/C; Direction: right
C.) Magnitude: 6 800 N/C; Direction: left
D.) Magnitude: 11 000 N/C; Direction: right

16.) In an experiment, a positively charged oil droplet weighing 6.5×10^{-15} N is held stationary by a vertical electric field as shown in the diagram. If the electric field strength is 5.3×10^{3} N/C, what is the charge on the oil droplet?



A.) 1.2×10^{-18} C
B.) 3.4×10^{-11} C
C.) 4.1×10^{4} C
D.) 8.2×10^{17} C

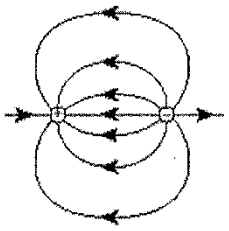
17.) An electron orbits the nucleus of an atom with velocity *v*. If this electron were to orbit the same nucleus with twice the previous orbital radius, its orbital velocity would now be

A.) v
B.) $\frac{v}{\sqrt{2}}$
C.) $2v$

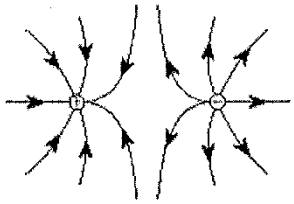
D.) $\frac{v}{2}$

18.) Which of the following diagrams shows the electric field between two equal but opposite charges?

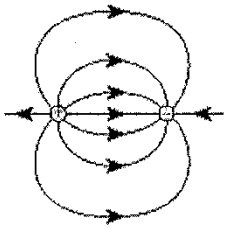
A.)



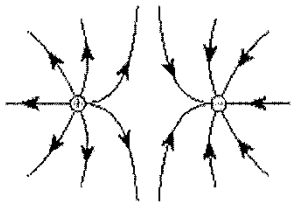
B.)



C.)



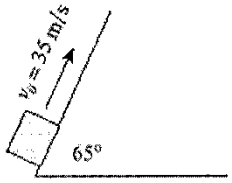
D.)



Physics D
April 8th 2014

VECTORS QUIZ

1) An object is fired up a frictionless ramp as shown in the diagram. If the initial velocity is 35 m/s, how long does the object take to return to the starting point?



A.) 7.9 s
B.) 17 s
C.) 3.9 s
D.) 3.6 s

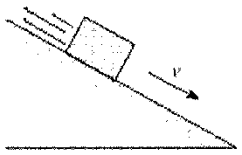
2.) A ball is thrown vertical upward at 20 m/s from a height of 30 m above the ground. What is its speed on impact with the ground below?

A.) 44 m/s
B.) 31 m/s
C.) 24 m/s
D.) 14 m/s

3.) A projectile is launched at 35.0° above the horizontal with an initial velocity of 120 m/s. What is the projectile's speed 3.00 s later?

A.) 106 m/s
B.) 120 m/s
C.) 68.8 m/s
D.) 98.3 m/s

4.) An object is sliding down an inclined plane at a constant speed. Which of the following represents the free-body diagram for the object?



A.)

B.)

C.)

D.)

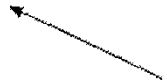
5.) A car travelling north at 20 m/s is later travelling west at 30 m/s. What is the direction of the change in velocity?

A.)

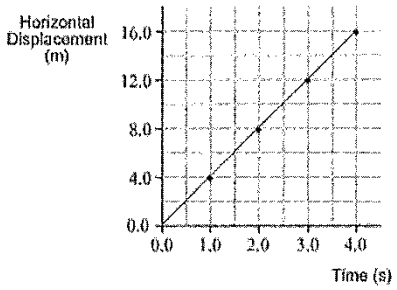
B.)

C.)

D.)

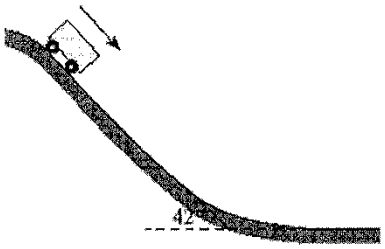


7.) A projectile is fired into the air at some angle above the horizontal. The horizontal displacement of the projectile is measured against time in flight and the collected data is shown as a horizontal displacement versus time graph. Based on this graph, the horizontal velocity of the projectile during this time interval is



A.) constant.
B.) increasing.
C.) equal to zero.
D.) decreasing.

8.) What is the acceleration of the roller coaster car in the diagram below? Ignore friction.



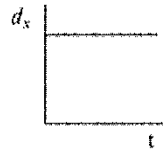
A.) 8.8 m/s²
B.) 6.6 m/s²
C.) 7.3 m/s²
D.) Depends on car's mass.

9.) A 16 kg object is dropped from a height of 25 m and strikes the ground with a speed of 18 m/s. How much heat energy was produced during the fall?

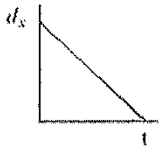
A.) 2 600 J
B.) 3 900 J
C.) 0 J
D.) 1 300 J

10.) Which of the following graphs best illustrates the horizontal displacement of a projectile as a function of time? Ignore friction.

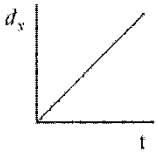
A.)



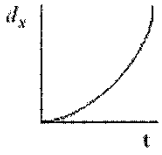
B.)



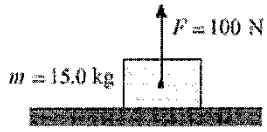
C.)



D.)

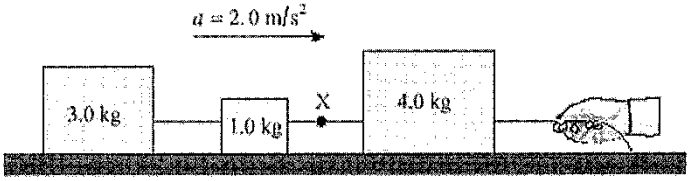


11.) A 15 kg block on horizontal surface has a 100 N force acting on it as shown. What is the normal force?



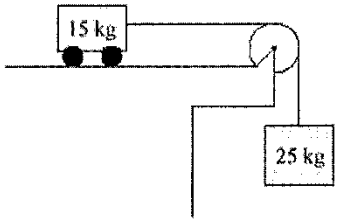
A.) 47 N
B.) 247 N
C.) 147 N
D.) 100 N

12.) The system of blocks on a frictionless surface in the diagram below is accelerating at 2.0 m/s². What is the tension in the cord at X?



A.) 8.0 N
B.) 16 N
C.) 2.0 N
D.) 6.0 N

13.) A 15 kg cart is attached to a hanging 25 kg mass. Friction is negligible. What is the acceleration of the 15 kg cart?



A.) 6.1 m/s^2
B.) 2.5 m/s^2
C.) 6.5 m/s^2
D.) 16 m/s^2

14.) Which of the following is true for projectile motion? (Ignore friction)

A.) Horizontal Component: changing velocity
Vertical Component: constant velocity

B.) Horizontal Component: changing velocity
Vertical Component: changing velocity

C.) Horizontal Component: constant velocity
Vertical Component: changing velocity

D.) Horizontal Component: constant velocity
Vertical Component: constant velocity

15.) An 810 kg dragster is being decelerated by a parachute at 2.5 m/s^2 as shown in the diagram. What is the tension in the cord at this moment?

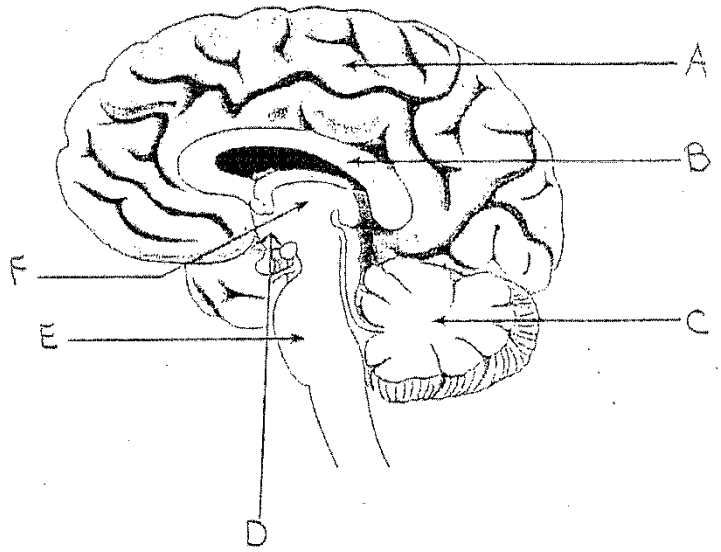
A.) 0 N
B.) 7.9 x 10^3 N
C.) 2.0 x 10^3 N
D.) 5.9 x 10^3 N

Biology B
Dec 20 2013

NERVOUS SYSTEM TEST

Multiple Choice
Identify the choice that best completes the statement or answers the question.

Use the diagram below to answer the following questions



1. Which part of the brain is responsible for increasing breathing rate during exercise?
   a. A b. B c. C d. E e. F

2. Which two areas of the brain regulate the responses of the autonomic nervous system?
   a. A and B b. D and E c. A and C d. A and D e. E and F

3. Which structure sorts incoming information and channels it to the appropriate part of the brain?
   a. B b. C c. D d. E e. F

4. Studying for an exam would produce high activity in which structure?
   a. A b. C c. D d. E e. F

5. Performing a gymnastics routine would produce high activity in which structure?
   a. A b. C c. D d. E e. F

6. If a person's ability to integrates information from both hemispheres of the brain is impaired, the portion of the brain most likely affected is
   a. A b. B c. D d. E e. F

7. Which part of the brain functions to maintain a blood pressure of 120/80?
   a. A b. B c. C d. D e. E

8. The part of the brain responsible for balance is
   a. A b. C c. D d. E e. F

9. After surgery to remove a brain tumor, a person suffers from poor appetite, alternating chills and fever, and difficulty in maintaining water balance and blood pressure. Memory and muscle control are normal. Which part of the brain is MOST likely affected?
   a. A b. C c. D d. E e. F

10. Which of the following indicates the part of the brain containing reflex centers for swallowing and vomiting?
    a. A b. B c. C d. D e. E

11. Structure A is the
    a. corpus callosum
    b. cerebrum
    c. cerebellum
    d. medulla oblongata
    e. hypothalamus

12. Structure B is the
    a. thalamus
    b. cerebrum
    c. cerebellum
    d. hypothalamus
    e. corpus callosum

13. Structure C is the
    a. cerebellum
    b. cerebrum
    c. hypothalamus
    d. corpus callosum
    e. medulla oblongata

14. Structure D is the
    a. cerebrum
    b. hypothalamus
    c. medulla oblongata
    d. thalamus
    e. cerebellum

15. Structure E is the
    a. cerebrum
    b. cerebellum
    c. medulla oblongata
    d. thalamus
    e. hypothalamus

16. Structure F is the
    a. hypothalamus
    b. corpus callosum
    c. cerebellum
    d. medulla oblongata
    e. thalamus

17. The function of structure B is to
    a. control the breathing and heart rates
    b. secrete hormones that control organs in the body
    c. channel nerve impulses to the appropriate part of the brain
    d. exchange information between right and left portions of the brain

18. The portion of the brain involved in speech, vision, learning, and memory is structure
    a. A b. B c. D d. E

19. Which labelled structure is responsible for smooth and coordinated body movement in the body?
    a. A b. C c. E d. F

20. Which of the following is a function of structure E?
    a. solving a math problem
    b. sweating to cool the body on a hot day
    c. waking up to music from an alarm clock
    d. sneezing when an irritant enters the nose

21. Which structure controls the release of hormones from the pituitary gland?
    a. B b. D c. E d. F

22. An inablility to maintain balance and walk in a smooth, graceful manner could indicate damage to which structure?
    a. A b. B c. C d. D

23. Which of the following activities accompanies high activity in structure C?
    a. sleeping
    b. swallowing
    c. studying for an exam
    d. performing a gymnastics routine

24. Damage to structure E would result in
    a. hearing loss
    b. impaired growth
    c. breathing difficulty
    d. loss of coordination

25. A person recovering from a head injury finds that she has difficulty maintaining balance. Which part of the brain has been injured?
    a. thalamus
    b. cerebellum
    c. hypothalamus
    d. medulla oblongata

26. Reflex actions, such as sneezing and vomitting, are controlled by which region?
    a. A b. B c. C d. E

27. Which structure is responsible for helping maintain body temperature at 37°C?
    a. B b. C c. D d. F

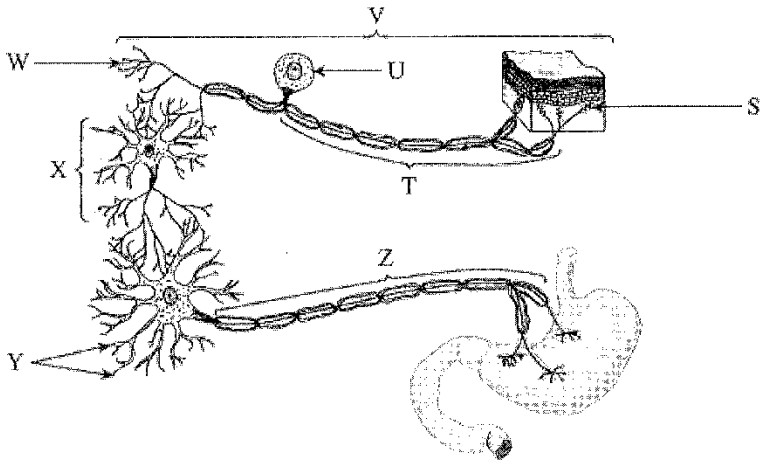
28. If damage to the brain leads to difficulties in voluntary muscle response and speech, what area of the brain is most likely affected?
    a. A b. D c. E d. C

29. Which of the following are functions of structureD?
    a. to regulate heart rate and breathing rate
    b. to control temperature and water balance
    c. to control muscle co-ordination and balance
    d. to integrate sensory information and act as a relay station

30. Which part of the brain is responsible for memory and thinking?
    a. A b. B c. C d. D

31. Structure E contains centers responsible for
    a. hunger b. heart rate c. water balance d. body temperature

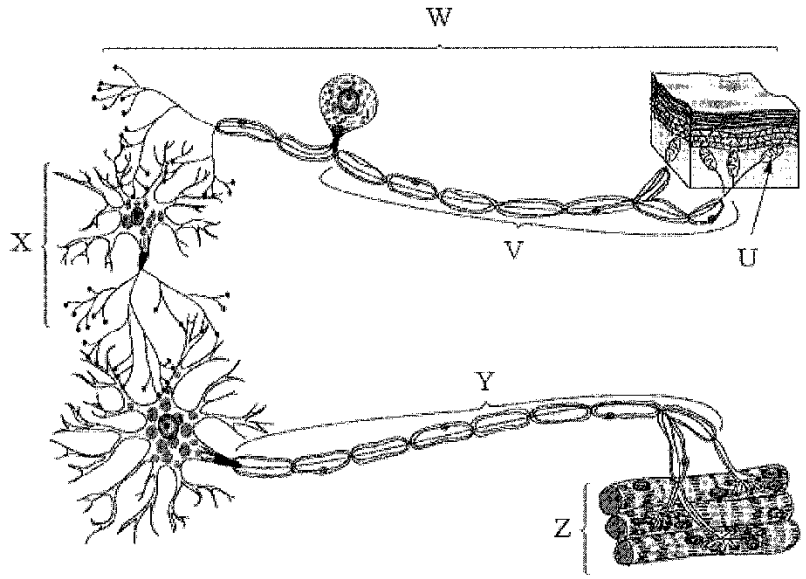
Use the diagram below to answer the following question



32. Which letter indicates the interneuron?
    a. V b. X c. Y d. Z

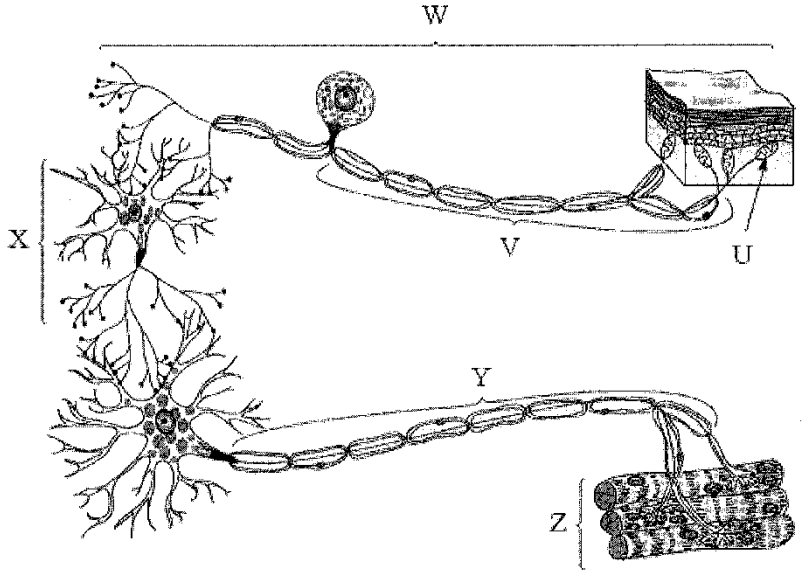
33. Which structure carries impulses away from the central nervous sytem?
    a. U b. V c. W d. Z

34. In the diagram below, which letter indicates the sensory receptor?



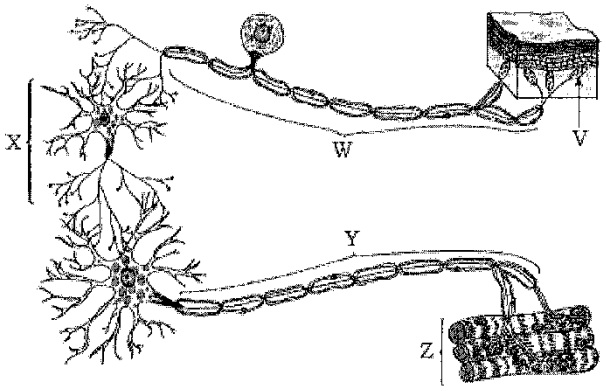
a. T b. U c. V d. W e. Y

35. In the diagram below, what is the function of structure Z?



a. to detect the stimulus
b. to carry an impulse to the interneuron
c. to carry the stimulus to the motor neuron
d. to carry out the response to a stimulus

36. In the diagram below, the motor nerve is structure



a. V b. W c. X d. Y e. Z

37. Which of the following is controlled by the somatic nervous system?
    a. rate of heartbeat
    b. contraction of skeletal muscle
    c. increased blood flow to muscle tissue
    d. movement of food through the intestines
    e. breathing rate

38. Which of the following would be considered part of the peripheral nervous system?
    a. an interneuron
    b. the hypothalamus
    c. a sympathetic nerve
    d. the brain and spinal cord

39. Which of the following would increase the heart rate?
    a. corpus callosum
    b. somatic nervous system
    c. sympathetic nervous system
    d. parasympathetic nervous system

40. The sympathetic nervous system would be most active while a person is
    a. digesting a large meal
    b. in an athletic competition
    c. recovering from an illness
    d. writing biology definitions

41. What type of neuron transmits an impulse to the central nervous system?
    a. motor b. sensory c. efferent d. interneuron

42. What is the pathway of an impulse in a reflex arc?
    a. from the brain to the interneuron, then to the sensory neuron
    b. from the motor neuron to the brain, then to the sensory neuron
    c. from the motor neuron to the interneuron, then to the sensory neuron
    d. from the sensory neuron to the interneuron, then to the motor neuron

43. What is the first component of a reflex arc?
    a. a muscle
    b. a motor neuron
    c. a sensory neuron
    d. a sensory receptor

44. What structure carries impulses towards the central nervous system?
    a. the effector
    b. the interneuron
    c. the motor neuron
    d. the sensory neuron

45. The central nervous sytem includes the
    a. brain and spinal cord
    b. somatic nervous system
    c. cranial and spinal nerves
    d. parasympathetic nervous system

46. The hormone that initiates the "fight or flight" response is produced by the
    a. adrenal gland
    b. hypothalamus
    c. pituitary gland
    d. medulla oblongata

47. The source gland for adrenalin is the
    a. pancreas
    b. adrenal cortex
    c. adrenal gland
    d. posterior pituitary

48. What structure in the brain regulates the heartbeat and contains reflex centers for swallowing?
    a. the thalamus
    b. the cerebellum
    c. the corpus callosum
    d. the medulla oblongata

49. The sympathetic nervous system is responsible for
    a. decreasing breathing rate
    b. increasing blood glucose levels
    c. increasing blood flow to the intestines
    d. decreasing blood flow to skeletal muscles

50. Damage to the corpus callosum could
    a. stimulate the parasympathetic system
    b. increase the heart rate but decrease the breathing rate
    c. inhibit the hypothalamus and stimulate the thyroid gland
    d. inhibit the sharing of information between cerebral hemispheres

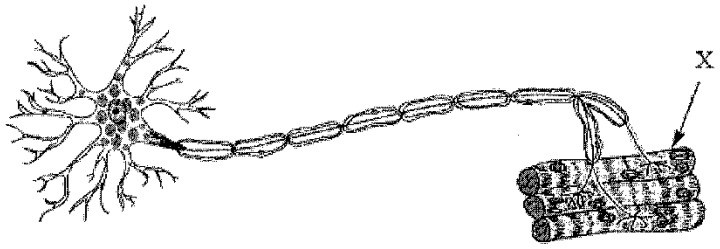
51. Which of the following is involved in the "fight or flight" response?
    a. thyroid gland
    b. prostate gland
    c. adrenal gland
    d. Cowper's gland

52. Which of the following is a function of the hormone produced by the adrenal gland?
    a. to increase the heart rate
    b. to decrease the blood pressure
    c. to stimulate the actions of the digestive system
    d. to stimulate the parasympathetic nervous system

53. What is the advantage of reflex arcs?
    a. they stop the sensation of pain in the brain
    b. they provide a quick response to a stimulus
    c. they take place independently of any nerve function
    d. they allow us to think about an appropriate response to a stimulus

54. What type of cells carry information to the central nervous system?
    a. receptors b. interneurons c. motor neurons d. sensory neurons

55. The structure labelled X represents a(n)

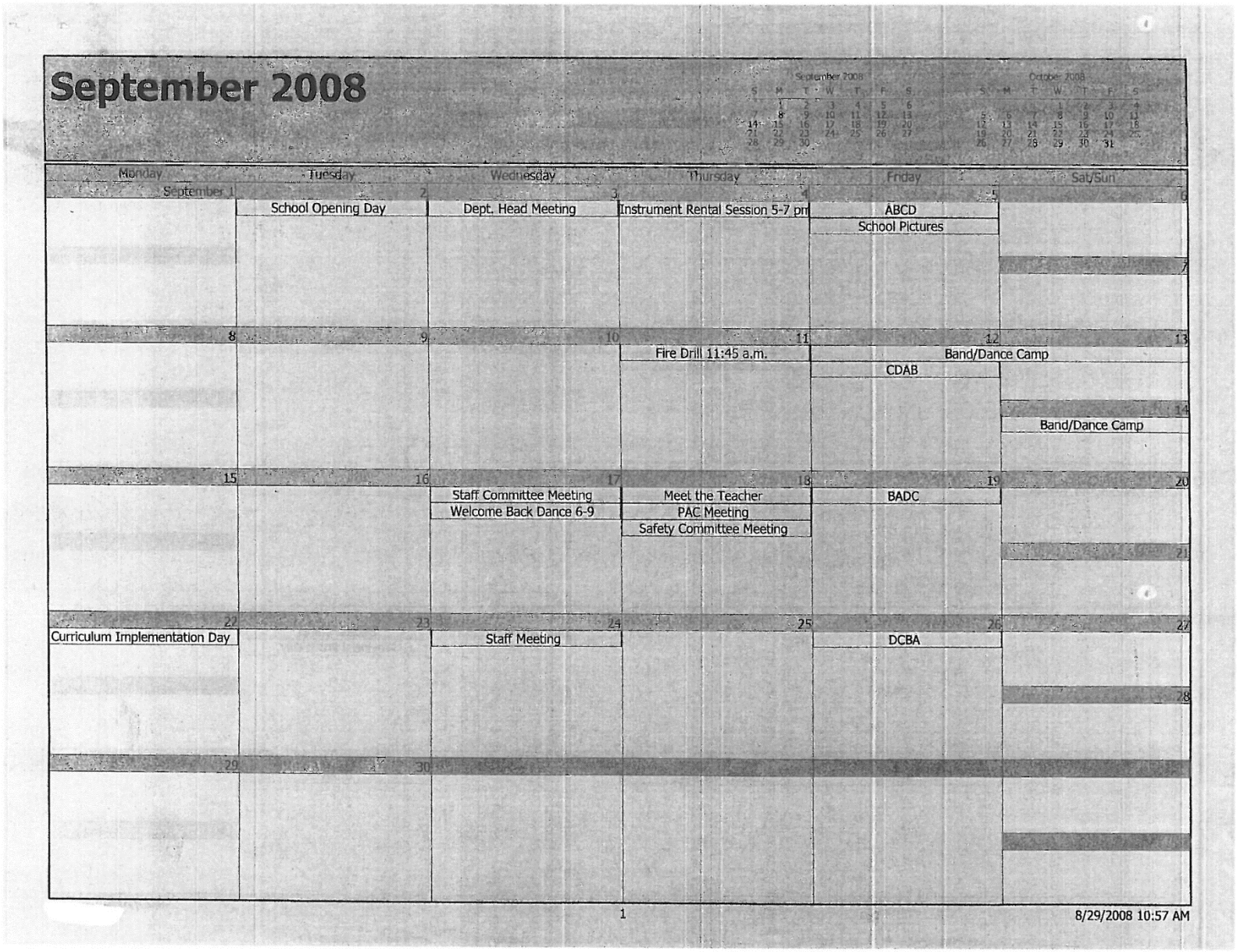


    a. effector b. receptor c. interneuron d. sensory neuron

56. Which of the following would result from stimulation by the sympathetic nervous system?
    a. low blood pressure
    b. constricted pupils
    c. decreased digestive rate
    d. reduced blood flow to skeletal muscles

57. Which of the following would inhibit the contraction of muscles which move food through the digestive system?
    a. cerebellum
    b. somatic nervous system
    c. parasympathetic nervous system
    d. sympathetic nervous system

Appendix F – School Calendars


September 2008
September 2008
October 2008
Monday
Tuesday
Wednesday
Thursday
Friday
Sat/Sun
September 1
School Opening Day
Dept. Head Meeting
Instrument Rental Session 5-7 pm
ABCD
School Pictures
Fire Drill 11:45 a.m.
Band/Dance Camp
CDAB
Band/Dance Camp
Staff Committee Meeting
Welcome Back Dance 6-9
Meet the Teacher
PAC Meeting
Safety Committee Meeting
BADC
Curriculum Implementation Day
Staff Meeting
DCBA
1
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October 2008

October 2008

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

November 2008

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

Monday	Tuesday	Wednesday	Thursday	Friday	Sat/Sun
		October 1 Dept. Head Meeting	2	3 ABCD	4 5
6	7	8 Earthquake Drill 11:30 Interim Day	9 Parent Interviews 2-3 pm	10 CDAB	11 12
13 Thanksgiving Day Holiday	14	15 Make-up Monday Staff Committee Meeting	16 Concert Series Safety Committee Meeting	17 BADC	18 19
20	21	22	23 Improv Camp	24 Improv Camp Provincial Pro-D Day	25 Improv Camp 26
27	28 PAC Meeting	29 Staff Meeting	30	31 DCBA	

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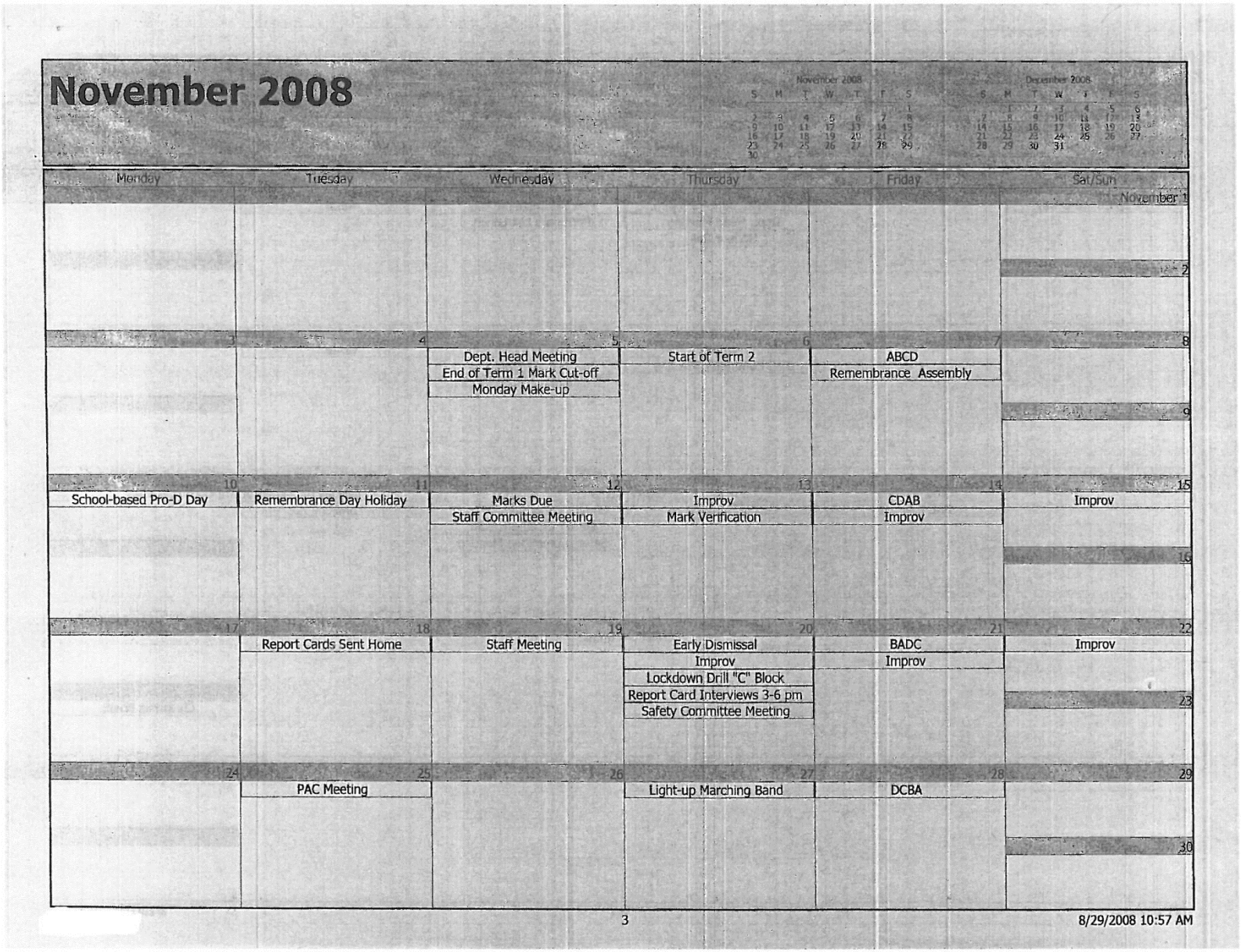
November 2008
November 2008
December 2008
Monday
Tuesday
Wednesday
Thursday
Friday
Sat/Sun
November 1
2
3
4
5
Dept. Head Meeting
End of Term 1 Mark Cut-off
Monday Make-up
6
Start of Term 2
7
ABCD
Remembrance Assembly
8
9
10
School-based Pro-D Day
11
Remembrance Day Holiday
12
Marks Due
Staff Committee Meeting
13
Improv
Mark Verification
14
CDAB
Improv
15
Improv
16
17
18
Report Cards Sent Home
19
Staff Meeting
20
Early Dismissal
Improv
Lockdown Drill "C" Block
Report Card Interviews 3-6 pm
Safety Committee Meeting
21
BADC
Improv
22
Improv
23
24
25
PAC Meeting
26
27
Light-up Marching Band
28
DCBA
29
30
3
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December 2008

December 2008

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

January 2009

S	M	T	W	T	F	S
					2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

Monday	Tuesday	Wednesday	Thursday	Friday	Sat/Sun
December 1	2	3	4	5	6
School-based Pro-D Day		Christmas Dance 6-9 p.m. Dept. Head Meeting Honour Roll	Post Sec Instiitute Day Principal's List Lunch	ABCD	7
8	9	10	11	12	13
		LPS Christmas Concert Staff Committee Meeting	9:00 a.m. to 11:00 a.m. Post Sec. Institute Day Seminars for Gr. 11 & 12	CDAB	14
15	16	17	18	19	20
	Grad Pictures PAC Meeting	Grad Pictures Staff Meeting	Christmas Concert 7:00pm Locker Clean-out 1:30 Safety Committee Meeting	Last Day of Classes before Christmas Break BADC	21
22	23	24	25	26	27
Christmas Break					28 Christmas Break
29	30	31			
Christmas Break					

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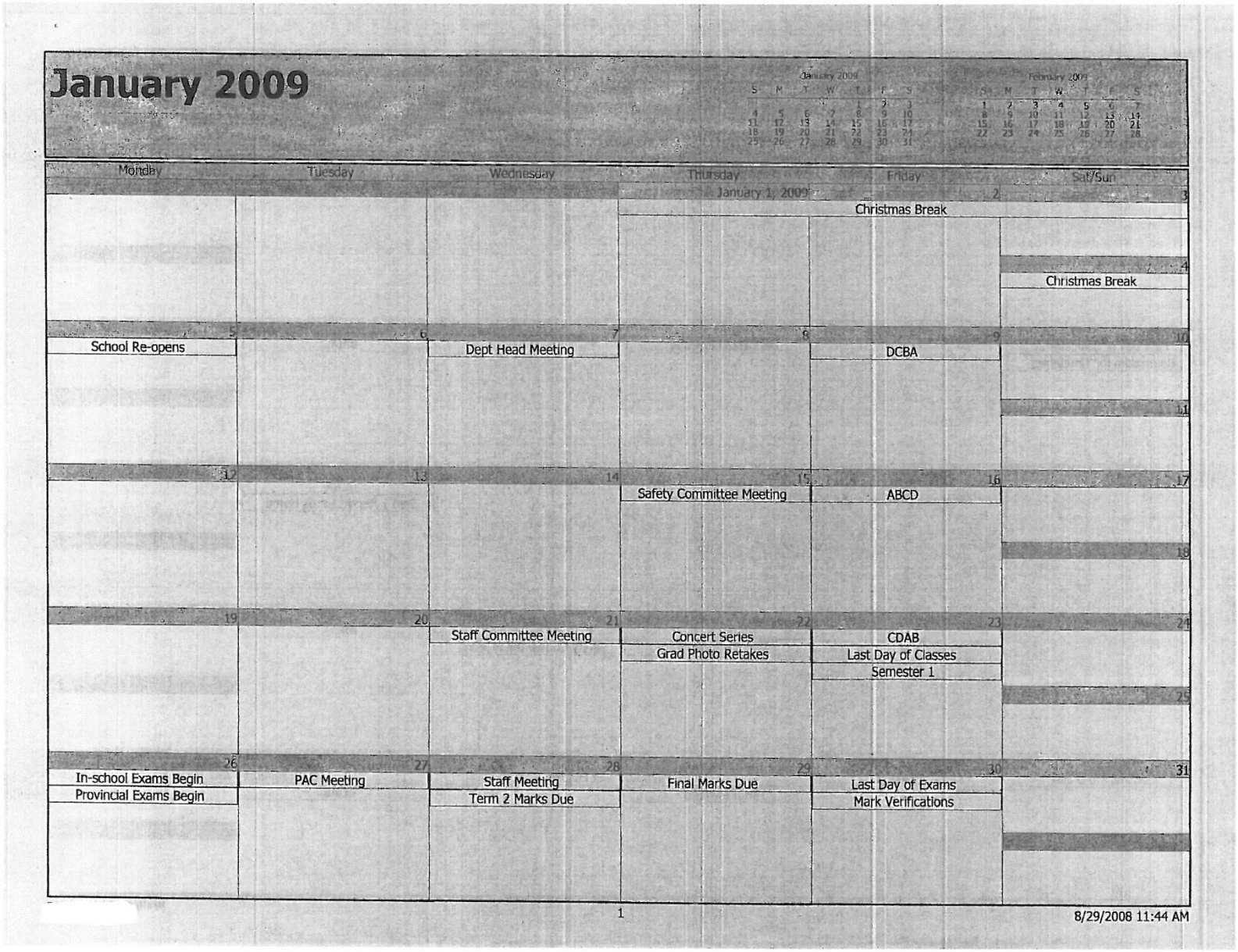

January 2009
Monday
Tuesday
Wednesday
Thursday
Friday
Sat/Sun
January 1, 2009
Christmas Break
Christmas Break
School Re-opens
Dept Head Meeting
DCBA
Safety Committee Meeting
ABCD
Staff Committee Meeting
Concert Series
Grad Photo Retakes
CDAB
Last Day of Classes
Semester 1
In-school Exams Begin
Provincial Exams Begin
PAC Meeting
Staff Meeting
Term 2 Marks Due
Final Marks Due
Last Day of Exams
Mark Verifications
1
8/29/2008 11:44 AM

February 2009

February 2009

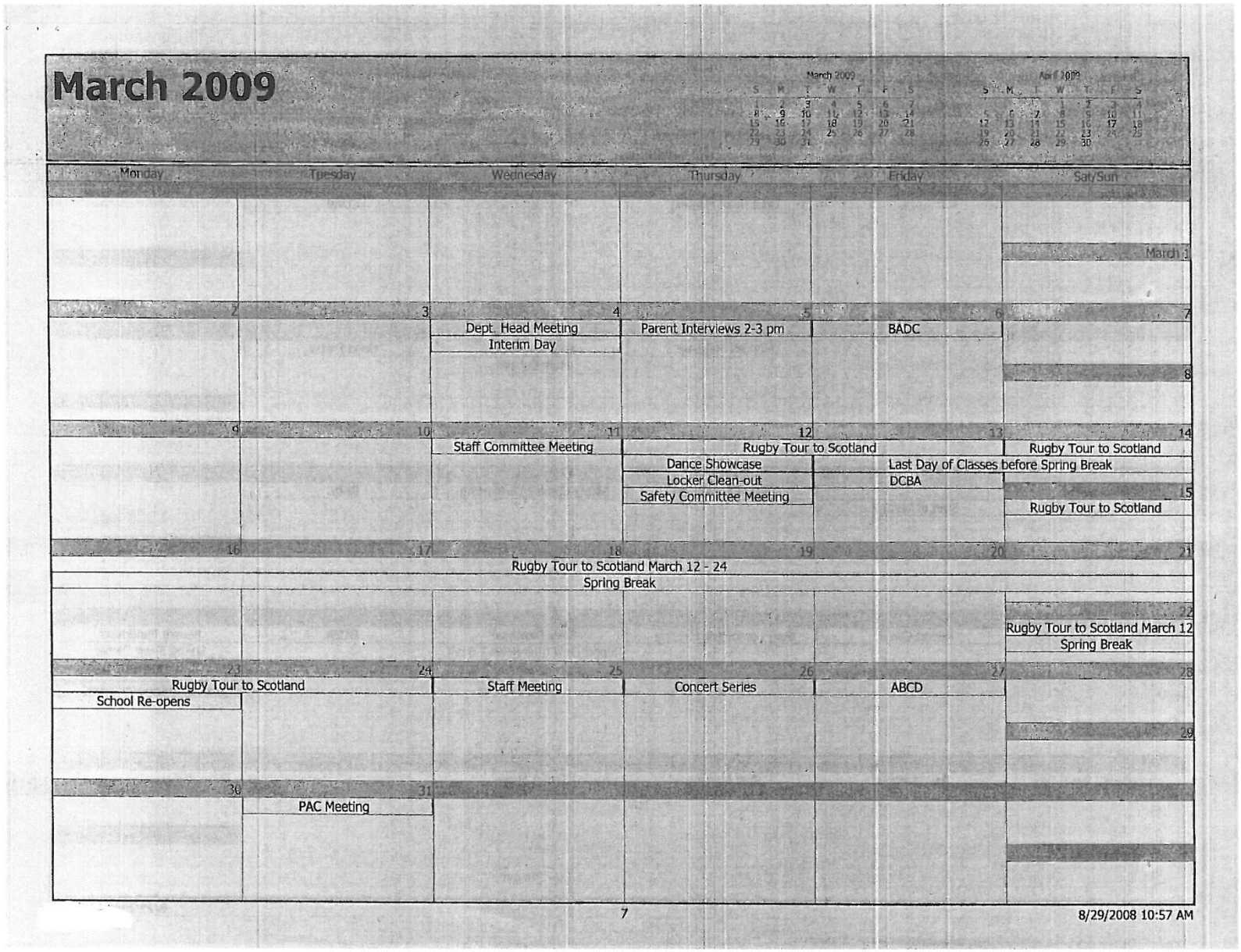
S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28

March 2009

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Monday	Tuesday	Wednesday	Thursday	Friday	Sat/Sun
					February 1
2 First Day of Semester 2 Homeroom for Timetables	3	4 Dept Head Meeting	5	6 BADC	7 8
9	10	11	12	13 DCBA Sem 1 Report Cards Home	14 15
16	17	18 Honour Roll Staff Committee	19 Principal's List Lunch Safety Committee Meeting	20 ABCD	21 22
23 District Pro-D Day	24 PAC Meeting	25 Lionel Hampton Jazz Festival Staff Meeting	26	27 Lionel Hampton Jazz Festival CDAB	28

8/29/2008 10:57 AM


March 2009
March 2009
April 2009
Monday
Tuesday
Wednesday
Thursday
Friday
Sat/Sun
March 1
2
3
4
Dept. Head Meeting
Interim Day
5
Parent Interviews 2-3 pm
6
BADC
7
8
9
10
11
Staff Committee Meeting
12
Rugby Tour to Scotland
Dance Showcase
Locker Clean-out
Safety Committee Meeting
13
Last Day of Classes before Spring Break
DCBA
14
Rugby Tour to Scotland
15
Rugby Tour to Scotland
16
17
18
19
20
21
Rugby Tour to Scotland March 12 - 24
Spring Break
22
Rugby Tour to Scotland March 12
Spring Break
23
Rugby Tour to Scotland
School Re-opens
24
25
Staff Meeting
26
Concert Series
27
ABCD
28
29
30
31
PAC Meeting
7
8/29/2008 10:57 AM

April 2009

April 2009

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

May 2009

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

Monday	Tuesday	Wednesday	Thursday	Friday	Sat/Sun
		April 1 Dept Head Meeting	2	CDAB	4 5
6	7	8 Monday Make-up	9 End of Term 1 Mark Cut-off	10 Good Friday	11 12
13 Easter Monday	14 Start of Term 2	15 Term 4 Marks Due	16 Safety Committee Meeting	17 BADC	18 19
20 Fire Drill during this week	21 Report Cards	22 Staff Committee Meeting	23 Ealry Dismissal Report Card Interviews 3-6 pm	24 DCBA	25 Benefit Fundraiser Spring Show Dinner 26
27 School-based Pro-D Day	28 PAC Meeting	29 Staff Meeting	30 Spring Show		

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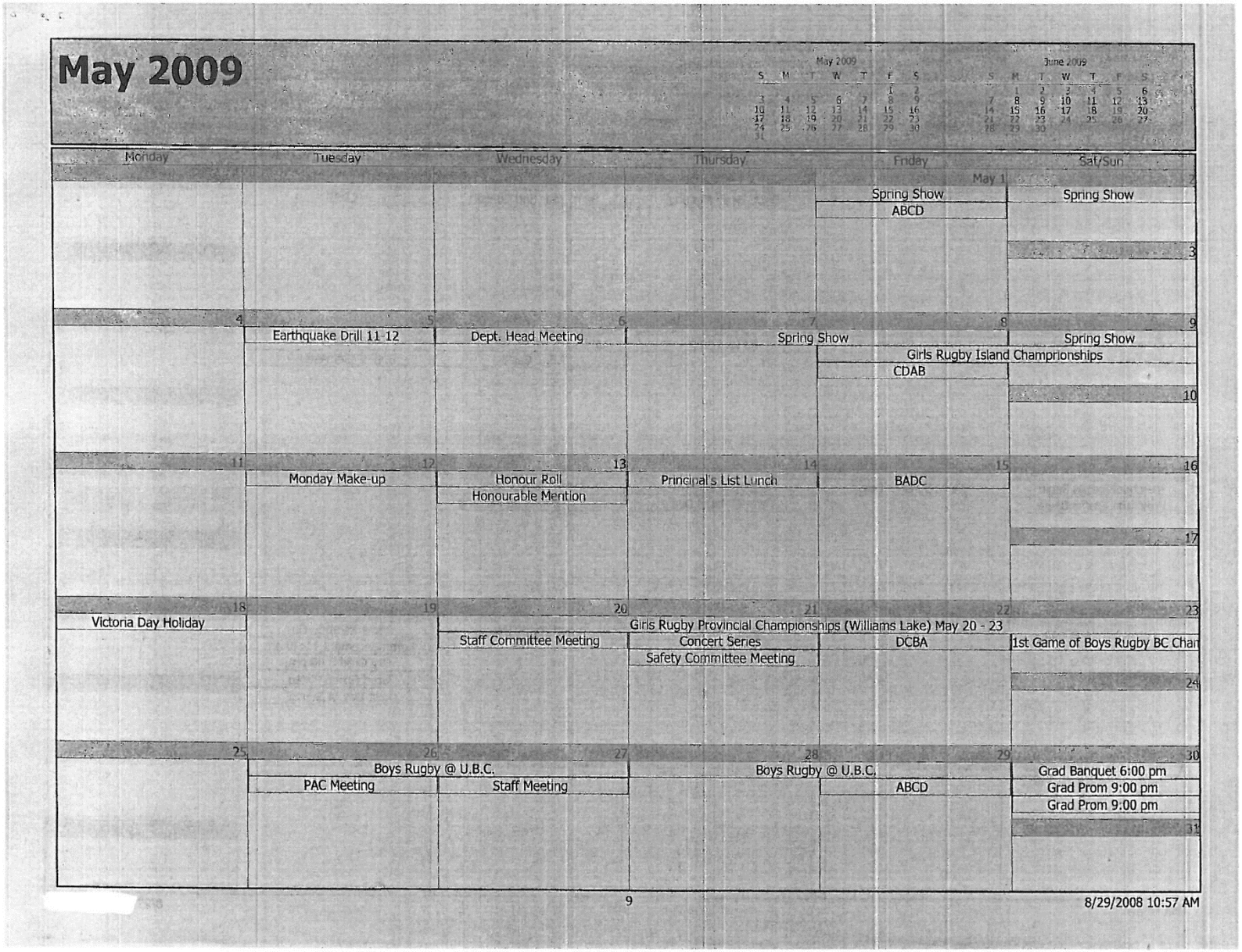
May 2009
May 2009
June 2009
Monday
Tuesday
Wednesday
Thursday
Friday
Sat/Sun
May 1
Spring Show
ABCD
Spring Show
3
4
5
Earthquake Drill 11-12
6
Dept. Head Meeting
7
Spring Show
8
Girls Rugby Island Champrionships
CDAB
Spring Show
9
10
11
12
Monday Make-up
13
Honour Roll
Honourable Mention
14
Principal's List Lunch
15
BADC
16
17
18
Victoria Day Holiday
19
20
Staff Committee Meeting
21
Girls Rugby Provincial Championships (Williams Lake) May 20 - 23
Concert Series
Safety Committee Meeting
22
DCBA
23
1st Game of Boys Rugby BC Chan
24
25
26
Boys Rugby @ U.B.C.
PAC Meeting
27
Staff Meeting
28
Boys Rugby @ U.B.C.
29
ABCD
30
Grad Banquet 6:00 pm
Grad Prom 9:00 pm
Grad Prom 9:00 pm
31
9
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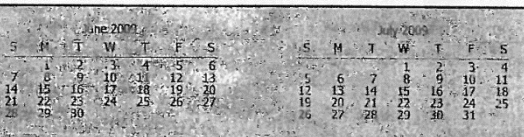
June 2009



Monday	Tuesday	Wednesday	Thursday	Friday	Sat/Sun
June 1	2	3 Dept. Head Meeting	4 Band Year End Concert	5 CDAB	6 7
8	9 S.F.L. Camp	10 S.F.L. Camp	11 Fun Day & Locker Clean-out S.F.L. Camp	12 BADC End of Semester 2	13 14
15 In-school Exams Begin Provincial Exams Begin	16 Term 5 Marks Due	17 Staff Committee Term 6 Marks Due	18 Mark Verifications Safety Committee Meeting	19	20 21
22 Promotion Meetings	23	24 Staff Meeting	25 Report Cards Issued	26 Administration Day Commencement 11:30 am Dry Grad 8:00 pm Grad Group Photo Last Day of School	27 28
29	30				

8/29/2008 10:57 AM

September 2009

Sun	Mon	Tue	Wed	Thu	Fri	Sat
		1	2	3	4	5
6	7	8 Schools Open Grade 8 Welcome day 11—3 for Gr. 8 11-12 for Gr. 9-11 11:20—12 for Gr. 12	9 Department Head Musical Instrumment rental 5-7	10 School Photos Student ID Photos in multipurpose room	11 ABCD	12 Music Kick-off Car Wash
13	14	15 Improv Starts Jazz Band Starts PAC Meeting	16 Staff Committee Meeting	17 Safety Committee Meeting Gr. 8 Meet the Teacher	18 Band at Camp Quanoes CDAB	19
20 Band at Camp Qwanoes	21	22	23	24	25 BADC	26
27	28 Curriculum Implementation Day	29	30 Gr 8 Time D-after lunch Staff Meeting			

October 2009

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				1	2 *DCBA*	3
4	5	6	7 Department Head Interim Day	8 Parent Interviews 2-3 pm	9 ABCD	10
11	12 Thanksgiving	13 Photo retakes—MPR Grade 9 boys & girls Immunization 9:00 am Library	14 Staff Committee	15 Safety Committee	16 CDAB	17 Grad Garage Sale
18	19	20 PAC Meeting	21	22 Symphony Field Trip	23 Non-instructional Day	24
25	26	27	28 Staff Meeting	29	30 Impov Camp BADC	31 Olympic Torch

November 2009

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1 Improv Camp	2	3	4 Gr8 Time 2nd D Department Head	5 Gr 8 Time Pizza /Study Social	6 DCBA	7
8	9	10 End of Term 1 Mark Cut-off Remembrance Day Assembly	11 Remembrance Day	12 Start of Term 2	13 Improv Variety Marks Due ABCD	14 Shows 7pm
15	16	17 Mark Verification PAC Meeting	18 Staff Meeting Staff Committee (to follow)	19 Safety Committee	20 Improv Variety Report Cards Printed CDAB	21 Shows 7pm
22	23	24 Comox Valley Concert Band Festival Report Cards Sent Home	25 Early Dismissal Report Card Interviews	26 Ladysmith Light-up	27 BADC	28
29	30 Post Secondary Institute Visitation Day 1:00-3:00					

December 2009

Sun	Mon	Tue	Wed	Thu	Fri	Sat
		1	2	3	4	5
			Department Head Honour Roll	Principal's Lunch	DCBA	
6	7	8	9	10	11	12
		Make Up Monday	School Dance Staff Committee		ABCD	
13	14	15	16	17	18	19
		PAC Meeting	Gr 8 Time 2nd D Staff Meeting	Safety Committee Locker Clean-out Christmas Band Concert 7pm	Last day of Classes before Winter Vacation CDAB	
20	21	22	23	24	25	26
		Winter Vacation				
27	28	29	30	31		
		Winter Vacation				

Grad Photos—Multi-purpose

Mulan Auditions 3-5pm

January 2010

Sun	Mon	Tue	Wed	Thu	Fri	Sat
					1	2
3	4 School re-opens West Side Story Rehearsals Begin	5 Grade 9 girls Immunization 9:00 am Library	6 Gr 8 Time 2nd D Department Head	7	8 BADC	9
10	11	12	13	14	15 DCBA	16
17	18	19 PAC Meeting	20 Staff Committee Meeting	21 Safety Committee	22 Last day of Classes for Semester 1 ABCD	23
24	25	26 Term 2 Marks Due	27 Staff Meeting Final Marks Due	28	29 Mark Verification CDAB	30
31						

Winter Vacation

Provincial Exams

February 2010

Sun	Mon	Tue	Wed	Thu	Fri	Sat
	1 Semester 2 begins Homeroom for Timetables	2	3 Department Head	4	5 Report Cards Printed BADC	6
7	8	9	10	11	12 Semester 1 Report Cards Sent Home DCBA	13
14	15	16 PAC Meeting	17 Make Up Monday Honour Roll Staff Committee	18 Principals Lunch Safety Committee	19 ABCD	20
21	22 District Non-instructional Day	23 School Based Non-instructional Day	24 Gr 8 Time 2nd D Staff Meeting	25	26 CDAB	27
28						

Lionel Hampton Jazz Festival

March 2010

Sun	Mon	Tue	Wed	Thu	Fri	Sat
	1	2	3 Interim Day Department Head	4 Locker Clean-out Early Dismissal 1:30 Parent Interviews 2—3 pm	5 Last day of Classes before Spring Vacation BADC	6
7	8 Spring Break	9	10	11	12	13
14	15 First day of Classes after Spring Vacation	16 PAC Meeting	17 Make Up Monday Staff Committee	18 Safety Committee	19 DCBA	20
21	22	23	24	25	26 ABCD	27
28	29	30	31 Staff Meeting			

April 2010

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				1	2 Good Friday	3
4	5 Easter Monday	6	7 Gr 8 Time 2nd D Department Head	8	9 Mulan Camp on Thetis ABCD	10
11 West Side Story Musical Camp on Thetis	12 End of Term 1 Mark Cut-off	13 Start of Term 2	14 Marks Due	15 Safety Commitee Mark Verification	16 Bamfield Senior Biology Trip CDAB	17
18	19	20 Make Up Monday PAC Meeting	21 Staff Committee Report Cards Sent Home	22 Early Dismissal 1:30pm Report Card Interviews 2-3pm	23 BADC	24
25	26 Non-instructional Day	27 Grade 9 girls Immunization 9:00 am Library	28 Staff Meeting	29	30 DCBA	

May 2010

Sun	Mon	Tue	Wed	Thu	Fri	Sat
						1 Mulan Dinner Benefit 6pm
2	3	4	5 Department Head	6 *Mulan 7pm*	7 ABCD *Mulan 7pm*	8 *Mulan 7pm*
9	10	11	12 Honour Roll Honourable Mention	13 Principals List Lunch *Mulan 7pm*	14 Girls Rugby Island Championships CDAB *Mulan 7pm*	15 *Mulan 7pm*
16	17 Implementation Planning Day	18 PAC Meeting	19 Staff Committee	20 Safety Committee	21 BADC	22
23	24 Victoria Day	25	26 Staff Meeting	27 Girls Rugby Provincial Championships (White Rock)	28 DCBA	29
30	31					

June 2010

Sun	Mon	Tue	Wed	Thu	Fri	Sat
		1	2 Department Head	3 Commencement Re-hearsal Grad Group Photo	4 Commencement Dry Grad ABCD	5 Banquet and Prom
6	7	8	9 Gr 8 Time 2nd D	10	11 CDAB	12
13	14 Locker Clear-out	15 Last day of Classes For Semester 2 PAC Meeting	16	17 Safety Committee Term Marks Due	18	19
20	21 Final Marks Due	22 Mark Verification	23 Staff Meeting	24	25 Promotion Meetings	26
27	28 Provincial Exams	29 Report Card Distribution	30 Administrative Day—Students do not attend	Provincial Exams Have a great summer!		

Appendix G – Course Outlines

RJ outline from Spring 2013

collected Jan. 2 2014

Biology 12 Course Outline

CURRICULUM

This course will focus on a study of the human body. As per the Biology 12 curriculum guide, material covered will include the following:

- Cell compounds
- Biological molecules
- Cell structure
- Cell membranes
- DNA
- Protein synthesis
- Enzymes
- Digestive system
- Circulatory system
- The heart
- Respiratory system
- The brain and nervous system
- Urinary system
- Reproductive system

EVALUATION

Within each term, students will be graded in the following manner:

Tests	80% of grade
Assignments	20% of grade

There will also be a final exam at the end of the course that will count for 20% of your grade for the course.

EXPECTATIONS

Students are expected to arrive at class on time and prepared to work. Both students and parents need to be aware that the #1 reason students are not successful in this course is due to poor attendance. Completing all assignments and regular home review of class material is strongly recommended if you wish to achieve success.

Extra help is available on a drop-in basis for students who are struggling with course concepts.

CONTACT INFORMATION

Parents requiring further information may contact me at the e-mail or phone number below:

Duncan Spring 2014.

Collected February 19th 2014.

Course Expectations and Parental Permission
Physics 12

rpose

Physics 12 is a critical prerequisite course for many post secondary programs in science, engineering, medicine and commerce. It is one of the most challenging courses in Grade 12 and requires a significant commitment of time and energy to ensure success.

Course Structure

Physics 12 is a self-paced, student directed course. The course is presented online via a course Moodle which I am in the process of developing. Have your son or daughter log on and show you what they are doing. This will help you to better understand their need to set deadlines and work consistently to get through the course by June. I have included a possible time line which gives them a fair degree of flexibility to meet their other commitments without falling behind.

Evaluation

How I am going to assess the course is still under consideration. The current plan is to use a service out of the University of Waterloo called MapleTA to present student assignments. Unit tests will probably be of the usual paper and pencil variety. The assignment questions are programmed so that students can attempt them multiple times and get a fresh question each time. Programming these questions takes a long time and we will have to see if I can keep up with the pace of the course. We may end up going back to paper assignments as well but I hope not. Check with your child from time to time to see how things turn out.

Teacher Expectations

I expect students to be responsible for their own learning. It is my job to find an effective model for presenting course material to students, and to encourage them and support them in their mastery of that material. In the end, whether or not they learn that material is their responsibility. These are senior students with demonstrated skills in mathematics so their success or failure must rest firmly on their own shoulders. This course is a challenging one and will require nightly home study to keep up!

Additional Tutoring

I am available for extra help after school for any student having difficulty. Student progress will be available at www.engrade.ca at anytime and I will update progress on a regular basis. If you, as a parent, would like to track your son/daughter's progress, please enter an email below and I will have engrade send you an invitation to sign up for a parent account.

Parent Email: _____

Note: This Moodle is currently being hosted on a server based in the United States. Canada privacy laws require me to have parental permission for a student to store any personal information (name and email address) outside of Canada. By signing this course outline you are giving the school district the right to store this two pieces of information on a US server.

Please sign below to indicate that you have read this document and understand what is expected in Physics 12.

Student: _____ Parent: _____

Physics 12 (D Block)

February 2012

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
30 Review	31 Review	1 Unit 1	2	3	4	5
6	7	8	9	10	11	12
13 Unit 2	14	15	16	17	18	19
20	21	22	23	24	25	26
27 Pro-D	28 Pro-D	29 Unit 3 (AM)				

March 2012

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
			1	2	3	4
5	6	7	8 E. Dis.	9	10	11
12 Unit 4	13	14	15	16	17	18
19 Spring Break	20 Spring Break	21 Spring Break	22 Spring Break	23 Spring Break	24	25
26	27	28	29 Unit 5	30	31	

April 2012

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
						1
2	3	4	5	6 Good Friday	7	8
9 Easter Monday	10	11	12	13	14	15
16 Unit 6	17	18	19	20	21	22
23 Pro-D	24	25	26	27	28	29
30 Unit 7						

May 2012

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
	1	2	3	4	5	6
7	8	9 Unit 8 (AM)	10	11	12	13
14 Pro-D	15	16	17 Unit 9	18	19	20
21 Victoria Day	22	23	24	25	26	27
28	29	30	31			

June 2012

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
				1 Unit 10	2	3
4	5	6	7	8	9	10
11	12	13	14 Unit 11	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29 Admin. Day	30	

Duncan Spring 2014.

Collected February 19th 2014.

Course Expectations and Parental Permission
Physics 12

rpose

Physics 12 is a critical prerequisite course for many post secondary programs in science, engineering, medicine and commerce. It is one of the most challenging courses in Grade 12 and requires a significant commitment of time and energy to ensure success.

Course Structure

Physics 12 is a self-paced, student directed course. The course is presented online via a course Moodle which I am in the process of developing. Have your son or daughter log on and show you what they are doing. This will help you to better understand their need to set deadlines and work consistently to get through the course by June. I have included a possible time line which gives them a fair degree of flexibility to meet their other commitments without falling behind.

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I am available for extra help after school for any student having difficulty. Student progress will be available at www.engrade.ca at anytime and I will update progress on a regular basis. If you, as a parent, would like to track your son/daughter's progress, please enter an email below and I will have engrade send you an invitation to sign up for a parent account.

Parent Email: _____

Note: This Moodle is currently being hosted on a server based in the United States. Canada privacy laws require me to have parental permission for a student to store any personal information (name and email address) outside of Canada. By signing this course outline you are giving the school district the right to store this two pieces of information on a US server.

Please sign below to indicate that you have read this document and understand what is expected in Physics 12.

Student: _____ Parent: _____

"Joe" Fall 2013. (Time of no exam). collected Feb 17th 2014

BIOLOGY 12 COURSE OUTLINE

Biology 12 is a very demanding course intended for serious students with a history of success in science courses. It is ***strongly*** recommended that students have a ***minimum*** mark of 60% in Biology 11 or Chemistry 11 before attempting Biology 12. ***Regular attendance is also a crucial part of success in Biology 12. Students with unexcused absences will receive a score of zero on the work done that day, including tests.***

TOPICS COVERED

CELL BIOLOGY

1) Cell Compounds
2) Biological Molecules
3) DNA
4) Cell Structure

CELL PROCESSES AND APPLICATIONS

1) Protein Synthesis
2) Transport Across Cell Membranes
3) Enzymes

HUMAN BIOLOGY

1) Digestive System
2) Circulatory System – Circulation and Blood
3) Circulatory System – Heart Structure and Function
4) Respiratory System
5) Nervous System – Neuron, Impulse Generation, and Reflex Arc
6) Nervous System – Divisions of the Nervous System and Brain
7) Urinary System
8) Reproductive System

PROVINCIAL EXAM

In August of 2011 the Ministry of Education eliminated all mandatory and optional provincial exams at the grade 12 level for all courses except English/Communications 12. Therefore, there is no longer an optional, mandatory, or scholarship exam for Biology 12 administered by the Ministry of Education. However, we will have a school-based final exam at the end of the course.

EVALUATION

Final grades for students will be determined in the following manner:

FIRST TERM MARK	37.5%
SECOND TERM MARK	37.5%
SCHOOL-BASED FINAL EXAM	25%

For each term mark, students will be graded as follows:

TESTS	80%
ASSIGNMENTS	20%

EXPECTATIONS

Success in this course is dependent on the following behaviors of the student:

- ***show up to every class on time with necessary materials and a positive attitude***
- ***complete all assignments on time and prepare (study) for all tests***
- ***YOU are responsible to complete ALL work missed while absent***

Failure to meet one or more of the above expectations will greatly impair the student's chances for success in this course.

CELL PHONES AND MUSIC PLAYERS

Cell phones and music players are distractions to student learning and are safety hazards in a science lab and thus ***have no place in the classroom***. These devices are not to be used in class and should be left in the student's locker.

"Joe" from time of exam.

Collected Feb 17th 2014

BIOLOGY 12 COURSE OUTLINE

Biology 12 is a very demanding course intended for serious students with a history of success in science courses. It is ***strongly*** recommended that students have a ***minimum*** mark of 60% in Biology 11 or Chemistry 11 before attempting Biology 12. ***Regular attendance is also a crucial part of success in Biology 12. Students with unexcused absences will receive a score of zero on the work done that day, including tests.***

TOPICS COVERED

CELL BIOLOGY

1) Cell Compounds
2) Biological Molecules
3) DNA
4) Cell Structure

CELL PROCESSES AND APPLICATIONS

1) Protein Synthesis
2) Transport Across Cell Membranes
3) Enzymes

HUMAN BIOLOGY

1) Digestive System
2) Circulatory System – Circulation and Blood
3) Circulatory System – Heart Structure and Function
4) Respiratory System
5) Nervous System – Neuron, Impulse Generation, and Reflex Arc
6) Nervous System – Divisions of the Nervous System and Brain
7) Urinary System
8) Reproductive System

PROVINCIAL EXAM

At the conclusion of the course, students are required to write a provincial exam counting for 40% of the student's mark. The date of this exam has not yet been posted by the Ministry of Education but will be some time in the week following our last class in January.

EVALUATION

Final grades for students will be determined in the following manner:

FIRST TERM MARK	30%
SECOND TERM MARK	30%
PROVINCIAL EXAM	40%

For each term mark, students will be graded as follows:

TESTS	90%
ASSIGNMENTS	10%

EXPECTATIONS

Success in this course is dependent on the following behaviors of the student:

- ***show up to every class on time with necessary materials and a positive attitude***
- ***complete all assignments on time and prepare (study) for all tests***
- ***YOU are responsible to complete ALL work missed while absent***

Failure to meet one or more of the above expectations will greatly impair the student's chances for success in this course.

CELL PHONES AND MUSIC PLAYERS

Cell phones and music players are distractions to student learning and are safety hazards in a science lab and thus ***have no place in the classroom***. These devices are not to be used in class and should be left in the student's locker.

"Duke" fall 2013 (time of no exam).

collected Dec 20th 2013

Biology 12 Course Outline

Biology 12 is a demanding course which requires regular effort and concentration on the part of the student. The language of Biology can make it particularly difficult for a student weak in language skills. Chemistry 11 is also recommended for success in Biology 12. The curriculum of Biology 12 is categorized under three curriculum organizers; cell biology, cell processes and applications, and human biology.

Personal Expectations of Students

Attendance

Frequent absences and/or tardiness are probably the two most common causes of failure, or a significant drop in percentage. It is expected that **ALL** absences should be accounted for by a phone call or note from the parent/guardian. Students are expected to find what material was missed while absent. Arrangements should be made **PRIOR** to test day for unavoidable, approved absences (e.g. field trips and other school related activities).

Classroom Performance

Attentiveness and participation in class activities are important steps in understanding what is being taught. Questioning , challenging, discussing, and involving one's self in the activity of the class are necessary to ensure success. Excessive socializing and disruptive behavior in class will not be tolerated. Individual student participation in lab activities may not always be possible due to safety concerns as a result of overcrowding in Science Labs.

Homework

It cannot be stressed enough that students **MUST** keep up with the content, assignments, and conceptual ideas presented in class. This dictates that all students regularly review the topics presented in class. Ideally, this should occur for a minimum of 20 minutes every night. If students are experiencing difficulty in grasping particular concepts, extra help is often available before or after regular school hours.

Assessment

Determination of School percentage:

Two Terms, each of which is worth 40% of the course and broken down as:

Chapter Tests, Term Tests, quizzes ---------- 75%

Assignments, Labs, Homework, Presentations ---------- 25%

There is a common final exam worth 20% of the course

"Duke" from time of exam.

collected Dec. 20th 2013

Biology 12 Course Outline

Biology 12 is a demanding course which requires regular effort and concentration on the part of the student. The language of Biology can make it particularly difficult for a student weak in language skills. Chemistry 11 is also recommended for success in Biology 12. The curriculum of Biology 12 is categorized under three curriculum organizers; cell biology, cell processes and applications, and human biology. A breakdown of the curriculum and is on the back of this outline.

Personal Expectations of Students

Attendance

Frequent absences and/or tardiness are probably the two most common causes of failure, or a significant drop in percentage. It is expected that **ALL** absences should be accounted for by a phone call or note from the parent/guardian. Students are expected to find what material was missed while absent. Arrangements should be made **PRIOR** to test day for unavoidable, approved absences (e.g. field trips and other school related activities).

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Homework

It cannot be stressed enough that students **MUST** keep up with the content, assignments, and conceptual ideas presented in class. This dictates that all students regularly review the topics presented in class. Ideally, this should occur for a minimum of 20 minutes every night. If students are experiencing difficulty in grasping particular concepts, extra help is often available before or after regular school hours.

Assessment

Determination of School percentage:

Two Terms, each of which is worth 30% of the course and broken down as:

Chapter Tests, Term Tests, quizzes ---------- 75%

Assignments, Labs, Homework, Presentations ---------- 25%

There is a provincial exam at the end of the course worth 40% of your mark

BIOLOGY 12

TABLE OF SPECIFICATIONS FOR THE PROVINCIAL EXAMINATION

CURRICULUM			COGNITIVE LEVEL			
ORGANIZERS	SUB-ORGANIZERS		Knowledge	Understanding and Application	Higher Mental Processes	TOTAL MARKS
Cell Biology	A	Cell Structure	<— 5 —>			16
	B/C	Cell Compounds / Biological Molecules	<— 7 —>			
	D	DNA	<— 4 —>			
Cell Processes and Applications	E	Protein Synthesis	<— 4 —>			16
	F	Cancer	<— 0 —>			
	G	Transport Across Cell Membrane	<— 6 —>			
	H	Enzymes	<— 6 —>			
Human Biology	I	Digestive System	<— 9 —>			58
	J/K	Circulatory System: Circulation and Blood / Heart Structure and Function	<— 13 —>			
	L	Respiratory System	<— 7 —>			
	M/N	Nervous System: Neuron, Impulse Generation and Reflex Arc / Divisions of the Nervous System and the Brain	<— 10 —>			
	O	Urinary System	<— 9 —>			
	P	Reproductive System	<— 10 —>			
		TOTAL	20	52	18	90

The values shown in this table are approximate and may fluctuate.

Examination configuration: 67 marks in multiple-choice format
23 marks in written-response format

Joanna Spring 2014

collected Feb 27th 2014

BIOLOGY 12 COURSE OUTLINE

While there are not pre-requisites for Biology 12 it is a course with a large amount of work and I recommend you have a successful experience in Biology 11 or Chemistry 11 before attempting this course.

CURRICULUM TOPICS

The Biology 12 course has three main components:

- cell biology
- cell processes and applications
- human biology

A greater description of these topics is available at https://www.bced.gov.bc.ca/irp/pdfs/sciences/2006biology1112.pdf

GRADING

For term report cards grades will be determined by

TESTS	70%
ASSIGNMENTS	30%

At the end of the course grades will be determined by

FIRST TERM MARK	40%
SECOND TERM MARK	40%
SCHOOL-BASED FINAL EXAM	20%

EXPECTATIONS

To achieve success in this course students need to show up to class, on time, and ready to work. Regular homework and/or review of concepts covered in class is also recommended. I will be available every morning from 8 am to the start of school for extra help for those who need it.

CONTACT INFO

"Gillian" from time of exam

collected Dec. 16/2013

CHEMISTRY 12 COURSE OUTLINE

To ensure that you obtain the maximum benefit from this course, the following are minimal standards expected from each student:

- Regular attendance
- Arrive to class on time, prepared to work
- Report to class with all the necessary books and supplies
- Complete each assignment to the best of your ability and hand it in on time
- Exhibit responsible, co-operative, and respectable behavior at all times

Goals for Chemistry 12

The Chemistry 12 program is designed to:

- Develop the capacity to think critically and abstractly
- Develop a positive attitude towards science
- Examine basic concepts, principles, laws, and theories through scientific inquiry
- Cultivate students' appreciation of the scientific endeavor and their potential to contribute to it

Attendance

In order to be successful in this course, regular attendance is essential. Students are responsible for all work missed while absent.

Late Assignments

All assignments must be completed by the beginning of class on the due date. Late assignments will be given a score of zero unless accompanied by a parental or doctors note explaining the nature of the tardiness.

Absence during a quiz or exam

If a student misses a quiz or exam, the following steps must be taken:

- A parent or guardian must phone the school in the day of your absence
- A note must be brought to your teacher on the first day back
- The student must write the test on the first day of return to school

Evaluation

Term 1 and 2

Chapter Tests	70%
Quizzes	15%
Assignments	15%

Final Mark

Term 1	30%
Term 2	30%
Provincial Exam	40%

Notebook

Students must keep an up to date notebook that has notes, assignments, and laboratory sections within it. It must be formatted in the sequence in which the course is delivered.

Textbook

Hebden Chemistry 12: A worbook for students

Course Content

The learning outcomes of Chemistry 12 are grouped under five units and twenty subunits.

TOPICS	TIME (Approx.)
1) Reaction Kinetics a) Introduction b)Collision Theory c) Reaction Mechanisms and Catalysts	10 hours
2) Equilibrium a) Introduction	15 hours

b) Le Chatelier's Principal
c) The Equlibrium Constant

3) Solubility Equilibrium — 15 hours
a) Concept of Solubility
b) Solubility and Precipitation
c) Quantitative Aspects

4) Acids, Bases, and Salts — 30 hours
a) Properties and definitions
b) Strong and Weak Acids and Bases
c) Kw, pH, and pOH
d) Ka and Kb problem solving
e) Hydolysis of Salts
f) Indicators
g) Neutralizations of Acids and Bases
h) Buffer Solutions and Acid Rain

5) Redox — 20 hours
a) Introduction
b) Balancing redox equations
c) Electrochemical cells
d) Corrosion
e) Electrolytic cells

**********A scientific calculator is required for this course**********

I have read the above course guidelines and understand the requirements and expectations of this course. I also acknowledge that my son/daughter will work safely within the lab in order to remain part of this class:

Student's signature: _____
By signing above, you also agree to conduct yourself in a responsible and safe manner in the lab at all times. Failure to do so may result in removal from class.

Parent/Guardian(s) signature: _____

Please feel free to contact me at

"Gillian" fall 2013 (time of no exam). collected Dec 16 for

CHEMISTRY 12 COURSE OUTLINE

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- Regular attendance
- Arrive to class on time, prepared to work
- Report to class with all the necessary books and supplies
- Complete each assignment to the best of your ability and hand it in on time
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Goals for Chemistry 12

The Chemistry 12 program is designed to:

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- Develop a positive attitude towards science
- Examine basic concepts, principles, laws, and theories through scientific inquiry
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In order to be successful in this course, regular attendance is essential. Students are responsible for all work missed while absent.

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All assignments must be completed by the beginning of class on the due date. Late assignments will be given a score of zero unless accompanied by a parental or doctors note explaining the nature of the tardiness.

Absence during a quiz or exam

If a student misses a quiz or exam, the following steps must be taken:

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- A note must be brought to your teacher on the first day back
- The student must write the test on the first day of return to school

Evaluation

Term 1 and 2

Chapter Tests	60%
Quizzes	20%
Assignments	20%

Final Mark

Term 1	37.5%
Term 2	37.5%
Final Exam	25%

Notebook

Students must keep an up to date notebook that has notes, assignments, and laboratory sections within it. It must be formatted in the sequence in which the course is delivered.

Textbook

Hebden Chemistry 12: A worbook for students

Course Content

The learning outcomes of Chemistry 12 are grouped under five units and twenty subunits.

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Student's signature: _____
By signing above, you also agree to conduct yourself in a responsible and safe manner in the lab at all times. Failure to do so may result in removal from class.

Parent/Guardian(s) signature: _____

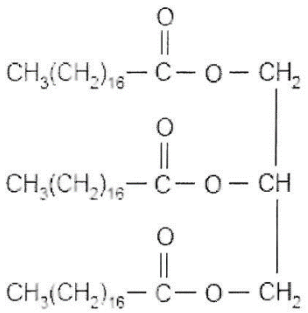
Please feel free to contact me at

Appendix H – Teacher Final Exams

BIOLOGY 12 FINAL EXAM PART #1

Multiple Choice
Identify the choice that best completes the statement or answers the question.

1.

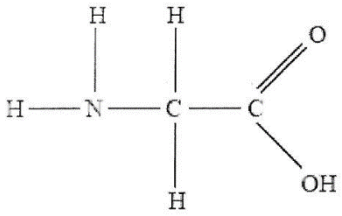


The above chemical compound is classified as a

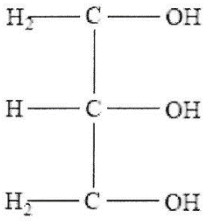
a. lipid b. nucleic acid c. protein d. carbohydrate

2. Which of the structures below is used for quick and short term energy?

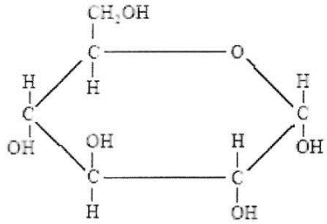
a.



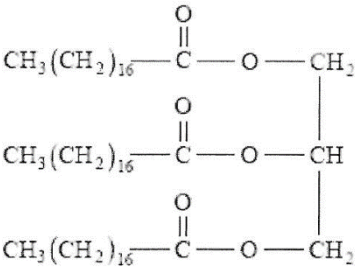
c.



b.

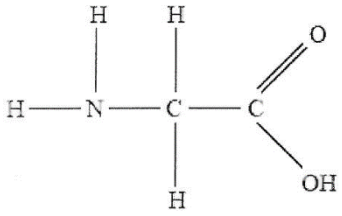


d.

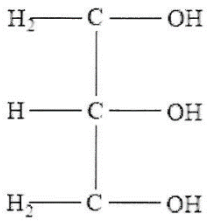


3. Which of the structures below is used for long-term energy storage?

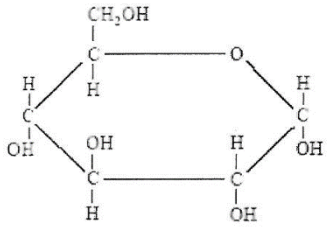
a.



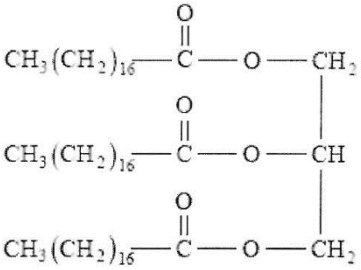
c.



b.

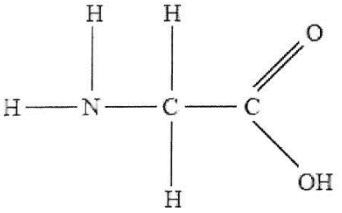


d.

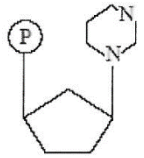


4. Which of the structures below is used to protect and cushion internal organs?

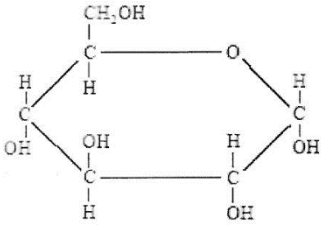
a.



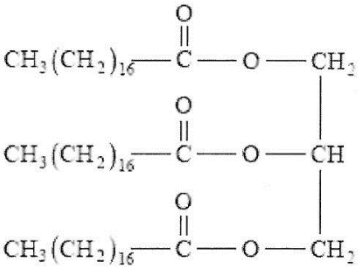
c.



b.

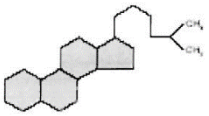


d.

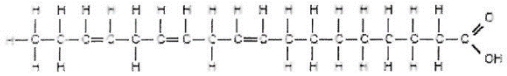


5. Which of the following can be converted into a hormone that determines male sex characteristics?

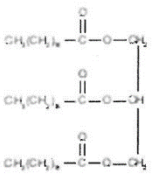
a.



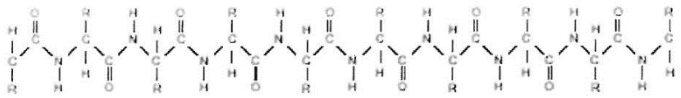
b.



c.

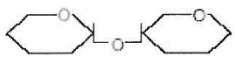


d.

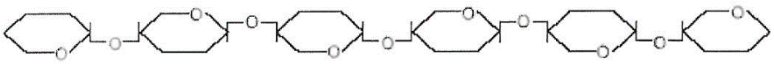


6. Which of the following would function as a structural component of plant cell walls?

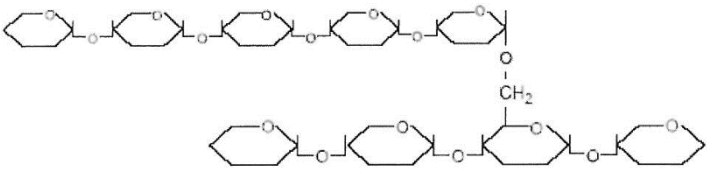
a.



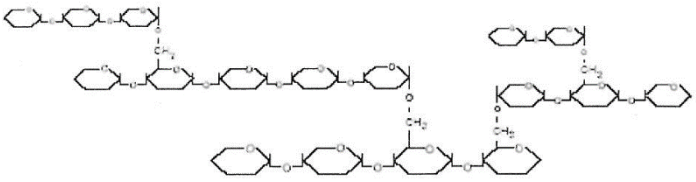
b.

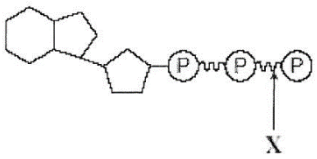


c.



d.



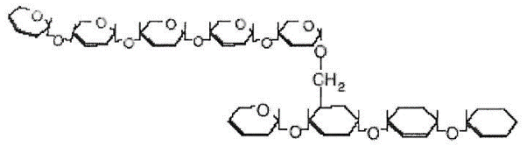


7. What occurs when the bond labelled X is broken?

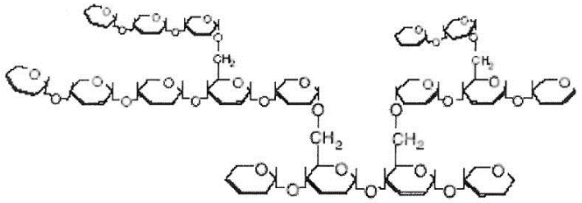
a. energy is released
b. water is produced
c. the molecule grows in size
d. none of these occur

8. Which molecule cannot be digested by humans?

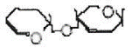
a.



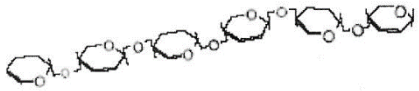
b.



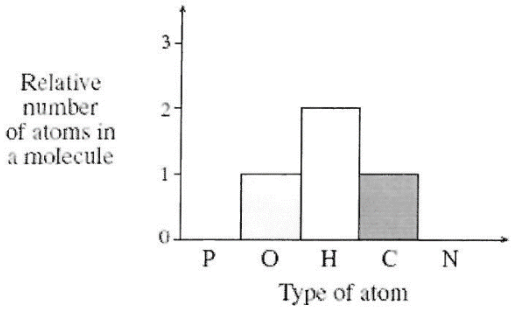
c.



d.



9. The graph below shows the relative number of atoms in a molecule/



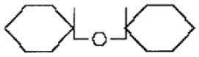
Which of the following molecules reflects the data shown by the graph?

a. ATP b. DNA c. ribose d. hemoglobin

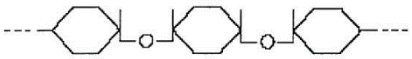
10. Which diagram represents a disaccharide?

a.

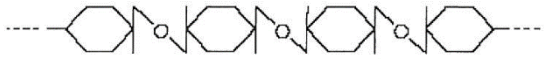
b.



c.

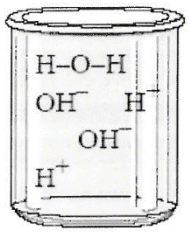


d.

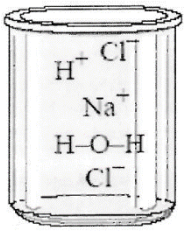


11. Which of the following diagrams correctly represents a solution with a pH of less than 7?

a.

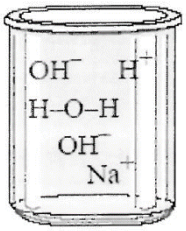


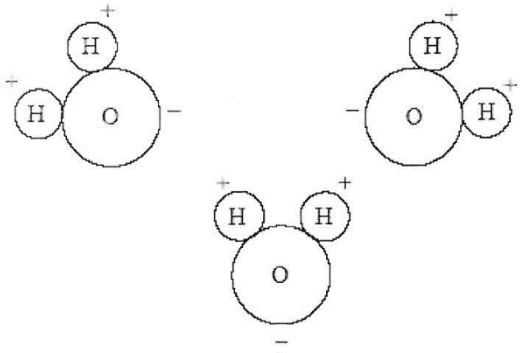
b.



c.

d.

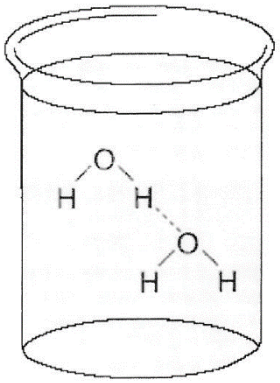




12.

The indicated charges allow these molecules to

a. act as a solvent
b. buffer a solution
c. form the cell membrane
d. store energy for future use

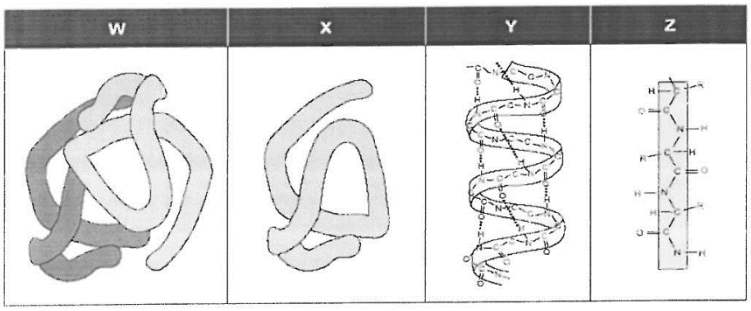


13.

The type of bond shown between the two water molecules is

a. ionic
b. peptide
c. covalent
d. hydrogen

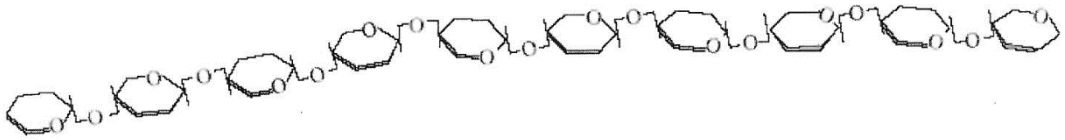
14.



Which of the above diagrams represents the tertiary structure of a protein?

a. W b. X c. Y d. Z

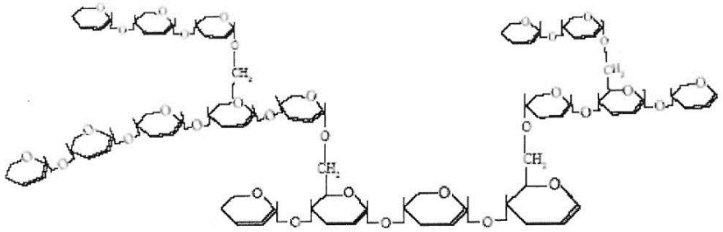
15.



The molecule above would likely be found in a

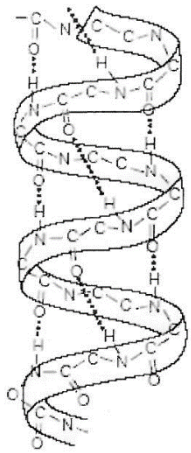
a. human kidney
b. liver cell
c. plant cell wall
d. all of these

16.



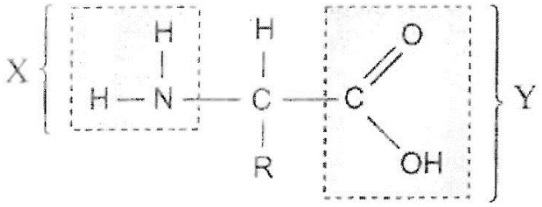
The diagram above shows a molecule that is found in the

a. liver b. blood c. pancreas d. gall bladder



17. The diagram above indicates which level(s) of protein structure?

a. only primary
b. primary and secondary
c. primary, secondary, and tertiary
d. primary, secondary, tertiary, and quaternary



18. X in the above diagram shows the

a. carboxyl group
b. amine (amino) group
c. R-group
d. peptide bond

19. Which of the following is not a role of water in the body?

a. solvent
b. catalyst
c. lubricant
d. temperature regulator

20. Which of the following molecules is a carbohydrate?

a. $C_3H_7O_2N$
b. $C_6H_{12}O_6$
c. $C_{13}H_{26}O_2$
d. $C_{20}H_{40}O_2$

21. The building blocks of a nucleic acid are:
    a. amino acids
    b. glycerol
    c. nucleotides
    d. carboxyl acids
    e. glucose

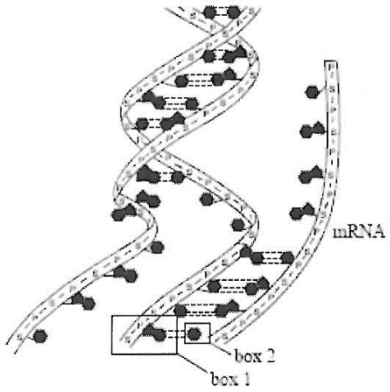
22. A pH of 2 is _____; a pH of 11 is _____; a pH of 7 is _____
    a. a base; neutral; an acid
    b. a base; an acid; neutral
    c. an acid; a base; neutral
    d. neutral; a base; an acid
    e. neutral; an acid; a base

23. The unit molecule of a protein is
    a. glucose b. glycerol c. a fatty acid d. an amino acid

24. Which of the following is a function of some proteins?
    a. emulsify fats
    b. make up genes
    c. speed up chemical reactions
    d. make up cell walls

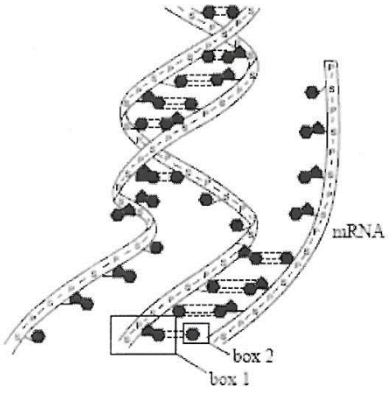
25. A substance that prevents large changes in the pH of a solution is
    a. DNA b. water c. a buffer d. an enzyme

26. The process shown in the diagram below is called



    a. translation
    b. transcription
    c. translocation
    d. transformation

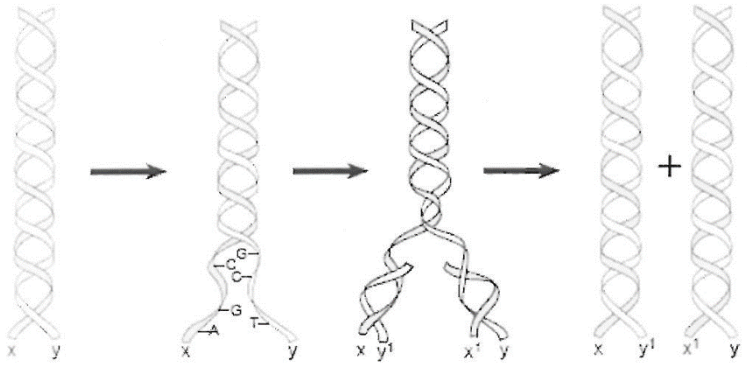
27. If the base in Box 1 in the diagram below is adenine, then the base in Box 2 must be



a. uracil
b. guanine
c. cytosine
d. thymine

28. If the nucleotide sequence of an anticodon was AUC, then the DNA triplet code would be
a. ATC b. TAG c. AUC d. UAG

29. The diagram below represents



a. DNA replication
b. mRNA translation
c. mRNA elongation
d. DNA transcription

30. RNA consists of how many of the molecules listed below?
    - uracil
    - adenine
    - thymine
    - phosphate
    - deoxyribose

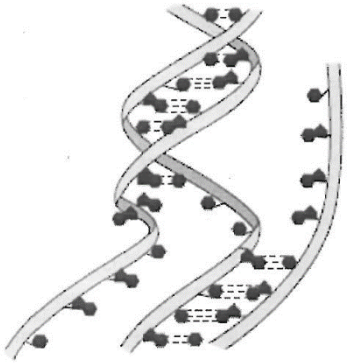
    a. 1 b. 2 c. 3 d. 4 e. 5

31. What type of chemical bond is broken during the first step in replication?
    a. ionic b. peptide c. covalent d. hydrogen

32. Using your chart provided, what is a base sequence for a section of DNA which codes for the amino acids serine and arginine?
    a. AGC AGA b. AGT GCT c. AGU AGA d. UCA UCU

33. Which of the following is a difference between DNA and RNA?
    a. the number of strands
    b. the presence of adenine
    c. the presence of guanine
    d. the presence of a five carbon sugar

34. Which of the following correctly describes the process being shown below?



    a. translation is occurring in the nucleus
    b. replication is occurring in the nucleus
    c. transcription is occurring in the nucleus
    d. translation is occurring in the cytoplasm

35. Which of the following molecules is produced during translation?
    a. DNA b. tRNA c. protein d. mRNA

36. Which of the following are characteristics of DNA but not RNA?

A.	single stranded	contains adenine	translates
B.	double stranded	contains guanine	replicates
C.	single stranded	contains thymine	replicates
D.	double stranded	contains uracil	translates

a. A b. B c. C d. D

37. What carries amino acids to the ribosomes?
a. DNA b. tRNA c. rRNA d. mRNA

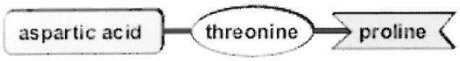
38. Which of the following is an example of how an enzyme is used in transcription?
a. RNA polymerase helps put together the mRNA strand
b. DNA polymerase breaks the H-bonds between bases in the double helix
c. helicase joins the nucleotides together in the step we call "joining"
d. helicase breaks the ionic bonds between bases in the double helix

39. Which of the following represents the structure of a nucleotide?
a. salt - lipid - base
b. glucose - glucose - glucose
c. phosphate - sugar - nitrogenous base
d. amino acid - amino acid - amino acid

40. Which of the following best describes the function of mRNA?
a. it stays in the nucleus and is copied by DNA
b. it carries amino acids to the growing polypeptide chain
c. it makes up the ribosomes and provides a site for protein synthesis
d. it is transcribed from the DNA and carries the information to the ribosome

41. A change in the sequence of bases in a strand of DNA that occurs as a result of exposure to x-rays is an example of
a. mutation
b. transcription
c. protein synthesis
d. translation

42. Using your chart, which DNA code represents the polypeptide chain below



a. CTG TGT GTT
b. CTA GGT AGT
c. GAC ACA CCA
d. CAU UGA GGU

43. How are DNA and mRNA functionally related in the process of protein synthesis?
    a. DNA copies the information contained on the mRNA molecule
    b. rRNA reads mRNA
    c. mRNA carries a copy of information from the DNA on how to construct the protein
    d. mRNA carries the amino acids to the DNA

44. How are mRNA and tRNA functionally related in the process of protein synthesis?
    a. tRNA copies the information contained on the mRNA molecule
    b. rRNA reads mRNA
    c. mRNA carries the code for which amino acids tRNA needs to deliver to the ribosome
    d. mRNA carries the amino acids to the tRNA

45. What is produced when transfer RNA joins to messenger RNA at the ribosome?
    a. a protein b. tRNA c. mRNA d. rRNA e. rDNA

46. Translation
    a. takes place in the nucleus and produces a protein
    b. takes place at a ribosome and produces mRNA
    c. takes place in the nucleus and produces mRNA
    d. takes place at a ribosome and produces a protein
    e. takes place in the nucleus and produces a new double helix

47. In which location of a human cell would recombinant DNA be found?
    a. nucleus and cytoplasm
    b. nucleus and ribosome
    c. cytoplasm and ribosome
    d. nucleus only

48. Using the diagram below and the chart provided, give the sequence of amino acids that would be produced by ***the right hand strand reading from top to bottom***

C - G
A - T
T - A
G - C
G - C
T - A
T - A
A - T
C - G

    a. methionine - proline - leucine
    b. leucine - proline - methionine
    c. histidine - glycine - tyrosine
    d. methionine - leucine - proline

49. Using the diagram below and the chart provided, give the sequence of amino acids that would be produced by ***the right hand strand, reading from top to bottom,*** if a third C is added between the two already found in the right-hand strand

C - G
A - T
T - A
G - C
G - C
T - A
T - A
A - T
C - G

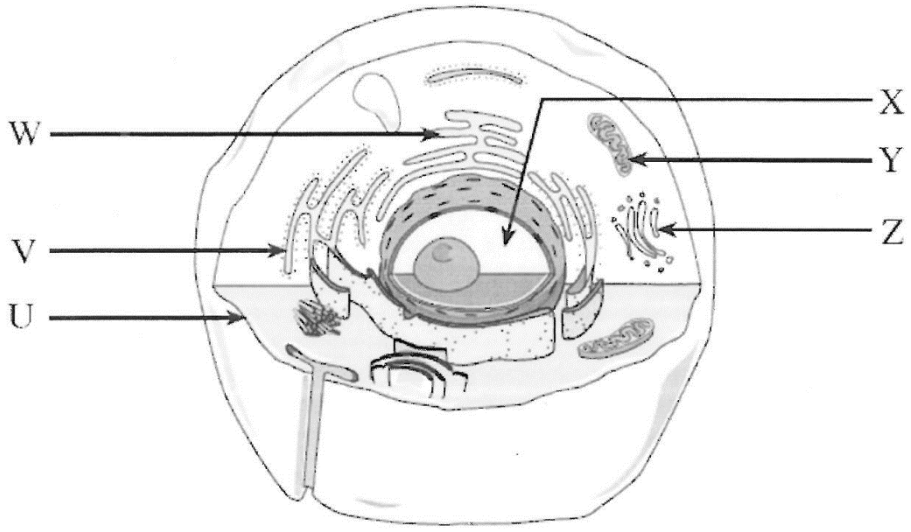
a. methionine - proline - leucine
b. leucine - proline - methionine
c. histidine - glycine - tyrosine
d. tyrosine - glycine - histidine
e. histidine - glycine - leucine

50. Environmental factors that cause mutations are called _____. Mutations might cause _____ in offspring if the DNA in the _____ is affected, or might cause _____ in an individual if the body cells are affected.

Which words, **IN THE CORRECT ORDER**, would complete the above paragraph?

a. mutations, genetic disorders, gametes, cancer
b. DNA, cancer, mother, no harm
c. mutagens, genetic disorders, gamete, cancer
d. cancer, gametes, genetic disorders, mutagens

Use the diagram below to answer the following SEVEN (7) questions



51. What occurs at the site of the structure labelled V?
    a. translation and protein synthesis
    b. ATP formation
    c. DNA replication
    d. rRNA synthesis

52. Which of the following is the correct sequence of organelles required in the production and export of a protein?
    a. V > W > X
    b. V > X > Z
    c. V > Z > U
    d. W > V > U

53. Which of the organelles in the above diagram is responsible for synthesizing steroid hormones and detoxifying drugs?
    a. W b. X c. Y d. Z

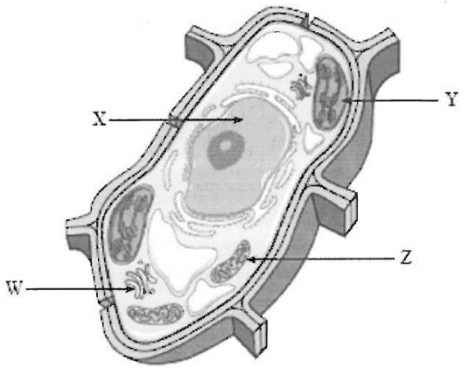
54. Which organelle contains information necessary to produce enzymes?
    a. W b. X c. Y d. Z

55. The structure labelled U is composed mostly of
    a. glycogen and protein
    b. nucleic acid and glycogen
    c. nucleic acids and phospholipids
    d. protein and phospholipids

56. Which letter in the diagram indicates the part of the cell where genetic information is stored?
    a. V b. W c. X d. Y e. Z

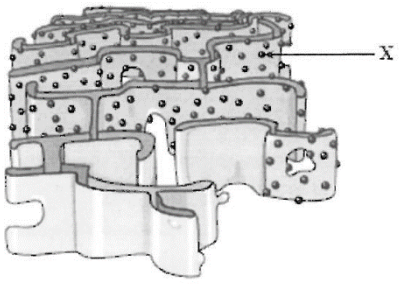
57. The structure labelled Z is the
    a. nucleus
    b. ribosome
    c. smooth endoplasmic reticulum
    d. Golgi body

58. In the diagram below, photosynthesis would occur in which structure?



a. W b. X c. Y d. Z

Use the diagram below to answer the following three (3) questions

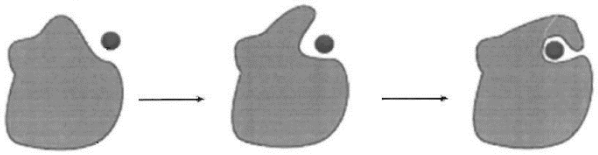


59. Structure X is composed of molecules produced by the
a. nucleus b. vesilces c. nucleolus d. lysosomes

60. What is a product of the process that occurs at X in the diagram above?
a. bile b. glycogen c. protein d. phopholipids

61. One function of structure X in the diagram above is
a. replicate DNA c. produce steroids
b. produce enzymes d. produce mRNA

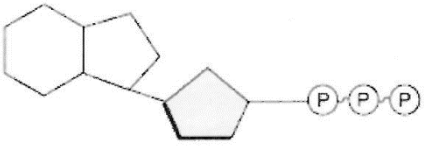
62. The process taking place in the diagram below is



a. osmosis
b. exocytosis
c. phagocytosis
d. facilitated transport

63. Which organelle provides energy for protein synthesis?
a. nucleus
b. nucleolus
c. rough endoplasmic reticulum
d. mitochondria

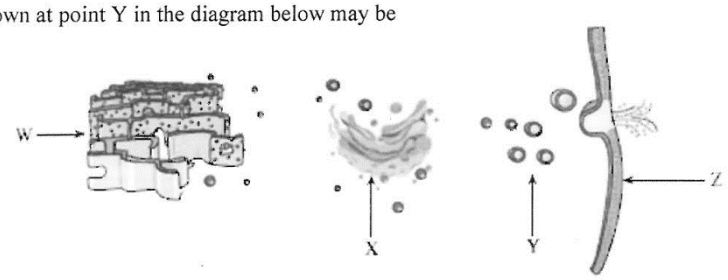
Use the diagram shown below to answer the following two (2) questions



64. The molecule shown above would be made in the
a. mitochondria b. nucleus c. ribosome d. cell membrane

65. The molecule above would be used by the cell membrane
a. in diffusion and active transport
b. in osmosis and diffusion
c. in active transport and exocytosis
d. in active transport and facilitated transport

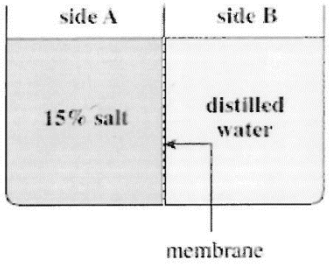
66. The structure shown at point Y in the diagram below may be



a. a bacteria
b. water
c. a steroid
d. insulin

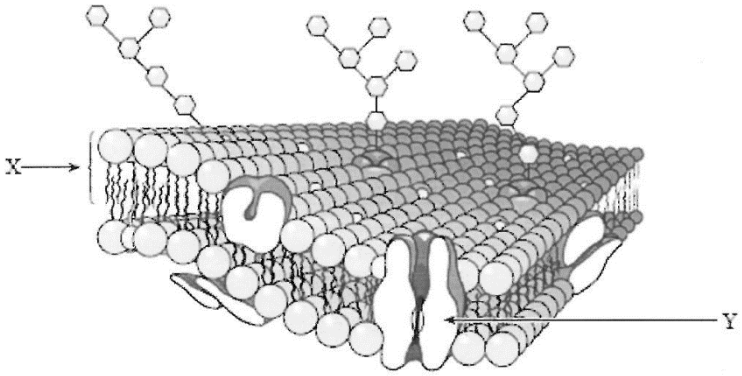
An experiment was carried out to study the movemwnt of molecules through a membrane. Two solutions were placed into a container on either side of a membrane which is permeabel to salt and water. The temperature was maintained at 40°C.

Use this information and the diagram below to answer the following question



67. What would happen to the volume of water on sides A and B after five hours?
    a. there will be no net movement of water
    b. water volume on both side will increase
    c. water volume on both sides will decrease
    d. water volume on side A will increase, but decrease on side B
    e. water volume on side B will increase, but decrease on side A

Use the diagram shown below to answer the next six (6) questions



68. Molecule X is
    a. an integral protein
    b. a phospholipid
    c. a peripheral protein
    d. a glycolipid

69. The function of molecule X is
    a. produce proteins
    b. cell to cell recognition
    c. structure
    d. produce vesicles for exocytosis

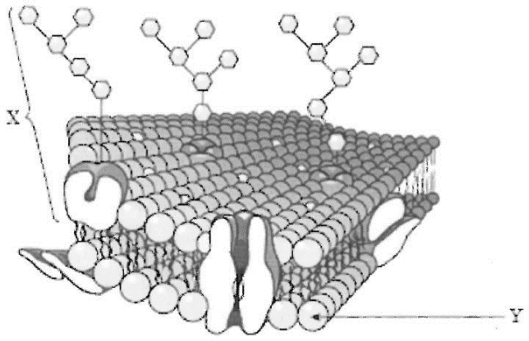
70. Structure Y is
    a. a peripheral protein
    b. a phospholipid
    c. a carrier protein
    d. a glycoprotein

71. The function of structure Y is
    a. cell to cell recognition
    b. transportation
    c. producing proteins
    d. producing vesicles for endocytosis

72. If a substance temporarily interferes with the function of structure Y in the diagram above, which of the following would occur?
    a. the breakdown of worn out cell organelles would stop
    b. there would be an increase in the production of mRNA
    c. the number of amino acid molecules entering the cell would decrease
    d. the active transport of water across the cell membrane would decrease

73. Which of the following is a component of X in the diagram above?
    a. glucose b. fatty acids c. nucleotides d. amino acids

Use the diagram below to answer the following two (2) questions



74. What is the function of the structure labelled X?
    a. move cells
    b. trap nutrient molecules
    c. enable cellular recognition
    d. increase the rate of diffusion

75. The molecule labelled Y contains
    a. protein b. glycerol c. steroids d. amino acids

76. As a cell increases in size
    a. it becomes difficult for the cell membrane to move enough food and wastes in and out of the cell
    b. the volume of the cell decreases
    c. the cell membrane shrinks
    d. only one thing can happen to the cell; it will eventually die

Use the scenario below to answer the following TWO (2) questions

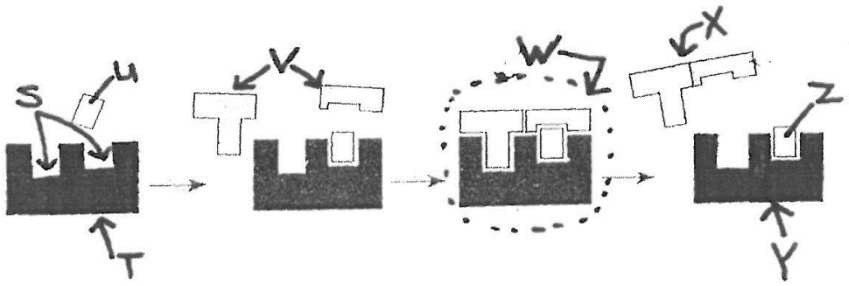
A group of cancer patients recovering from chemotherapy are taking an experimental drug to try and put on weight lost during treatment. 100 patients are gathered and each day 50 are given the drug, 50 are given a sugar pill.

77. The group of patients receiving the sugar pill are called
    a. the test group
    b. the data group
    c. the hypothesis group
    d. the control group
    e. the hypothesis group

78. Why does one group receive a sugar pill instead of the drug being tested?
    a. we need to also explore how sugar may lead to weight gain in cancer patients
    b. the cancer drug is too expensive to give it to each patient
    c. the sugar pill group provides us with our "hypothesis group", which is needed in every experiment
    d. we examine the weight gain of the group that received the drug and compare it to the weight gain of the group that received the sugar pill to evaluate the drug's effectiveness
    e. none of these are correct

79. A reaction catalyzed by a human enzyme was carried out at 20°C. If there is an excess (large amount) of substrate, which of the following would cause the ***greatest*** increase in the rate of the reaction?
    a. lowering the temperature to 10°C
    b. adding more enzyme and raising the temperature to 30°C
    c. adding more substrate and raising the temperature to 30°C
    d. adding more enzyme and lowering the temperature to 10°C
    e. adding heavy metals and raising the temperature to 37°C

Use the diagram below to answer the following FIVE (5) questions



80. Lead ions are added to the reaction above. Which of the following is most likely to occur as a result?
    a. an increase in the concentration of Z
    b. an increase in the concentration of V
    c. a decrease in the concentration of X
    d. an increase in the concentration of W
    e. none of these

81. In the reaction above, which letter represents the co-enzyme?
    a. S b. T c. U d. V e. X

82. Adding more of **T** to a reaction would have which of the following effects?
    a. it would denature the enzyme and speed up the reaction
    b. it would destroy the substrates and slow down the reaction
    c. it would provide more active sites, thus speeding up the reaction
    d. it would cause less enzyme-substrate complex to be formed
    e. none of the above would occur in this situation

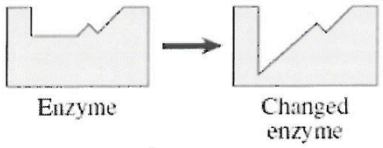
83. If the reaction above happens at a pH of 7.2, what would occur if the pH were increased to 12?
    a. T would denature, slowing down the reaction
    b. S would denature, slowing down the reaction
    c. less W would form
    d. less X would form
    e. all of these may occur if the pH was increased to 12

84. The structure labeled **T** in the diagram is a(n)
    a. enzyme
    b. substrate
    c. co-enzyme
    d. enzyme-substrate complex
    e. product

85. Which of the following does ***not*** affect the rate of an enzyme-catalyzed reaction?
    a. pH
    b. temperature
    c. substrate concentration
    d. thallium concentration
    e. normal water pressure

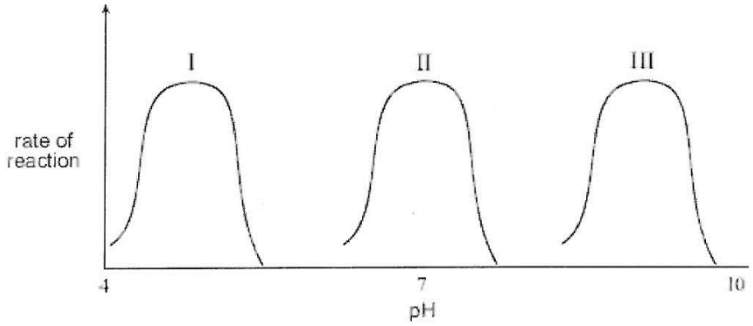
86. How do enzymes increase the rate of a chemical reaction?
    a. they denature the substrate
    b. they decrease the energy of activation
    c. they increase the substrate concentration
    d. they donate atoms or ions to the reactants
    e. they act as co-enzymes

87. What may have caused the changes shown in the enzyme below?



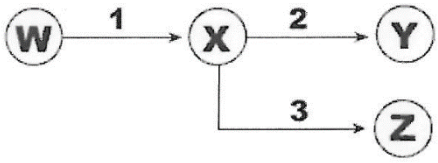
    a. adding lead ions
    b. reducing the activation energy
    c. increasing the substrate concentration
    d. heating the enzyme-catalyzed reaction to 37°C
    e. the addition of co-enzymes

88. The graph below shows the effect of pH on three different enzyme-catalyzed reactions. Which of the following would BEST describe the effect of pH on enzyme-catalyzed reactions?



    a. enzymes action increases as pH increases
    b. enzyme action decreases as pH increases
    c. all enzymes work best in an acidic environment
    d. all enzymes work best in a basic environment
    e. each enzyme works best within its own specific pH range

Use the diagram below to answer the following TWO (2) questions



89. Production of **Z** may be increased by
    a. increasing the amount of enzyme #2
    b. decreasing the amount of W
    c. adding a competitive inhibitor for enzyme #3
    d. adding a competitive inhibitor for enzyme #2
    e. decreasing the amount of X

90. A substance is added to a test tube where the above reactions are occurring. As a result, no product **Y** is formed, but product **Z** is still formed. Which of the following best explains why this occurred?
    a. the substance denatures enzyme #1
    b. the substance denatures enzyme #2
    c. the substance denatures enzyme #3
    d. the substance destroys reactant X
    e. none of these would produce the result described

91. Examine the equation shown below:

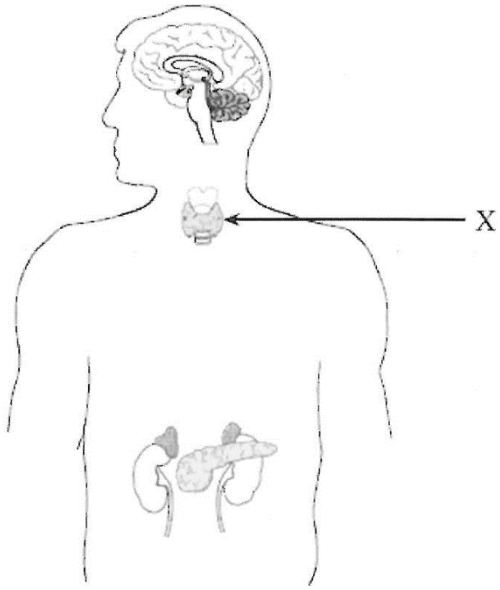
$$\mathbf{A} + \mathbf{OXYGEN} + \mathbf{WATER} \rightarrow \mathbf{B} + \mathbf{CO_2} + \mathbf{C}$$

    Which of the following answers would correctly fill in the missing materials for A, B, and C?

    a. A is thyroxin, B is glucose, C is carbon dioxide
    b. A is heat, B is oxygen, C is ATP
    c. A is glucose, B is energy/ATP, C is thyroxin
    d. A is carbon dioxide, B is energy/ATP, C is heat
    e. A is glucose, B is energy/ATP, C is heat

92. Production of thyroxin
    a. can be expected to increase in a cold climate
    b. can be expected to decrease in a warm climate
    c. varies from person to person
    d. is critical for maintaining a steady metabolism
    e. all of these are correct

93. Examine the diagram below:



Secretions from gland **X** cause decreased

a. metabolism
b. body temperature
c. oxygen uptake in cells
d. production of carbon dioxide
e. concentration of blood glucose

94. Which structure is not part of the pathway that food follows on its way through the digestive tract?
a. pharynx b. duodenum c. cardiac sphincter d. gall bladder

95. Insulin secretion is increased when the level of
a. sodium in the blood is low
b. sodium in the blood is high
c. glucose in the blood is low
d. glucose in the blood is high

96. Which enzyme is most effective at pH 2?
a. lipase b. pepsin c. nuclease d. salivary amylase

Use the diagram of the digestive system provided to answer question #97 - 120.

97. Abnormal function of structure E would affect the digestion of
a. fats b. sugars c. protein d. starch

98. Most water absorption occurs at structure
a. D b. H c. G d. J e. K

99. Which structure would have a pH that would destroy most bacteria?
a. D b. H c. J d. K

100. Amylase is produced by which organs?
a. E and F b. G and I c. A and E d. A and I

101. Two structures responsible for producing protein digesting enzymes are
a. A and H b. H and I c. D and E d. G and J

102. Organisms producing vitamins, growth factors, and essential amino acids that are beneficial to the body are found in structure
a. E b. H c. I d. J e. K

103. Excess products of carbohydrate digestion are stored in
a. E b. F c. G d. H e. P

104. The reaction shown below is catalyzed by secretions from which organs?

$$\text{protein} + H_2O \rightarrow \text{peptides}$$

a. E and I b. E and G c. H and I d. G and H

105. High levels of toxins in the blood may indicate a problem with the function of the
a. A b. E c. H d. I e. J

106. Structure I
a. produces salivary amylase and digests proteins
b. produces pepsin and digests proteins
c. produces lipase and digests fats
d. produces bile and digests carbohydrates
e. produces peptidase and digests proteins

107. Insulin is produced by structure
a. E b. F c. G d. H e. I

108. Bicarbonate ions and digestive enzymes are present in secretions from
a. E b. H c. I d. G

109. Which letter indicates the gallbladder?
a. E b. F c. G d. H e. I

110. Which organs are involved in maintaining constant levels of glucose in the blood?
a. E and I b. E and F c. H and I d. I and J

111. What is structure N?
a. liver b. pancreas c. appendix d. duodenum

112. Which of the following breaks down old red blood cells?
a. E b. F c. G d. H e. I

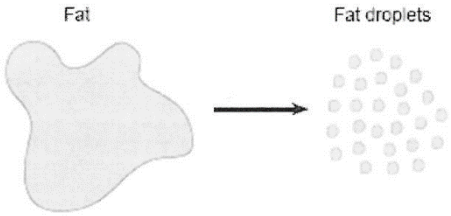
113. Emulsification of fat occurs in structure
a. E b. F c. G d. H

114. In which structure is pH the lowest?
a. D b. H c. G d. J

115. In what structure does digestion not occur?
a. G b. H c. I d. K

116. Structure O is known as
a. muscle tissue
b. columnar epithelial cells
c. nervous tissue
d. connective tissue

117. Secretions from which structure would have the effect shown in the diagram?



a. mouth b. E c. H d. G

118. Which structure produces enzymes that digest protein, carbohydrates, and fats?
a. G b. H c. I d. E

119. Which structure stores bile?
a. E b. F c. G d. H e. I

120. Structure I produces enzymes that catalyze which of the following reactions?
a. maltose + water → glucose
b. protein + water → peptides
c. peptides + water → amino acids
d. fat + bile → fat droplets
e. nucleic acids + water → nucleotides

ID: A

BIOLOGY 12 FINAL EXAM PART #1

Answer Section

MULTIPLE CHOICE

1. ANS: A PTS: 1
2. ANS: B PTS: 1
3. ANS: D PTS: 1
4. ANS: D PTS: 1
5. ANS: A PTS: 1
6. ANS: B PTS: 1
7. ANS: A PTS: 1
8. ANS: D PTS: 1
9. ANS: C PTS: 1
10. ANS: B PTS: 1
11. ANS: B PTS: 1
12. ANS: A PTS: 1
13. ANS: D PTS: 1
14. ANS: B PTS: 1
15. ANS: C PTS: 1
16. ANS: A PTS: 1
17. ANS: B PTS: 1
18. ANS: B PTS: 1
19. ANS: B PTS: 1
20. ANS: B PTS: 1
21. ANS: C PTS: 1
22. ANS: C PTS: 1
23. ANS: D PTS: 1
24. ANS: C PTS: 1
25. ANS: C PTS: 1
26. ANS: B PTS: 1
27. ANS: A PTS: 1
28. ANS: A PTS: 1
29. ANS: A PTS: 1
30. ANS: C PTS: 1
31. ANS: D PTS: 1
32. ANS: B PTS: 1
33. ANS: A PTS: 1
34. ANS: C PTS: 1
35. ANS: C PTS: 1
36. ANS: B PTS: 1
37. ANS: B PTS: 1
38. ANS: A PTS: 1
39. ANS: C PTS: 1

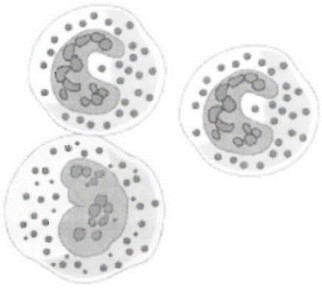
40. ANS: D PTS: 1
41. ANS: A PTS: 1
42. ANS: A PTS: 1
43. ANS: C PTS: 1
44. ANS: C PTS: 1
45. ANS: A PTS: 1
46. ANS: D PTS: 1
47. ANS: D PTS: 1
48. ANS: C PTS: 1
49. ANS: E PTS: 1
50. ANS: C PTS: 1
51. ANS: A PTS: 1
52. ANS: C PTS: 1
53. ANS: A PTS: 1
54. ANS: B PTS: 1
55. ANS: D PTS: 1
56. ANS: C PTS: 1
57. ANS: D PTS: 1
58. ANS: C PTS: 1
59. ANS: C PTS: 1
60. ANS: C PTS: 1
61. ANS: B PTS: 1
62. ANS: C PTS: 1
63. ANS: D PTS: 1
64. ANS: A PTS: 1
65. ANS: C PTS: 1
66. ANS: D PTS: 1
67. ANS: D PTS: 1
68. ANS: B PTS: 1
69. ANS: C PTS: 1
70. ANS: C PTS: 1
71. ANS: B PTS: 1
72. ANS: C PTS: 1
73. ANS: B PTS: 1
74. ANS: C PTS: 1
75. ANS: B PTS: 1
76. ANS: A PTS: 1
77. ANS: D PTS: 1
78. ANS: D PTS: 1
79. ANS: B PTS: 1
80. ANS: C PTS: 1
81. ANS: C PTS: 1
82. ANS: C PTS: 1
83. ANS: E PTS: 1
84. ANS: A PTS: 1

85. ANS: E PTS: 1
86. ANS: B PTS: 1
87. ANS: A PTS: 1
88. ANS: E PTS: 1
89. ANS: D PTS: 1
90. ANS: B PTS: 1
91. ANS: E PTS: 1
92. ANS: E PTS: 1
93. ANS: E PTS: 1
94. ANS: D PTS: 1
95. ANS: D PTS: 1
96. ANS: B PTS: 1
97. ANS: A PTS: 1
98. ANS: D PTS: 1
99. ANS: B PTS: 1
100. ANS: D PTS: 1
101. ANS: B PTS: 1
102. ANS: D PTS: 1
103. ANS: A PTS: 1
104. ANS: C PTS: 1
105. ANS: B PTS: 1
106. ANS: C PTS: 1
107. ANS: E PTS: 1
108. ANS: C PTS: 1
109. ANS: B PTS: 1
110. ANS: A PTS: 1
111. ANS: C PTS: 1
112. ANS: A PTS: 1
113. ANS: C PTS: 1
114. ANS: B PTS: 1
115. ANS: C PTS: 1
116. ANS: B PTS: 1
117. ANS: B PTS: 1
118. ANS: C PTS: 1
119. ANS: B PTS: 1
120. ANS: B PTS: 1

BIOLOGY 12 2012 FINAL EXAM PART #2

Multiple Choice
Identify the choice that best completes the statement or answers the question.

Use the diagram below to answer the following THREE (3) questions

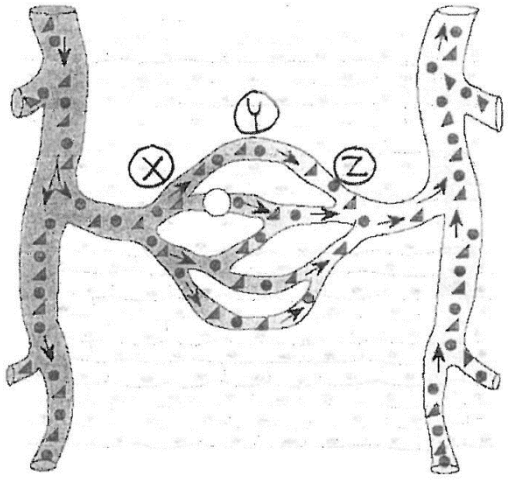


1. The diagram shows
   a. thrombocytes
   b. leukocytes
   c. erythrocytes
   d. fragmentation

2. A function of the cells above is to
   a. carry oxygen
   b. fight infection
   c. promote clotting
   d. carry dissolved nutrients

3. Which of the following best describes the shape of these structures?
   a. no fixed shape
   b. always oval
   c. circular with dents in the middle
   d. always circular

Use the diagram below to answer the following FOUR (4) questions



4. Which of the following describes the net movement of water at location X?
   a. net movement of water into the tissues because blood pressure is less than osmotic pressure
   b. net movement of water into the tissues because blood pressure is greater than osmotic pressure
   c. net movement of water into the capillaries because blood pressure is less than osmotic pressure
   d. net movement of water into the capillaries because blood pressure is greater than osmotic pressure

5. If osmotic pressure is constant at 25 mm Hg, which of the following BEST describes what occurs at Y?

	EVENT	BLOOD PRESSURE (mm Hg)
A.	nutrients move from the capillaries to the tissues	10
B.	nutrients move from the capillaries to the tissues	40
C.	wastes move into the capillaries from the tissues	25
D.	wastes move into the capillaries from the tissues	40

a. A b. B c. C d. D

6. How many of the substances in the chart below would be found in higher concentrations at location Z when compared to location X?

substances
urea
oxygen
glucose
amino acids
carbon dioxide

a. 1 b. 2 c. 3 d. 4

7. Oxygen, glucose, and amino acids
   a. are forced from the capillaries to the tissues at point Z
   b. are forced from the tissues to the capillaries at point Y
   c. are forced from the capillaries to the tissues at point X
   d. are forced from the tissues to the capillaries at point X

Use the diagram below to answer the following THREE (3) questions

8. The diagram shows
   a. thrombocytes b. erythrocytes c. leukocytes d. white blood cells

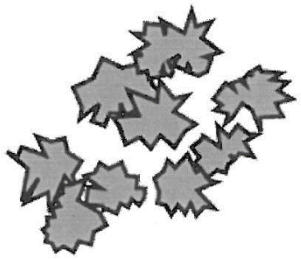
9. These structures
   a. clot blood and fight infection
   b. carry oxygen
   c. carry carbon dioxide and engulf bacteria
   d. transport carbon dioxide and provide immunity against disease

10. Which of the following correctly describes the structure and function of the above structure?

	STRUCTURE	FUNCTION
A	cell fragment	initiates clotting
B	has a nucleus	fights infection
C	biconcave	produces antibodies
D	no nucleus	transports oxygen

a. A b. B c. C d. D

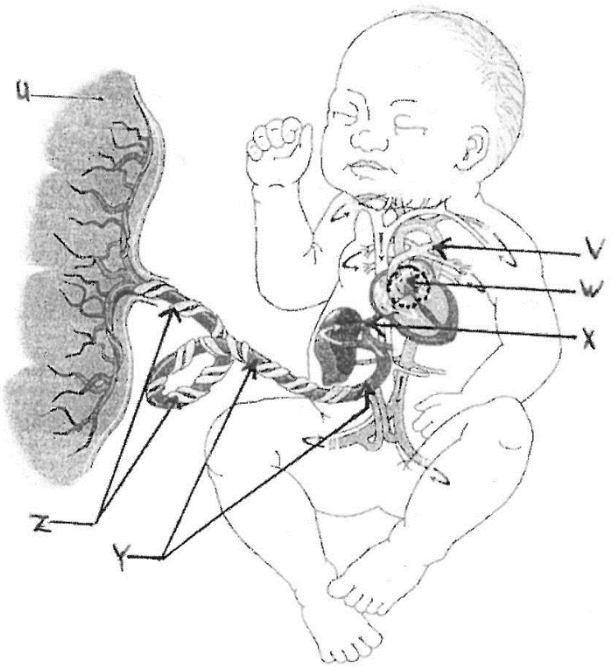
Use the diagram below to answer the following TWO (2) questions



11. Blood which lacks these structures would not be able to
    a. clot
    b. carry oxygen
    c. fight infections
    d. transport nutrients

12. These structures are known as
    a. erythrocytes b. leukocytes c. thrombocytes d. plasmocytes

Use the diagram below to answer the following FOUR (4) questions



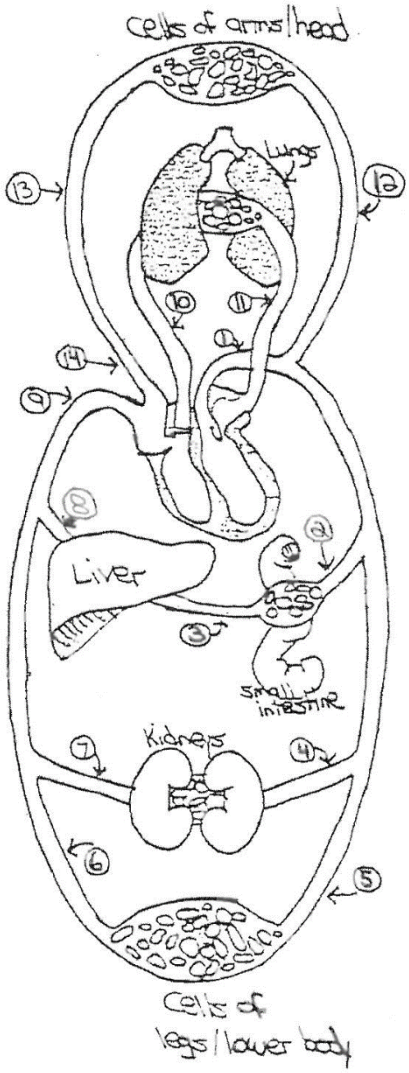
13. The function of structure V in a fetus is to
    a. allow blood to bypass the lungs
    b. increase the supply of blood to the lungs
    c. allow blood to flow from the aorta to the ventricle
    d. equalize the pressure between the right and left atria

14. The venous duct is structure
    a. V b. W c. X d. Y e. Z

15. Which structure would have the highest concentration of nutrients?
    a. V b. w c. X d. Y e. Z

16. Which of the following would occur as a result of structure W remaining open after birth?
    a. blood pressure in the lungs would increase
    b. the heart would immediately stop beating
    c. blood in the right atrium would mix with blood in the left atrium
    d. a greater amount of blood would flow into the pulmonary system

Use the diagram below to answer the following SEVEN (7) questions



17. Which of the following accurately compares blood vessels #1 and #10
    a. both are high in oxygen
    b. both are high in carbon dioxide
    c. #1 is high in oxygen, #10 is low in oxygen
    d. #1 is high in carbon dioxide, #10 is high in oxygen

18. Which number indicates the subclavian artery?
    a. 1 b. 5 c. 13 d. 12

19. In which structure does blood contain the greatest concentration of oxygen?
    a. 1 b. 13 c. 10 d. 9

20. Blood vessel 7 is the
    a. renal artery b. renal vein c. iliac vein d. mesenteric vein

21. In which of the following vessels would blood contain the highest concentration of carbon dioxide?
    a. 1 b. 12 c. 10 d. 11

22. The superior vena cava is labeled
    a. 9 b. 10 c. 12 d. 14

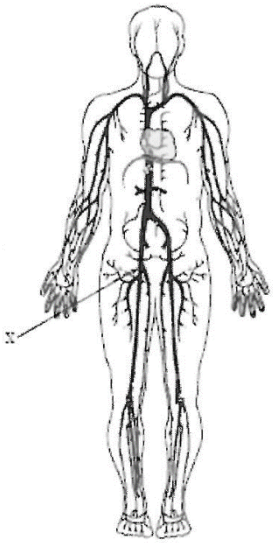
23. Structure #3 is the
    a. iliac vein
    b. renal vein
    c. jugular vein
    d. hepatic portal vein

24. Which of the following would describe the path of blood in the pulmonary circuit?
    a. right ventricle, pulmonary trunk, pulmonary vein, left atrium
    b. left ventricle, pulmonary vein, pulmonary trunk, right atrium
    c. right ventricle, pulmonary vein, pulmonary artery, left atrium
    d. right atrium, pulmonary trunk, aorta, vena cava, right atrium

25. The blood vessel shown carries blood between organs at locations X and Y. Blood flow through the vessel would be from the

    a. heart at X to the kidneys at Y
    b. intestine at Y to the liver at X
    c. heart at Y to the kidneys at X
    d. intestine at X to the liver at Y

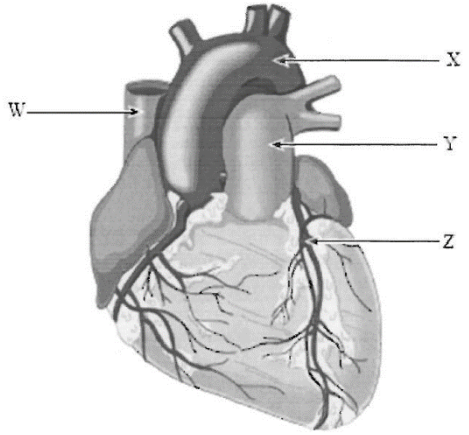
26. The structure labeled X in the diagram below is the



a. iliac vein
b. renal vein
c. subclavian vein
d. posterior vena cava

27. Antibodies function to
a. engulf and destroy antigens
b. spread antigen throughout the lymphatic system
c. deactivate antigens
d. deactivate white blood cells

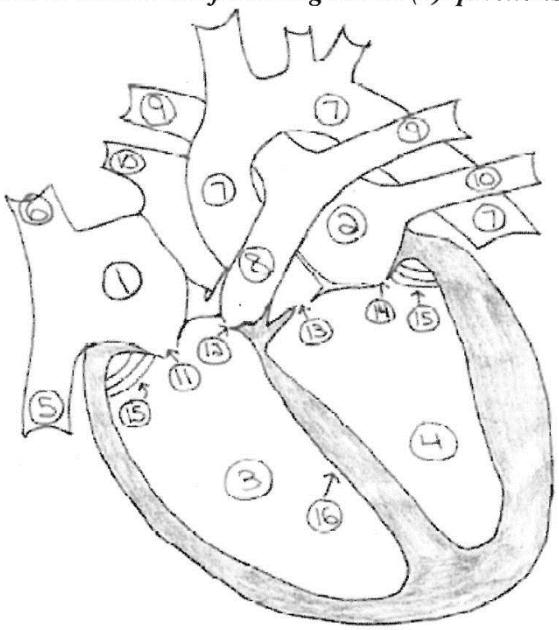
Use the diagram below to answer the following two (2) questions



28. The blood vessel labeled Z is the
    a. carotid artery b. aorta c. coronary artery d. heart vessel

29. Build-up of fats in Z
    a. may result in less oxygen and nutrients reaching the heart
    b. helps in clearing wastes away from the heart muscle
    c. is mainly caused by a high fibre diet
    d. is always harmless and is a natural part of the ageing process

Use the diagram below to answer the following NINE (9) questions



30. The blood vessel labelled #8 carries high levels of
    a. oxygen towards the heart
    b. oxygen away from the heart
    c. carbon dioxide towards the heart
    d. carbon dioxide away from the heart

31. Under which of the following conditions would structure #13 be open?
    a. the aorta is constricting
    b. the atrium is contracting
    c. the ventricle is contracting
    d. the pulmonary vein is constricting

32. What structure is the superior vena cava?
    a. 5 b. 6 c. 7 d. 9 e. 15

33. The function of structure #2 is
    a. pump low oxygen blood to the lungs
    b. receive high oxygen blood from the lungs
    c. pump high oxygen blood to the body tissues
    d. receive low oxygen blood from the body tissues

34. In which vessel is blood pressure the highest?
    a. 5 b. 6 c. 7 d. 9

35. Purkinje fibres would be found in structure #
    a. 6 b. 7 c. 11 d. 15 e. 16

36. The mitral valve is structure #
a. 11 b. 12 c. 13 d. 14

37. The tricuspid valve is structure #
a. 11 b. 12 c. 13 d. 14

38. In which structure is the SA node located?
a. 1 b. 2 c. 3 d. 4

39. Examine the statements below

1. atria contract
2. Purkinje fibres conduct
3. SA node stimulates
4. AV node stimulates
5. ventricles contract

Which of the following describes a correct sequence?
a. 1 > 4 > 2 > 5 b. 2 > 5 > 4 > 1 c. 3 > 5 > 4 > 1 d. 4 > 1 > 2 > 5

40. Initiation of the cardiac cycle is dependent on the
a. sinoatrial (SA) node
b. sympathetic nervous system
c. parasympathetic nervous system
d. nerve impulses from the AV node

The average resting blood pressure and blood velocities were measured in various blood vessels of an person as shown in the table below.

Use the chart below to identufy the type of blood vessel asked for in the following FOUR (4) questions

BLOOD VESSEL	AVERAGE BLOOD VELOCITY (cm/s)	AVERAGE BLOOD PRESSURE (mm Hg)
A	48.0	100
B	0.5	22
C	15.0	60
D	25.0	2
E	4.0	10

41. Vessel A is a(n)
a. artery b. arteriole c. capillary d. venule e. vein

42. Vessel C is a(n)
    a. artery b. arteriole c. capillary d. venule e. vein

43. The velocity in structure B is due to
    a. low cross sectional area
    b. a large blood vessel diameter
    c. distance from the heart
    d. high branching

44. Velocity in D is higher than velocity in C because
    a. D is closer to the heart than C
    b. C has a larger cross sectional area
    c. D has a wider diameter than C
    d. C has a higher blood pressure

45. High blood pressure can be the result of
    a. decreased blood volume
    b. increased salt in the diet
    c. opening of the capillary beds
    d. decreased stress

46. Which of the following is normal systolic blood pressure for an adult at rest?
    a. 50 mm Hg b. 80 mm Hg c. 120 mm Hg d. 180 mm Hg

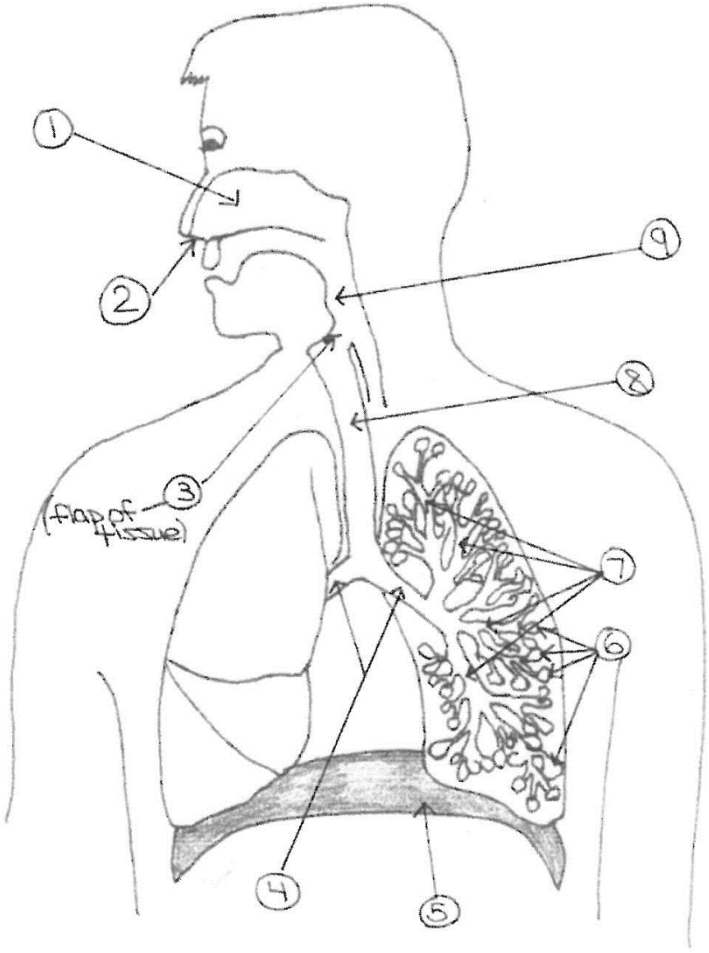
47. Use the table of events shown below to answer the question that follows:

    1 - systole of the ventricles
    2 - opening of the atrio-ventricular valves
    3 - electrical impulse sent from the SA node
    4 - atria fill with blood

    The order in which the events below occur during one heartbeat (the cardiac cycle) is

    a. 2,1,3,4 b. 2,3,4,1 c. 4,1,3,2 d. 4,3,2,1

Use the diagram below to answer the following SIX (6) questions



48. In which area do voice sounds originate?
    a. 1 b. 2 c. 3 d. 9 e. 8

49. What structure prevents food from entering the respiratory system?
    a. 1 b. 2 c. 3 d. 8 e. 9

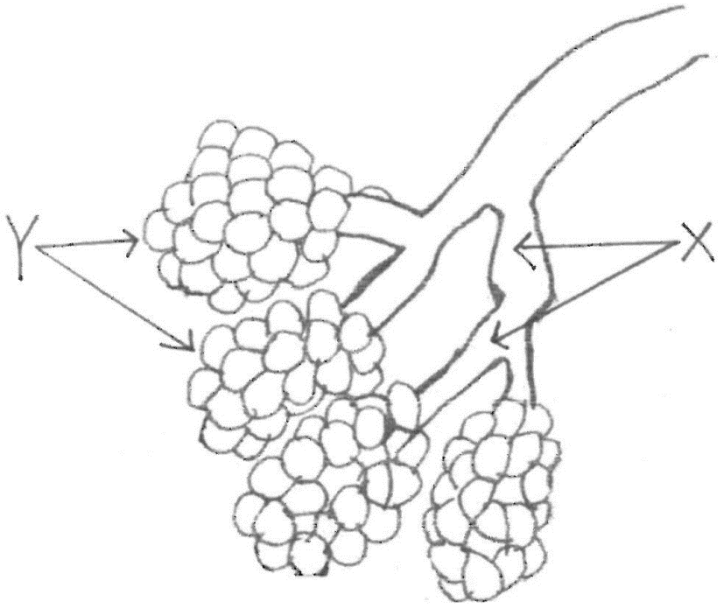
50. Which structure is capable of constricting and dilating as a result of the contraction of the surrounding smooth muscle?
    a. 8 b. 9 c. 7 d. 6 e. 5

51. Which structure responds to nerve impulses from the medulla oblongata?
    a. 1 b. 2 c. 9 d. 8 e. 5

52. Which reaction happens at structure #6?
    a. $Hb + CO_2 \rightarrow HbCO_2$
    b. $CO_2 + H_2O \rightarrow H^+ + HCO_3^-$
    c. $HbO_2 \rightarrow Hb + O_2$
    d. $H^+ + HCO_3^- \rightarrow CO_2 + H_2O$

53. Which of the following is caused by the contraction of structure #5?
    a. exhalation
    b. relaxation of the rib muscles
    c. downward movement of the rib cage
    d. increased volume of the chest cavity

Use the diagram below to answer the following THREE (3) questions



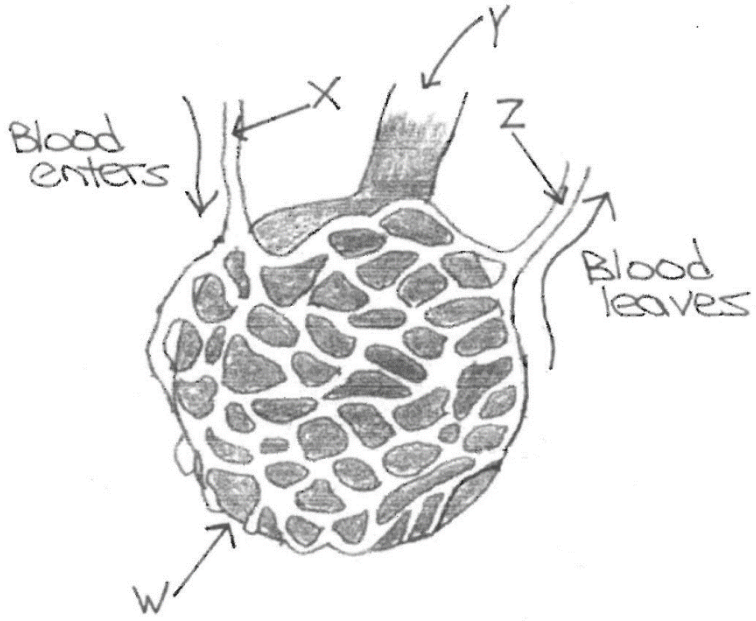
54. The structure labelled X in the diagram is a(n)
    a. trachea b. alveolus c. bronchus d. bronchiole

55. The structures labelled Y are
    a. villi
    b. alveoli
    c. bronchioles
    d. lymph nodes
    e. bronchi

56. Which of the following pairs of reactions occurs most frequently in the blood surrounding the structure shown?
    a. $Hb + O_2 \rightarrow HbO_2$ and $HHb \rightarrow Hb + H^+$
    b. $HbO_2 \rightarrow Hb + O_2$ and $Hb + H^+ \rightarrow HHb$
    c. $H^+ + Hb \rightarrow HHb$ and $H_2CO_3 \rightarrow HCO_3^- + H^+$
    d. $CO_2 + H_2O \rightarrow H_2CO_3$ and $H_2CO_3 \rightarrow HCO_3^- + H^+$

57. Which of the following is a characteristic that aids in the function of the structures shown at Y?
    a. they have lipoproteins to prevent collapse
    b. they have cilia and mucus to remove debris
    c. they have a two or three cell layer thickness to provide strength
    d. they have a low surface-area-to-volume ratio to allow for quick exchange of gases

Use the diagram below to answer the following THREE (3) questions



58. What is a characteristic of the blood vessel X if it is carrying blood towards Z?
    a. the concentration of oxyhemoglobin is high
    b. the concentration of bicarbonate ions is high
    c. the concentration of reduced hemoglobin is low
    d. the concentration of carbaminohemoglobin is low

59. Which of the following represents the composition of blood at X shown in the diagram above?

	OXYHEMOGLOBIN (HbO_2)	BICARBONATE ION (HCO_3^-)	REDUCED HEMOGLOBIN (HHb)
A	low	high	high
B	high	low	low
C	low	low	high
D	high	high	low

a. A b. B c. C d. D

60. Which of the following represents the composition of blood at Z shown in the diagram above?

	OXYHEMOGLOBIN (HbO_2)	BICARBONATE ION (HCO_3^-)	REDUCED HEMOGLOBIN (HHb)
A	low	high	high
B	high	low	low
C	low	low	high
D	high	high	low

a. A b. B c. C d. D

61. The exchange of oxygen and carbon dioxide in external respiration occurs by
a. osmosis
b. diffusion
c. active transport
d. facilitated diffusion

62. Which of the following reactions would occur in the capillary of a leg?
a. $Hb + H^+ \rightarrow HHb$
b. $HbCO_2 \rightarrow Hb + CO_2$
c. $Hb + O_2 \rightarrow HbO_2$
d. $H^+ + HCO_3^- \rightarrow H_2CO_3$

63. If the hydrogen ion concentration in the blood increases, the breathing control center in the brain will
a. decrease thoracic cavity volume
b. decrease rib muscle contractions
c. increase contractions of the diaphragm
d. increase pressure in the thoracic cavity

64. What is the correct order of the events below?

#1 - the volume of the thoracic cavity increases
#2 - the intercostal muscles contract
#3 - air enters the lungs
#4 - exhalation occurs
#5 - the diaphragm relaxes

a. $2 \rightarrow 1 \rightarrow 3 \rightarrow 5 \rightarrow 4$
b. $2 \rightarrow 3 \rightarrow 5 \rightarrow 1 \rightarrow 4$
c. $5 \rightarrow 1 \rightarrow 2 \rightarrow 3 \rightarrow 4$
d. $5 \rightarrow 1 \rightarrow 3 \rightarrow 4 \rightarrow 2$

65. Blood supply to an arm is cut off. Blood in the arm is sampled after five minutes and analyzed. Which of the following would occur?

	CONCENTRATION OF HHb	CONCENTRATION OF HbO_2	CONCENTRATION OF HCO_3^-
A	low	high	low
B	low	low	high
C	high	low	high
D	high	high	low

a. A b. B c. C d. D

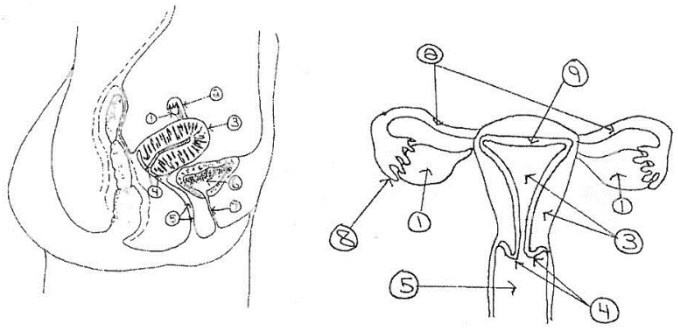
66. Partial pressure of carbon dioxide (PCO_2)
   a. causes active transport of carbon dioxide from capillary to alveoli
   b. is higher in the body tissue than the capillaries in the body tissue
   c. is higher in the alveoli than in the capillaries surrounding the alveoli
   d. is higher in the capillaries inside the body tissue than in the body tissue itself

Use the chart below to answer the following question

ACTIVITY	RATE OF AIR INTAKE
EXRECISE	**7-8 LITRES POER MINUTE**
SITTING (AT REST)	**4-5 LITRES PER MINUTE**
SLEEPING	**2 LITRES PER MINUTE**

67. What is ***directly*** responsible for the change in the rate of air intake during exercise?
   a. the increased need for oxygen
   b. the increased need for energy
   c. an increase in CO_2 levels iun the blood
   d. all of these are correct

Use the diagram below to answer the following questions



68. Structure 4 is the
    a. ovary b. cervix c. vagina d. oviduct

69. What will occur in structure 3 if there is a reduction in hormones secreted from the ovary?
    a. the release of an egg c. the maturation of a follicle
    b. increased vascularization d. the breakdown of the endometrium

70. In which structure does fertilization normally occur?
    a. 1 b. 2 c. 3 d. 4 e. 5

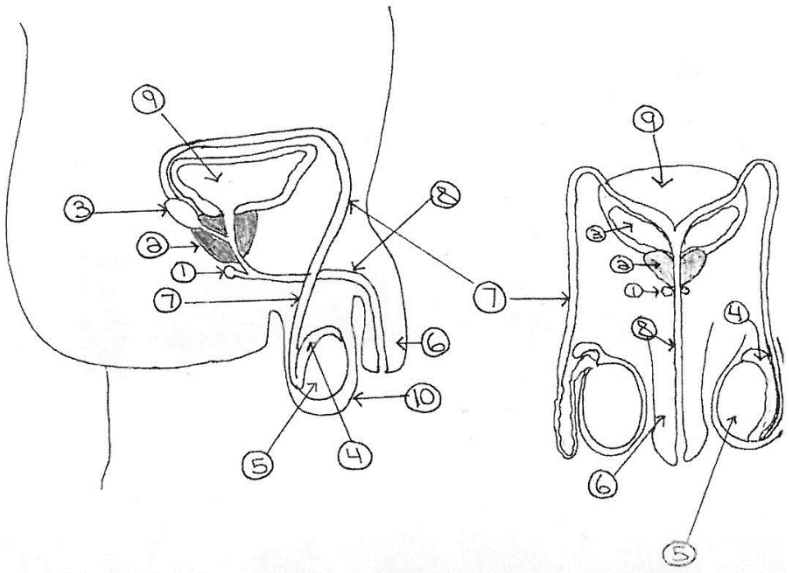
71. Which structure is the site of fetal development?
    a. 1 b. 2 c. 3 d. 4 e. 5

72. The stimulation of which structure results in the release of oxytocin during childbirth?
    a. 1 b. 2 c. 3 d. 5 e. 7

73. Which labeled structure secretes hormones that cause the changes that occur in the female body during puberty?
    a. 1 b. 2 c. 3 d. 4 e. 5

74. Which structure reacts to prostaglandins?
    a. 1 b. 2 c. 3 d. 4 e. 6

Use the diagram below to answer the following SEVEN (7) questions



75. Which of the following correctly describes the pathway sperm follow from their formation to their exit from the body?
    a. 6 > 9 > 5 > 8 b. 5 > 4 > 9 > 3 c. 5 > 4 > 3 > 9 d. 5 > 4 > 7 > 8

76. Which of the following is a function of the secretions from structure #5?
    a. to buffer the pH of the semen
    b. to cause beard growth at puberty
    c. to cause rhythmic contractions of the uterus
    d. to cause increased secretion of releasing hormones

77. Structure #3 refers to which of the following?
    a. testes b. epididymis c. vas deferens d. seminal vesicles

78. Which two structures contribute fluids that make up semen?
    a. 4 and 9 b. 3 and 8 c. 2 and 9 d. 2 and 3 e. 1 and 9

79. Which letter indicates a structure that does not produce fluids that make up semen?
    a. 1 b. 2 c. 3 d. 9

80. Which letter indicates the seminal vesicle?
    a. 1 b. 2 c. 3 d. 7 e. 8

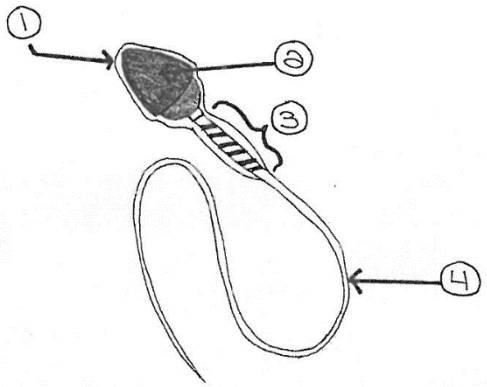
81. Which structure in the diagram is the target of follicle-stimulating hormone (FSH)?
    a. 1 b. 2 c. 3 d. 4 e. 5

82. In the diagram below, where does sperm maturation occur?
a. 1 b. 2 c. 3 d. 4 e. 5

83. Spermatogenesis occurs in structure #
a. 4 b. 5 c. 9 d. 2 e. 3

84. Which structure is responsible for producing a substance that causes contraction in the uterus of the female?
a. 1 b. 2 c. 3 d. 4 e. 5

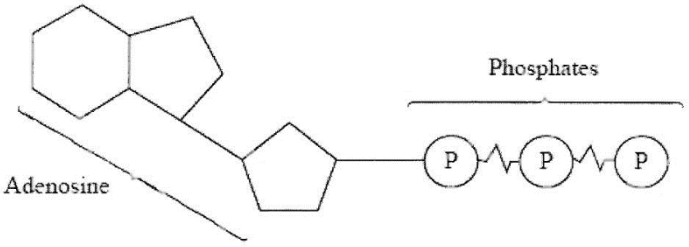
Use the diagram below to answer the following THREE (3) questions



85. Which structure contains enzymes that help the sperm to penetrate the egg?
a. 1 b. 2 c. 3 d. 4

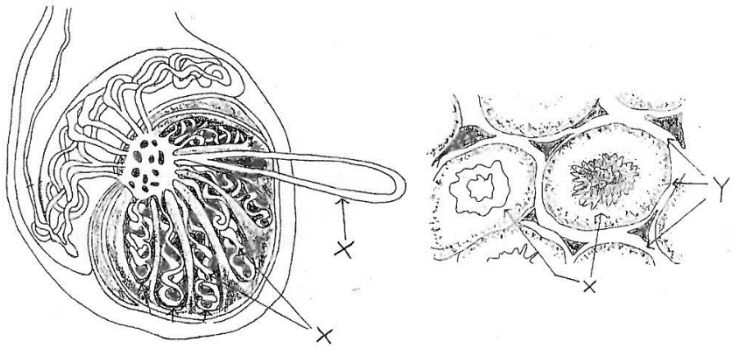
86. Which structure contains high numbers of mitochondria?
a. 1 b. 2 c. 3 d. 4

87. The molecule shown below is produced in which structure?



a. 1 b. 2 c. 3 d. 4

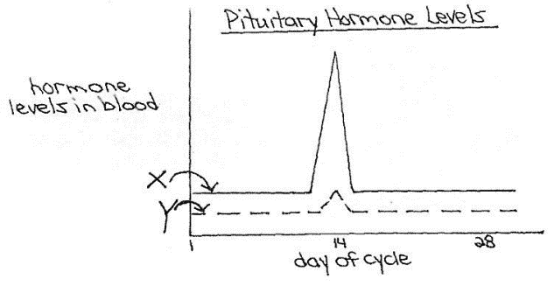
Use the diagram below to answer the following TWO (2) questions



88. What hormone works on structure Y?
    a. luteinizing hormone
    b. follicle stimulating hormone
    c. gonadotropin releasing hormone
    d. oxytocin

89. What hormone works on structure X?
    a. luteinizing hormone
    b. follicle stimulating hormone
    c. gonadotropin releasing hormone
    d. oxytocin

Use the graph below to answer the following THREE (3) questions

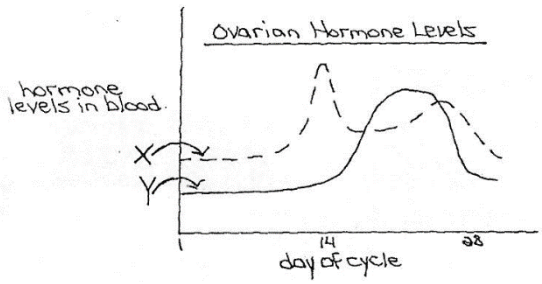


90. On what day in this cycle does ovulation take place?
    a. 1 b. 7 c. 14 d. 28

91. Which of the following best describes the function(s) of hormone X?
    a. trigger ovulation and help with development of primary oocyte
    b. develop the primary follicle and corpus luteum
    c. to trigger contractions of the uterus during child delivery
    d. trigger ovulation and help develop the corpus luteum
    e. aid in development of the follicle

92. Which of the following best describes the function(s) of hormone Y?
    a. trigger ovulation and help with development of primary oocyte
    b. develop the primary follicle and corpus luteum
    c. to trigger contractions of the uterus during child delivery
    d. trigger ovulation and help develop the corpus luteum
    e. aid in development of the follicle

Use the diagram below to answer the following THREE (3) questions

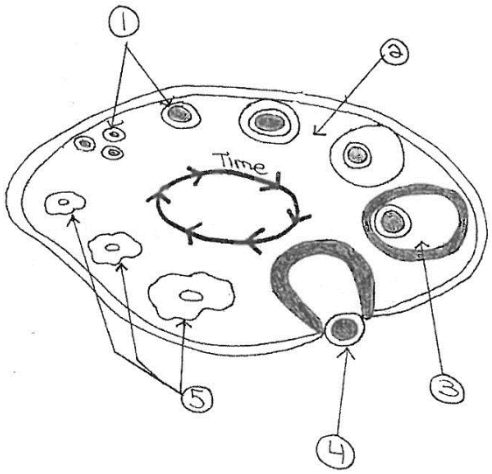


93. Hormone X is
    a. estrogen b. progesterone c. LH d. FSH e. GnRH

94. What affect does the rise in hormone Y have on the pituitary gland?
    a. a decrease in secretion of estrogen
    b. a decrease in secretion of progesterone
    c. a decrease in release of follicle stiumulating hormone (FSH)
    d. a decrease in release of luteinizing hormone (LH)
    e. a decrease in release of oxytocin

95. What affect do the rising levels of hormone Y have on the endometrium?
    a. it causes the endometrium to break down c. it causes the endometrium to thicken
    b. it causes ovulation d. causes break-down of the follicle

Use the diagram below to answer the following FIVE (5) questions



96. Which substance causes the development of structure #5?
    a. estrogen
    b. luteinizing hormone (LH)
    c. follicle stimulation hormone (FSH)
    d. human chorionic gonadotropin (HCG)

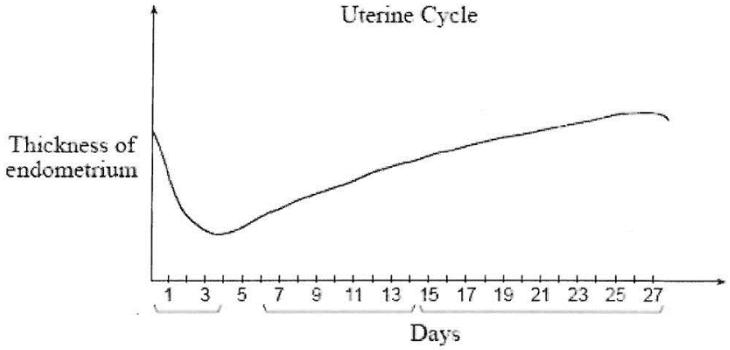
97. Which structure is maintained by the release of human chorionic gonadotropin (HCG)?
    a. 1 b. 2 c. 3 d. 4 e. 5

98. ***"Produces large amounts of estrogen and some progesterone"*** best describes which structure?
    a. 2 b. 3 c. 4 d. 5

99. ***"Produces large amounts of progesterone and some estrogen"*** best describes which structure?
    a. 1 b. 2 c. 3 d. 4 e. 5

100. The event shown at #4 occurs mainly in response to
    a. a surge in oxytocin levels
    b. a surge in FSH levels
    c. a surge in LH levels
    d. a surge in progesterone levels
    e. a surge in testosterone levels

Use the diagram below to answer the following TWO (2) questions

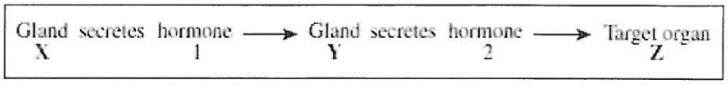


101. What occurs to cause the change that begins at about day 5?
   a. the corpus luteum increases progesterone production
   b. the anterior pituitary increases release of follicle stimulating hormone (FSH)
   c. the anterior pituitary increases release of luteinizing hormone (LH)
   d. the hypothalamus decreases release of gonadotropin releasing hormone (GnRH)

102. What event happens on about day 24 that leads to the changes seen at days 1-3 on the graph?
   a. the corpus luteum produces increased levels of estrogen and progesterone
   b. the pituitary increases its release of luteinizing hormone
   c. the corpus luteum breaks down
   d. the follicle breaks down
   e. increased production of human chorionic gonadotropin (HCG)

103. During days 1-13 of the ovarian cycle, what would occur if follicle stimulating hormone (FSH) was not secreted?
   a. the egg would mature too quickly
   b. estrogen levels would be very low
   c. progesterone levels would rise
   d. the female would ovulate on day 6

104. Which of the following correctly matches the glands and the hormones they secrete in the flowchart below?



	Gland X	Hormone 1	Gland Y	Hormone 2	Target organ Z
A.	hypothalamus	GnRH	anterior pituitary	LH	testes
B.	hypothalamus	GnRH	anterior pituitary	estrogen	ovaries
C.	anterior pituitary	LH	posterior pituitary	oxytocin	uterus
D.	anterior pituitary	FSH	testes	LH	interstitial cells

a. A b. B c. C d. D

105. Which of the following describes the hormonal levels on day one of the 28-day uterine cycle?

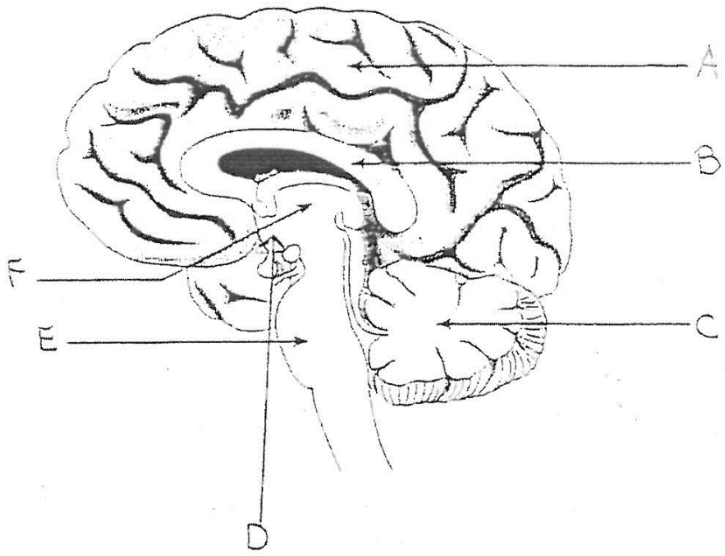
	ESTROGEN	PROGESTERONE
A.	low	high
B.	high	high
C.	low	low
D.	high	low

a. A b. B c. C d. D

106. What are days 5 to 13 of the uterine cycle called?
a. the luteal phase
b. the follicular phase
c. the secretory phase
d. the proliferation phase

107. What is an effect of oxytocin?
a. release of an egg
b. development of breasts
c. loss of the endometrium
d. production of milk
e. contraction of the uterus

Use the diagram below to answer the following FOURTEEEN (14) questions



108. Which part of the brain is responsible for increasing breathing rate during exercise?
a. A b. B c. C d. E e. F

109. Which structure sorts incoming information and channels it to the appropriate part of the brain?
a. B b. C c. D d. E e. F

110. Elevated body temperature due to a prolonged infection is due to a stimulation of which of the following structures?
a. A b. B c. C d. D e. E

111. When the hormone estrogen was administered to patients with Alzheimers disease, the memories of these patients improved. On which structure in the diagram could estrogen have an effect?
a. A b. B c. C d. D e. F

112. Studying for an exam would produce high activity in which structure?
a. A b. C c. D d. E e. F

113. Performing a gymnastics routine would produce high activity in which structure?
a. A b. C c. D d. E e. F

114. If a person's ability to integrates information from both hemispheres of the brain is impaired, the portion of the brain most likely affected is
a. A b. B c. D d. E e. F

115. The part of the brain responsible for balance is
a. A b. C c. D d. E e. F

116. Level of carbon dioxide in the blood is monitored by
a. A b. C c. D d. E e. F

117. Which of the following indicates the part of the brain containing reflex centers for swallowing and vomiting?
a. A b. B c. C d. D e. E

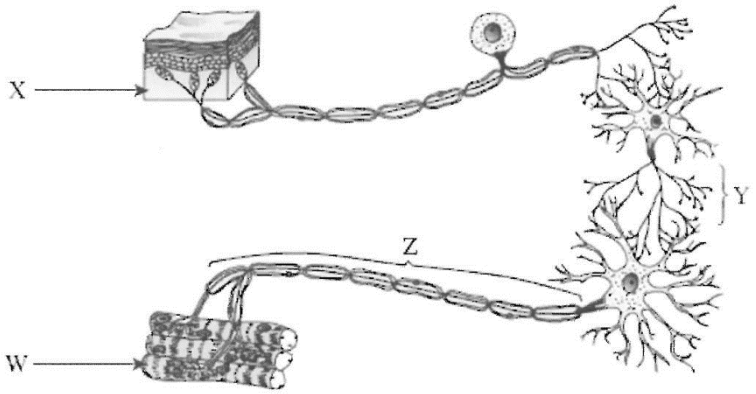
118. Structure A is the
a. corpus callosum
b. cerebrum
c. cerebellum
d. medulla oblongata
e. hypothalamus

119. Structure C is the
a. cerebellum
b. cerebrum
c. hypothalamus
d. corpus callosum
e. medulla oblongata

120. The portion of the brain involved in speech, vision, learning, and memory is structure
a. A b. B c. D d. E

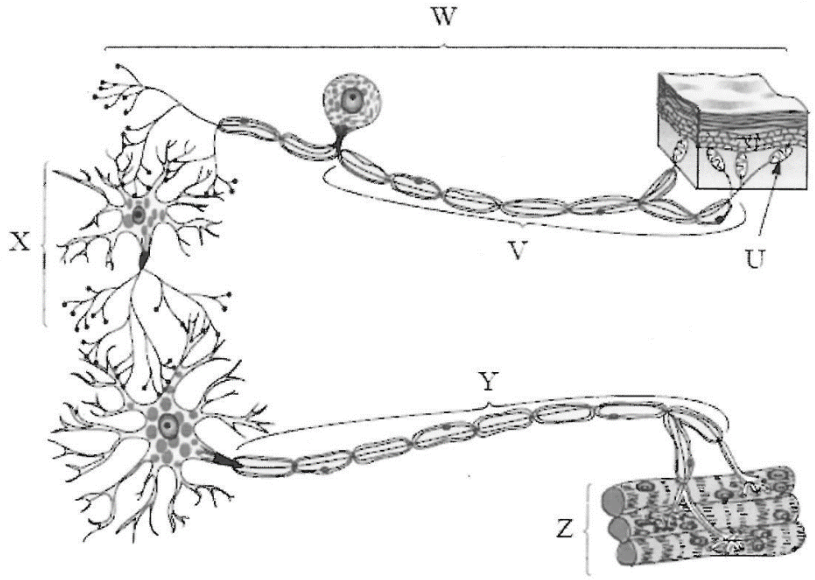
121. Structure E contains centers responsible for
a. hunger b. heart rate c. water balance d. body temperature

122. To where does the nerve impulse travel after it leaves the axon of the motor neuron?



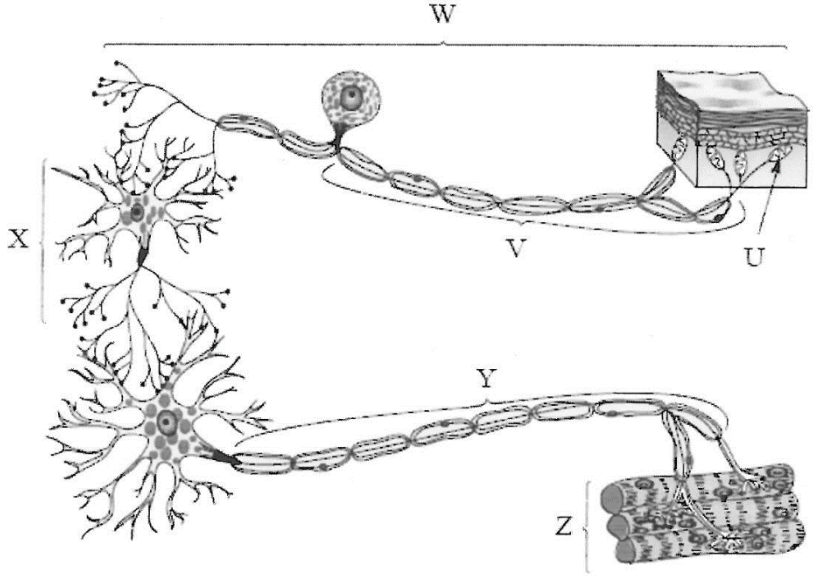
a. W b. X c. Y d. Z

123. In the diagram below, which letter indicates the sensory receptor?



a. T b. U c. V d. W e. Y

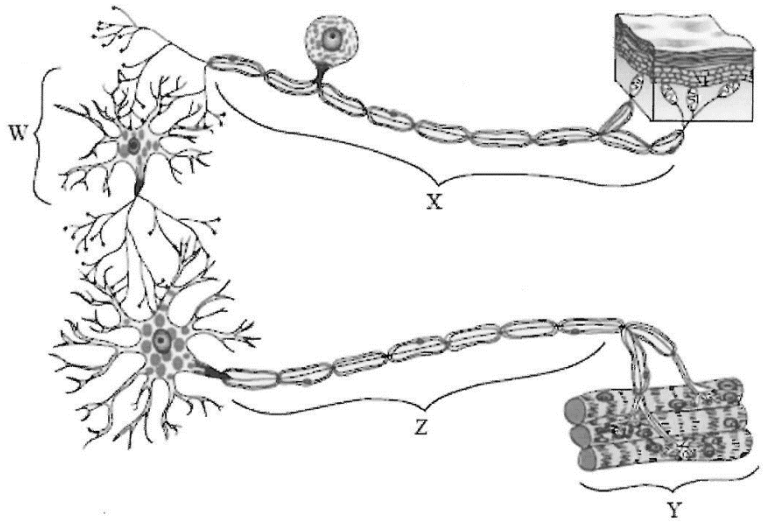
124. In the diagram below, what is the function of structure Z?



a. to detect the stimulus
b. to carry an impulse to the interneuron
c. to carry the stimulus to the motor neuron
d. to carry out the response to a stimulus

125. In a reflex arc, the
a. brain is stimulated by the effector
b. effector is stimulated before the brain
c. sensory receptor directly stimulates the effector
d. brain is stimulated at the same time as the receptor

126. In the diagram blow, what letter indicates a structure that is part of the central nervous system?



a. W b. X c. Y d. Z

127. Which of the following would be considered part of the peripheral nervous system?
a. an interneuron
b. the hypothalamus
c. a sympathetic nerve
d. the brain and spinal cord

128. In a reflex arc, interneurons initiate nerve impulses in
a. effectors
b. motor neurons
c. sensory neurons
d. sensory receptors

129. Which of the following statements about the autonomic nervous system is FALSE
a. it controls the internal organs
b. it functions in a voluntary manner
c. it is responsible for the "fight or flight" response
d. each impulse travels through two motor neurons and one ganglion

130. The somatic nervous system controls
a. peristalsis
b. cardiac muscles
c. smooth muscles
d. skeletal muscle

ID: A

BIOLOGY 12 2012 FINAL EXAM PART #2

Answer Section

MULTIPLE CHOICE

1. ANS: B PTS: 1
2. ANS: B PTS: 1
3. ANS: A PTS: 1
4. ANS: B PTS: 1
5. ANS: C PTS: 1
6. ANS: B PTS: 1
7. ANS: C PTS: 1
8. ANS: B PTS: 1
9. ANS: B PTS: 1
10. ANS: D PTS: 1
11. ANS: A PTS: 1
12. ANS: C PTS: 1
13. ANS: A PTS: 1
14. ANS: C PTS: 1
15. ANS: D PTS: 1
16. ANS: C PTS: 1
17. ANS: C PTS: 1
18. ANS: D PTS: 1
19. ANS: A PTS: 1
20. ANS: B PTS: 1
21. ANS: C PTS: 1
22. ANS: D PTS: 1
23. ANS: D PTS: 1
24. ANS: A PTS: 1
25. ANS: B PTS: 1
26. ANS: A PTS: 1
27. ANS: C PTS: 1
28. ANS: C PTS: 1
29. ANS: A PTS: 1
30. ANS: D PTS: 1
31. ANS: C PTS: 1
32. ANS: B PTS: 1
33. ANS: B PTS: 1
34. ANS: C PTS: 1
35. ANS: E PTS: 1
36. ANS: D PTS: 1
37. ANS: A PTS: 1
38. ANS: A PTS: 1
39. ANS: A PTS: 1

40. ANS: A PTS: 1
41. ANS: A PTS: 1
42. ANS: B PTS: 1
43. ANS: D PTS: 1
44. ANS: C PTS: 1
45. ANS: B PTS: 1
46. ANS: C PTS: 1
47. ANS: D PTS: 1
48. ANS: D PTS: 1
49. ANS: C PTS: 1
50. ANS: C PTS: 1
51. ANS: E PTS: 1
52. ANS: D PTS: 1
53. ANS: D PTS: 1
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83. ANS: B PTS: 1
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86. ANS: C PTS: 1
87. ANS: C PTS: 1
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92. ANS: E PTS: 1
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94. ANS: D PTS: 1
95. ANS: C PTS: 1
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99. ANS: E PTS: 1
100. ANS: C PTS: 1
101. ANS: B PTS: 1
102. ANS: C PTS: 1
103. ANS: B PTS: 1
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105. ANS: C PTS: 1
106. ANS: D PTS: 1
107. ANS: E PTS: 1
108. ANS: D PTS: 1
109. ANS: E PTS: 1
110. ANS: D PTS: 1
111. ANS: A PTS: 1
112. ANS: A PTS: 1
113. ANS: B PTS: 1
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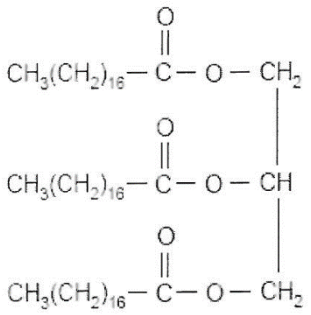
117. ANS: E PTS: 1
118. ANS: B PTS: 1
119. ANS: A PTS: 1
120. ANS: A PTS: 1
121. ANS: B PTS: 1
122. ANS: A PTS: 1
123. ANS: B PTS: 1
124. ANS: D PTS: 1
125. ANS: B PTS: 1
126. ANS: A PTS: 1
127. ANS: C PTS: 1
128. ANS: B PTS: 1
129. ANS: B PTS: 1

130. ANS: D PTS: 1

BIOLOGY 12 FINAL EXAM

Multiple Choice
Identify the choice that best completes the statement or answers the question.

1.

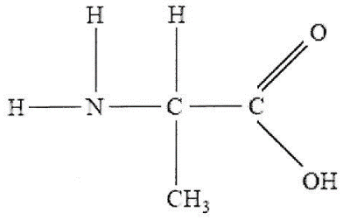


The above chemical compound is classified as a

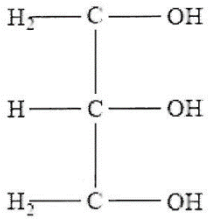
A) lipid B) nucleic acid C) protein D) carbohydrate

2. Which of the following would be produced by hydrolysis of an enzyme?

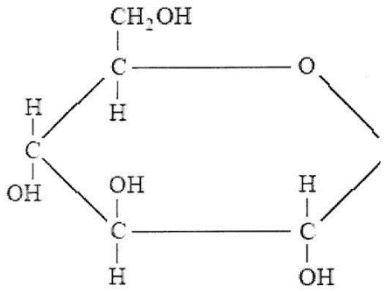
A)



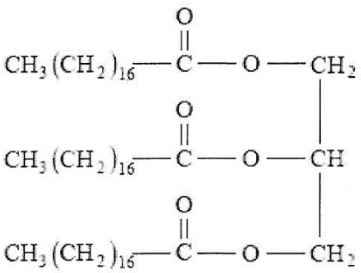
C)



B)

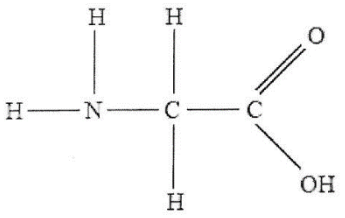


D)

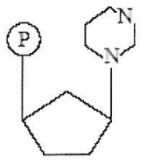


3. Which of the structures below is used for insulation of body heat in humans?

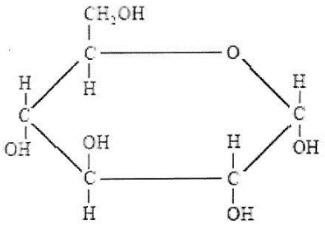
A)



C)



B)



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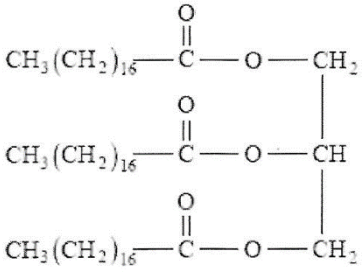
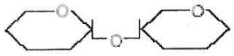
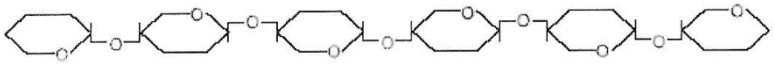


4. Which of the following would function as a structural component of plant cell walls?

A)



B)



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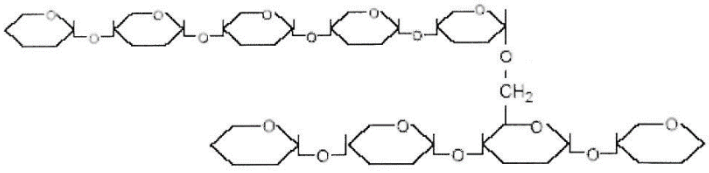

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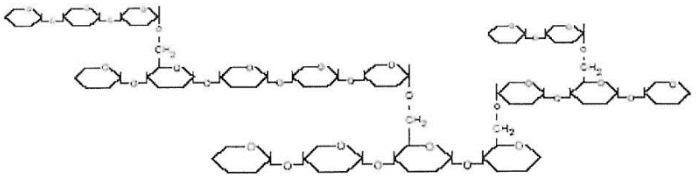
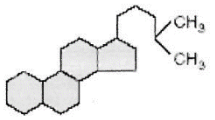
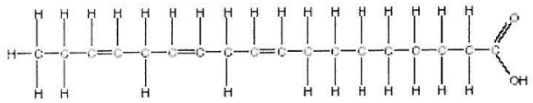


5. Which of the following molecules helps reactions to occur in the body?

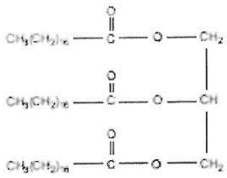
A)



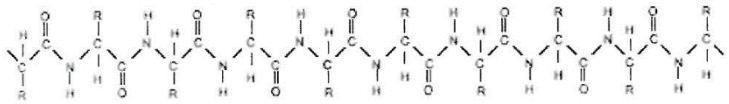
B)



C)

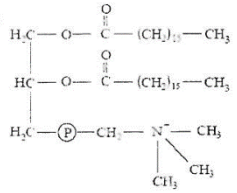


D)

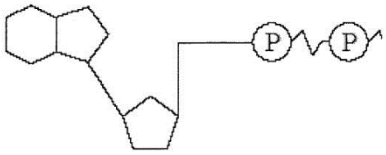


6. Which of the following represents ATP?

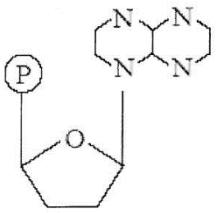
A)



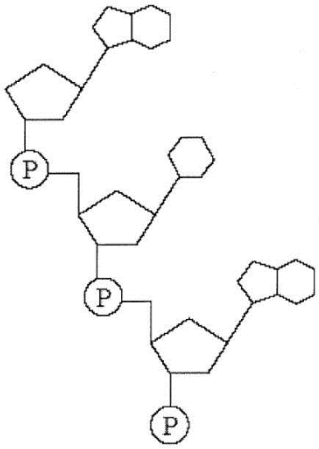
C)



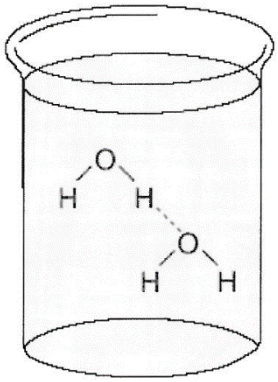
B)



D)

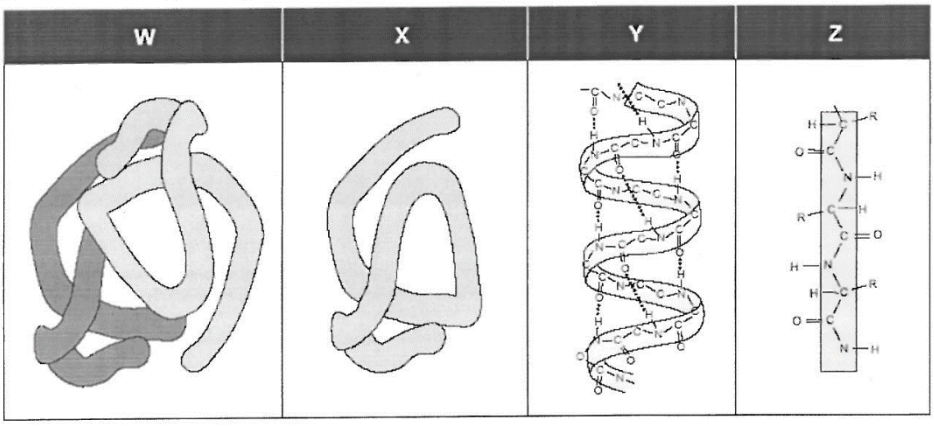


7. The type of bond shown between the two water molecules is



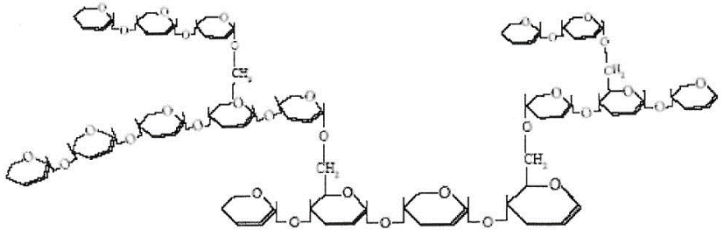
A) ionic B) peptide C) covalent D) hydrogen

8. Which of the above diagrams represents the tertiary structure of a protein?



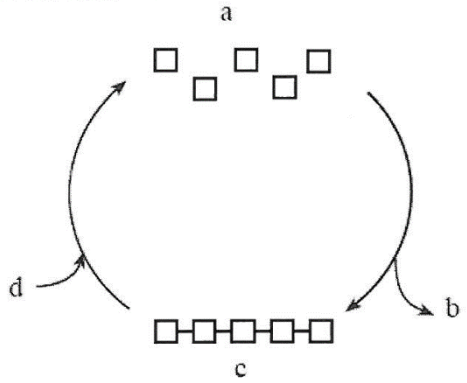
A) W B) X C) Y D) Z

9. The diagram below shows a molecule that is found in the



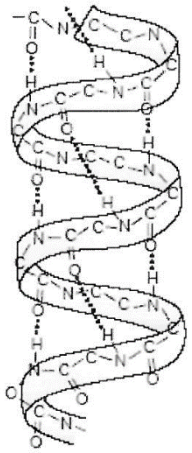
A) liver B) blood C) pancreas D) gall bladder

10. An example of a specific process that occurs in a manner similar to when A becomes C in the diagram below is



A) amino acids form a protein
B) glycerol is formed from fats
C) nucleotides are formed from nucleic acids
D) egg white coagulates when an acid is added to it

11. This diagram indicates which level(s) of protein structure?



A) only primary
B) primary and secondary
C) primary, secondary, and tertiary
D) primary, secondary, tertiary, and quaternary

12. If two amino acids are joined together, the resulting molecule is
A) a protein
B) a disaccharide
C) a fatty acid
D) a dipeptide
E) an enzyme

13. The lower the pH
    A) the greater the hydrogen ion concentration
    B) the more acidic the solution
    C) the lower the pH number
    D) all of the above answers are correct
    E) none of these

14. If the pH of a solution changes from 2 to 5, the solution has
    A) become a base
    B) lost hydrogen ions
    C) become more acidic
    D) gained hydrogen ions
    E) become neutral

15. Which of the following is a monomer?
    A) glucose B) cellulose C) starch D) glycogen E) maltose

16. Which of the following is a product of the hydrolysis of DNA?
    A) water B) ribose C) nucleotides D) an amine group

17. Which of the following describes the action of a buffer?
    A) proteins are hydrolyzed in the cell
    B) during exercise, hydrogen ions (H^+) are absorbed
    C) stomach acid breaks down food in the stomach
    D) red blood cells absorb oxygen in the lungs

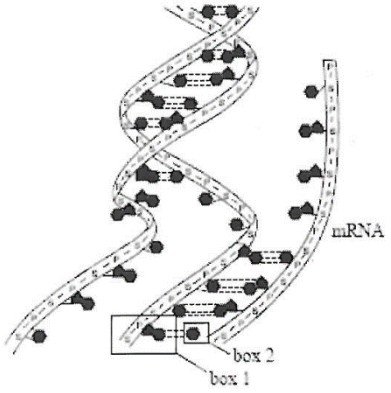
18. Which of the following food molecules is classified as a disaccharide?
    A) $C_6H_{12}O_6$
    B) $C_{12}H_{22}O_{11}$
    C) $C_{18}H_{32}O_{16}$
    D) $C_{120}H_{300}O_{120}$

19. How do saturated fats differ from unsaturated fats?
    A) they are water soluble
    B) they contain cholesterol
    C) they form straight chains
    D) their hydrogen-to-carbon ratio is larger

20. - solvent - lubricant
    - catalyst - temperature regulator

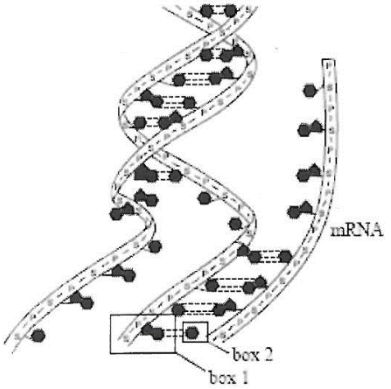
    How many of the above are role of water in the body?
    A) 0 B) 1 C) 2 D) 3 E) 4

21. The process shown in the diagram below is called



A) translation
B) transcription
C) translocation
D) transformation

22. If the base in Box 1 in the diagram below is adenine, then the base in Box 2 must be



A) uracil
B) guanine
C) cytosine
D) thymine

23. If 20% of the base molecules are guanine, how many thymine molecules are present in a DNA molecule with 1000 bases?

A) 200 B) 300 C) 400 D) 600

24. RNA consists of how many of the molecules listed below?
    - uracil
    - adenine
    - thymine
    - phosphate
    - deoxyribose

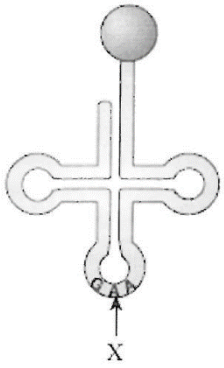
    A) 1 B) 2 C) 3 D) 4 E) 5

25. What type of chemical bond is broken during the first step in replication?
    A) ionic B) peptide C) covalent D) hydrogen

26. Which of the following is a difference between DNA and RNA?
    A) the number of strands
    B) the presence of adenine
    C) the presence of guanine
    D) the presence of a five carbon sugar

27. The sequence of bases in a portion of DNA is CCG TAC. Which of the following represents the sequence of bases in the corresponding mRNA codons?
    A) CCG TAC B) CCG UAC C) GGC ATG D) GGC AUG

28. Which DNA base sequence corresponds to the sequence of bases at X?



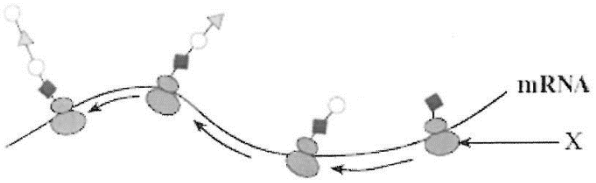
A) CTT B) CUU C) GAA D) GUU E) TTC

29. Which of the following are characteristics of DNA but not RNA?

A.	single stranded	contains adenine	translates
B.	double stranded	contains guanine	replicates
C.	single stranded	contains thymine	replicates
D.	double stranded	contains uracil	translates

A) A B) B C) C D) D

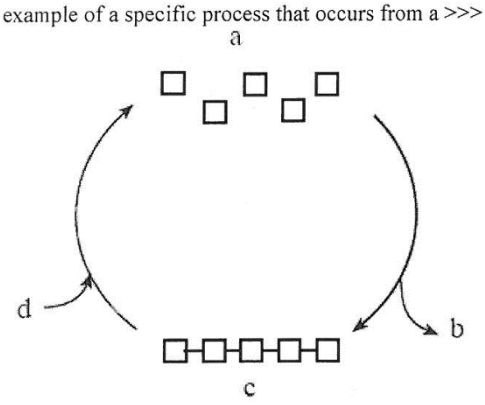
30. What is structure X in the diagram below?



A) tRNA
B) mRNA
C) ribosome
D) cytoplasm

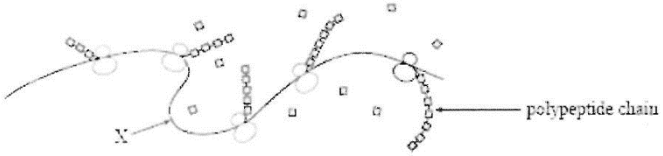
31. What carries amino acids to the ribosomes?
A) DNA B) tRNA C) rRNA D) mRNA

32. An example of a specific process that occurs from a >>> c in the diagram below would be:



A) a protein forms amino acids
B) a nucleic acid makes nucleotides
C) RNA makes nucleic acids
D) nucleotides make DNA

33. The molecule shown by the line labeled X in the below diagram is



A) DNA
B) mRNA
C) tRNA
D) rRNA

34. Which of the following is the correct sequence to describe DNA replication?

1.	complementary nitrogenous bases join by hydrogen bonding
2.	the sugar of one nucleotide joins to the phosphate of the adjacent nucleotide
3.	hydrogen bonds break to expose both strands of DNA
4.	two identical molecules of DNA are formed

A) 1,2,3,4 B) 2,3,4,1 C) 3,1,2,4 D) 4,3,2,1

35. In the following DNA base sequence:

GCA CCT ATA GGA ACC

What would occur during the translation of this gene if the ATA underwent a mutation and was converted to ATT? (use your chart provided to help answer this question)

A) one amino acid would be replaced by another
B) there would be no affect on the protein
C) tyrosine would be replaced by another amino acid
D) the protein would not be made as protein production would stop before completion

36. What is produced when transfer RNA joins to messenger RNA at the ribosome?
A) a protein B) tRNA C) mRNA D) rRNA E) rDNA

37. Using the chart provided, what is the DNA base sequence that codes for the amino acid tryptophan?
A) UGG B) ACC C) GGU D) CCA E) CCC

38. Translation
    A) takes place in the nucleus and produces a protein
    B) takes place at a ribosome and produces mRNA
    C) takes place in the nucleus and produces mRNA
    D) takes place at a ribosome and produces a protein
    E) takes place in the nucleus and produces a new double helix

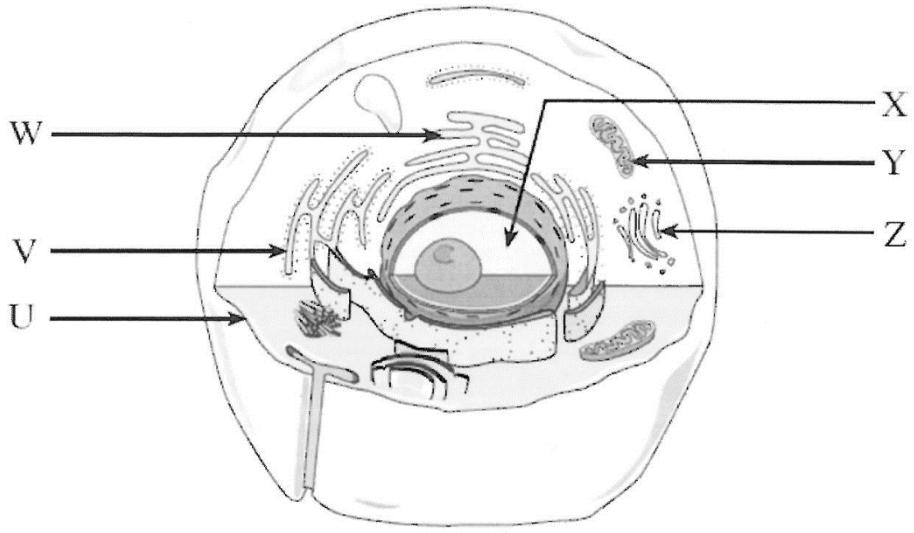
39. In which location of a human cell would recombinant DNA be found?
    A) nucleus and cytoplasm
    B) nucleus and ribosome
    C) cytoplasm and ribosome
    D) nucleus only

40. Using the diagram below and the chart provided, give the sequence of amino acids that would be produced by ***the right hand strand reading from top to bottom***

C - G
A - T
T - A
G - C
G - C
T - A
T - A
A - T
C - G

    A) methionine - proline - leucine
    B) leucine - proline - methionine
    C) histidine - glycine - tyrosine
    D) methionine - leucine - proline

Use the diagram below to answer the following six (6) questions



41. What occurs at the site of the structure labeled V?
A) translation and protein synthesis
B) ATP formation
C) DNA replication
D) rRNA synthesis

42. Which of the following is the correct sequence of organelles required in the production and export of a protein?
A) V > W > X
B) V > X > Z
C) V > Z > U
D) W > V > U

43. Which organelle contains information necessary to produce enzymes?
A) W B) X C) Y D) Z

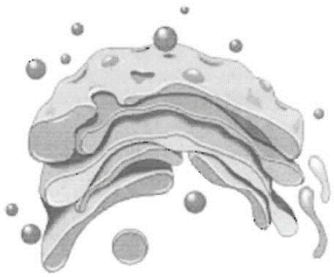
44. The structure labeled U is composed mostly of
A) glycogen and protein
B) nucleic acid and glycogen
C) nucleic acids and phospholipids
D) protein and phospholipids

45. Which letter in the diagram indicates the part of the cell where genetic information is stored?
A) V B) W C) X D) Y E) Z

46. The function of structure X in the diagram is
A) store water
B) produce ATP
C) hydrolyze water
D) control cellular activities

47. Photosynthesis would occur in which structure?
A) Golgi body B) vacuole C) chloroplast D) mitochondria

Use the diagram below to answer the following three (3) questions



48. The cell structure shown above is the
    A) smooth endoplasmic reticulum
    B) Golgi body
    C) nucleolus
    D) rough endoplasmic reticulum

49. Which of the following is packaged and stored in the structure above?
    A) water
    B) enzymes
    C) mRNA
    D) carbon dioxide

50. One function of the organelle shown in the diagram above is to
    A) produce ATP
    B) detoxify alcohol
    C) export molecules to the cell membrane
    D) synthesize nucleic acids

51. The process taking place in the diagram below is

    A) osmosis
    B) exocytosis
    C) phagocytosis
    D) facilitated transport

A potato cell was placed in a starch solution. The following data were collected over an 80 minute period. ***Use the chart below to answer the following two (2) questions***

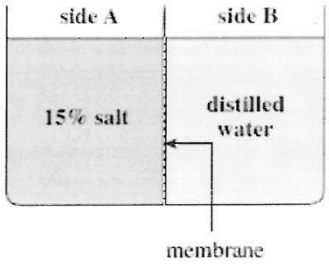
Time (min.)	0	10	20	30	40	50	60	70	80
Tissue mass (g)	20	17	15	13	10	8	5	9	12

52. What is occurring in the plant cell tissue between 0 and 60 minutes?
    A) water and starch are moving into the cell
    B) water and starch are leaving the cell
    C) water is leaving the cell, starch is entering
    D) water is entering the cell, starch is leaving the cell

53. What is added to the solution at 60 minutes?
A) starch B) water C) salt D) all of these

54. A cell has a solute concentration of 0.05%. The cell is placed in a solution that causes the cell to swell and burst. The solute concentration of the solution is
A) 0.005% B) 0.05% C) 0.5% D) 5%

55. If the membrane is permeable to salt and water, what would happen to the volume of water on sides A and B after five hours?



A) there will be no net movement of water
B) water volume on both side will increase
C) water volume on both sides will decrease
D) water volume on side A will increase, but decrease on side B
E) water volume on side B will increase, but decrease on side A

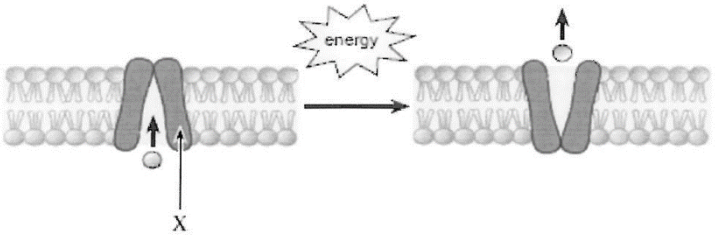
56. Which of the following processes requires ATP?
A) osmosis C) facilitated transport
B) protein synthesis D) diffusion of oxygen

57. Which of the following cells would be most efficient in terms of diffusion of wastes out of the cell?

CELL	SURFACE AREA (μ^2)	VOLUME (μ^3)
A	2	3
B	4	5
C	6	5
D	5	5

A) cell A B) cell B C) cell C D) cell D

58. What is the function of the structure labeled X in the diagram below?



A) to engulf a bacteria by phagocytosis
B) to transport lipid-soluble molecules
C) to aid carbon dioxide in diffusion
D) to move molecules against the concentration gradient

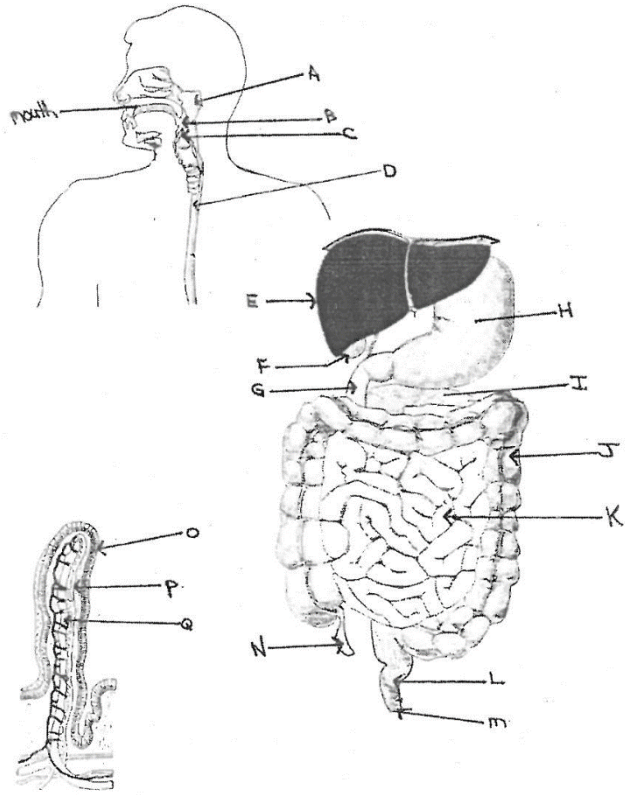
59. When sodium is moved across the cell membrane AGAINST the concentration gradient
A) osmosis is occurring
B) ATP is used
C) diffusion is occurring
D) vesicles are formed

60. Red blood cells are placed in a highly concentrated salt solution. Which of the following describes their environment and what would happen to the cells?

	Environment Inside of Cells Relative to Environment Outside of Cells	Environment Outside of Cells Relative to Environment Inside of Cells	What Happens to the Cells
A.	hypertonic	hypotonic	swell
B.	hypertonic	hypotonic	shrink
C.	hypotonic	hypertonic	swell
D.	hypotonic	hypertonic	shrink

A) A B) B C) C D) D

Use the diagram below to answer the next twelve (12) questions



61. Abnormal function of structure E would affect the digestion of
A) fats B) sugars C) protein D) starch

62. Most water absorption occurs at structure
A) D B) H C) G D) J E) K

63. Products of structure E include
A) pepsin, gastric juice, and bile
B) trypsin, bile, and urea
C) bile, urea, and plasma proteins
D) pepsin, pancreatic amylase, and lipase

64. Two structures responsible for producing protein digesting enzymes are
A) A and H B) H and I C) D and E D) G and J

65. Organisms producing vitamins, growth factors, and essential amino acids that are beneficial to the body are found in structure
A) E B) H C) I D) J E) K

66. The products of carbohydrate digestion are absorbed by
A) E B) I C) J D) P

67. Digestion of peptides and absorption of their products occurs in
A) Q B) H C) I D) K

68. Structure H
A) produces trypsin and digests proteins
B) produces pepsin and digests proteins
C) produces lipase and digests fats
D) produces amylase and digests carbohydrates
E) produces peptidase and digests proteins

69. Which organs are involved in maintaining constant levels of glucose in the blood?
A) E and I B) E and F C) H and I D) I and J

70. The removal of structure F would most likely have an effect on the digestion of which of the following?
A) proteins B) lipids C) carbohydrates D) nucleic acids

71. Which two structures produce amylase?
A) C and G B) G and H C) A and I D) E and I

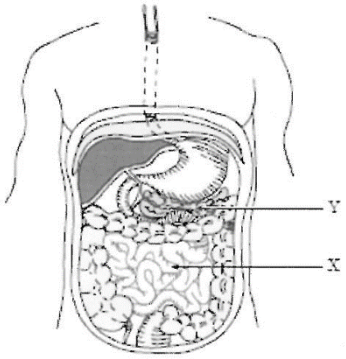
72. Where would chemical digestion of protein occur?
A) H and K B) E and H C) I and J D) H and L

73. The role of the pyloric sphincter is to
A) control entry from the esophagus into the stomach
B) control exit of wastes from the rectum
C) perform peristalsis
D) control exit of food from the stomach

74. Emulsification of fat is the function of
A) bile C) lipase
B) pepsin D) sodium bicarbonate

75. Which of the following enzymes is correctly matched with its site of production?
A) amylase - liver C) maltase - pancreas
B) pepsin - stomach D) trypsin - small intestine

Use the diagram and scenario explained below to answer the following three (3) questions



Secretion from X and Y are collected and added to test tubes containing three substances as shown below. The test tubes are allowed to stand for one hour. Blue litmus paper, which turns red in the presence of an acid, is used as an indicator

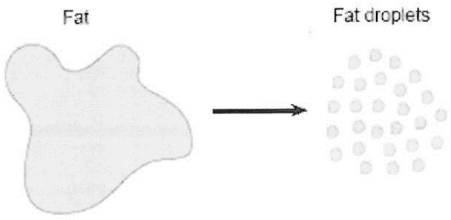
	1	2	3
Substrate	starch	fats	protein
Secretions from	X and Y	X and Y	X and Y

76. After one hour, what substances would likely be present in test tube #1?
    A) only starch as no digestion occurs
    B) peptides and amino acids
    C) some starch, maltose, and glucose
    D) glycerol and three fatty acids

77. After one hour, what substances would likely be present in test tube #2?
    A) only fats as no digestion occurs in the absence of bile
    B) peptides and amino acids
    C) some starch, maltose, and glucose
    D) glycogen and fatty acids

78. At the end of one hour, the litmus paper in test tube #3 turned from blue to red. Why?
    A) fatty acids were present
    B) the enzymes from X and Y function best in a strongly acidic environment
    C) amino acids are present
    D) stomach acid has leaked into the small intestine

79. Which of the following is necessary to produce the reaction shown?



A) water B) amylase C) lipase D) bile

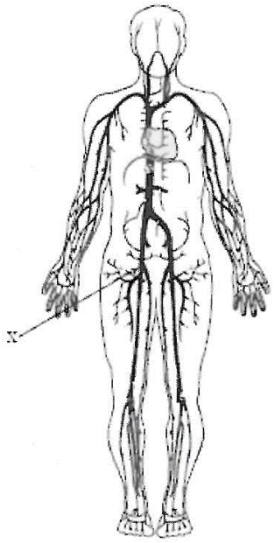
80. Which of the following conditions would allow digestion to occur at an optimum rate if maintained at body temperature?
A) trypsin digesting fats at a pH of 2
B) maltase digesting maltose at a pH of 2
C) pancreatic amylase digesting starch at a pH of 8
D) pepsin digesting protein at a pH of 8

81. The correct path of blood from the heart to the head and back to the heart again is
A) right ventricle, vena cava, carotid artery, jugular vein, left atrium
B) left ventricle, aorta, jugular vein, vena cava, carotid artery, right atrium
C) left ventricle, aorta, carotid artery, jugular vein, vena cava, right atrium
D) right atrium, carotid artery, aorta, jugular vein, vena cava, left ventricle

82. The blood vessel shown carries blood between organs at locations X and Y. Blood flow through the vessel would be from the

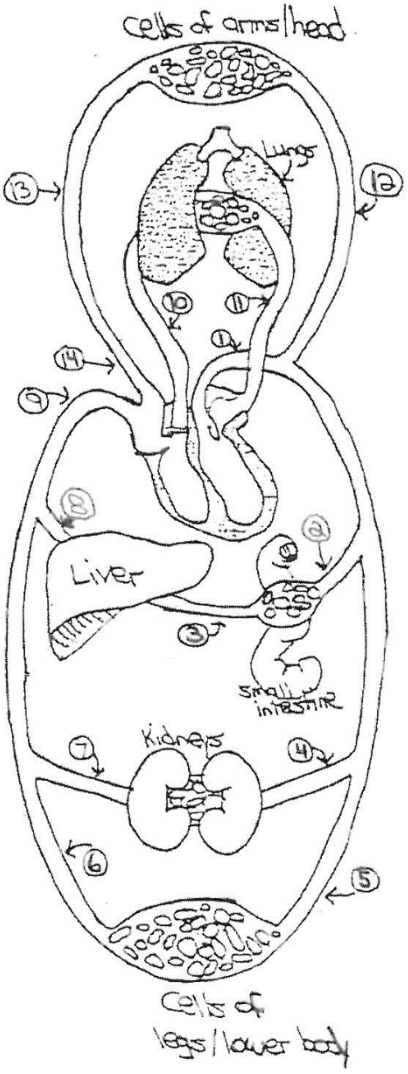
A) heart at X to the kidneys at Y
B) intestine at Y to the liver at X
C) heart at Y to the kidneys at X
D) intestine at X to the liver at Y

83. The structure labeled X in the diagram below is the



A) iliac vein
B) renal vein
C) subclavian vein
D) posterior vena cava

Use the diagram below to answer the following three (3) questions

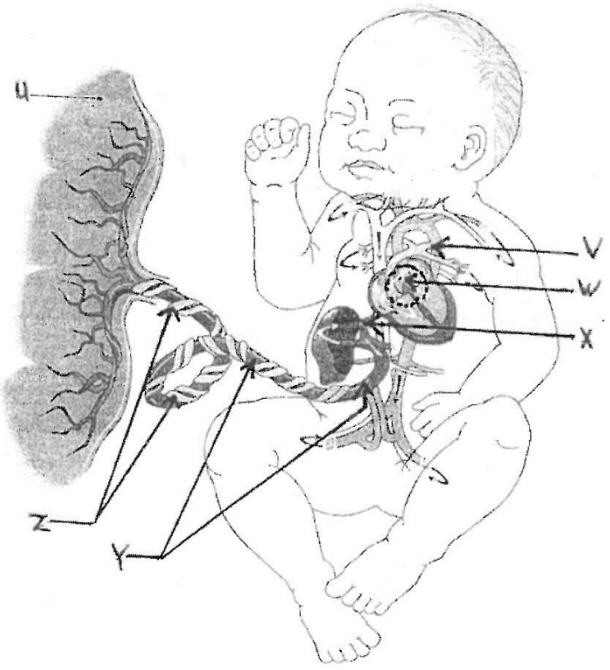


84. Which of the following accurately compares blood vessels #1 and #10
    A) both are high in oxygen
    B) both are high in carbon dioxide
    C) #1 is high in oxygen, #10 is low in oxygen
    D) #1 is high in carbon dioxide, #10 is high in oxygen

85. Which number indicates the subclavian artery?
A) 1 B) 5 C) 13 D) 12

86. Which of the following best describes structure 3?
A) a vein which carries blood rich in glucose
B) a vein which carries high oxygen blood to the heart
C) an arteriole which carries blood to the small intestine
D) an artery which carries nutrients to the rest of the body

Use the diagram below to answer the following four (4) questions



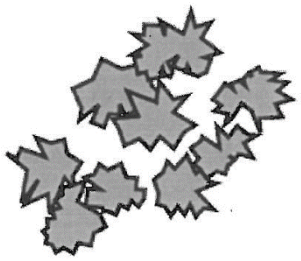
87. What would be the result of structure V remaining functional after birth?
A) blood would flow from the left ventricle to the right ventricle
B) the levels of oxygen in baby's aorta would be lower than normal
C) the levels of carbon dioxide in the baby's pulmonary artery would be lower than normal
D) blood in the left atrium would have higher concentrations of oxygen than blood in the right atrium

88. Which of the following accurately compares Y and Z?
    A) Y is the umbilical artery, Z is the umbilical vein
    B) Y is high in carbon dioxide, Z is high in oxygen
    C) Y is high in nutrients, Z is high in wastes
    D) both are high in oxygen

89. Which of the following statements is accurate?
    A) blood in Y is high in oxygen
    B) blood in Z is high in oxygen and nutrients
    C) blood in Y is high in carbon dioxide
    D) blood in Z is high in carbon dioxide and nutrients

90. The placenta is structure
    A) U B) V C) W D) X E) Y

Use the diagram below to answer the following two (2) questions



91. The main function of this structure is to
    A) fight disease
    B) carry oxygen
    C) carry nutrients
    D) aid in blood clotting

92. This structure would be produced in the
    A) liver B) bone marrow C) lymph nodes D) plasma

Use the diagram below to answer the following three (3) questions

93. The diagram shows
    A) thrombocytes B) erythrocytes C) leukocytes D) white blood cells

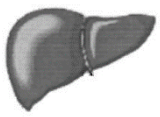
94. Which structure shown below is responsible for destroying the structure shown above?

A.

B.

C.

D.



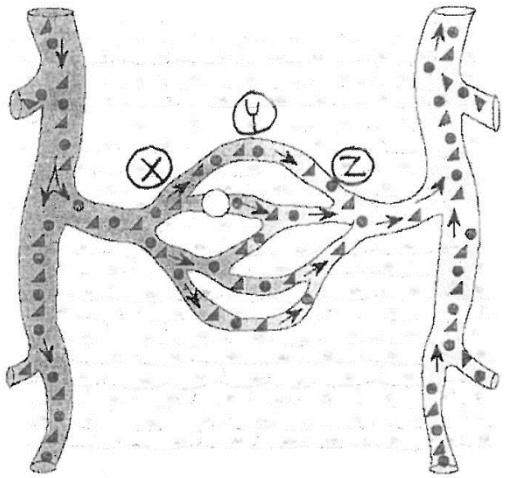
A) A B) B C) C D) D

95. Which of the following correctly describes the structure and function of the above structure?

	STRUCTURE	FUNCTION
A	cell fragment	initiates clotting
B	has a nucleus	fights infection
C	biconcave	produces antibodies
D	no nucleus	transports oxygen

A) A B) B C) C D) D

Use the diagram below to answer the following three (3) questions



96. In the diagram below, the blood at point X would likely contain a high concentration of
    A) urea
    B) oxygen
    C) carbon dioxide
    D) sodium bicarbonate

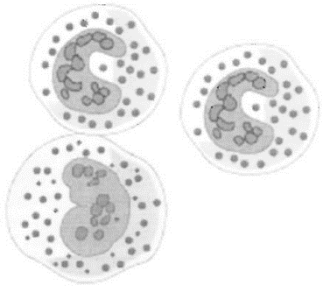
97. Which of the following describes the net movement of water at location X?
    A) net movement of water into the tissues because blood pressure is less than osmotic pressure
    B) net movement of water into the tissues because blood pressure is greater than osmotic pressure
    C) net movement of water into the capillaries because blood pressure is less than osmotic pressure
    D) net movement of water into the capillaries because blood pressure is greater than osmotic pressure

98. If osmotic pressure is constant at 25 mm Hg, which of the following BEST describes what occurs at Y?

	EVENT	BLOOD PRESSURE (mmHG)
A	nutrients move from the capillaries to the tissues	10
B	nutrients move from the capillaries to the tissues	40
C	wastes move into the capillaries from the tissues	25
D	wastes move into the capillaries from the tissues	40

A) A B) B C) C D) D

Use the diagram below to answer the following two (2) questions



99. The diagram shows
    A) thrombocytes
    B) leukocytes
    C) erythrocytes
    D) fragmentation

100. Which of the following best describes the shape of these structures?
    A) no fixed shape
    B) always oval
    C) circular with dents in the middle
    D) always circular

101. Examine the list of heart structures shown below

    1. sinoatrial node
    2. Purkinje fibres
    3. atrioventricular node

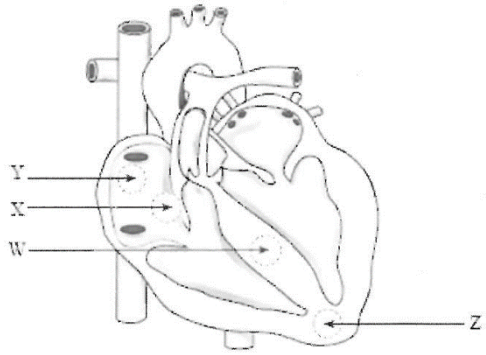
    Trace the pathway of electrical activity of the heart beginning with atrial systole and ending with ventricular systole by identifying, in order, the structures above
    A) 1,2,3 B) 1,3,2 C) 3,1,2 D) 3,2,1 E) 2,3,1

102. Initiation of the cardiac cycle is dependent on the
    A) sinoatrial (SA) node
    B) sympathetic nervous system
    C) parasympathetic nervous system
    D) nerve impulses from the AV node

103. An irregular heartbeat where contraction of the atria does not always result in contraction of the ventricles likely indicates a problem with the
    A) SA node B) AV node C) AV valve D) semi-lunar valve

104. The first indication of a malfunctioning SA node would likely be
    A) an irregular heart beat
    B) degeneration of the heart muscle
    C) increased oxygen content in the arterial blood
    D) back flow of blood from the pulmonary artery to the ventricle

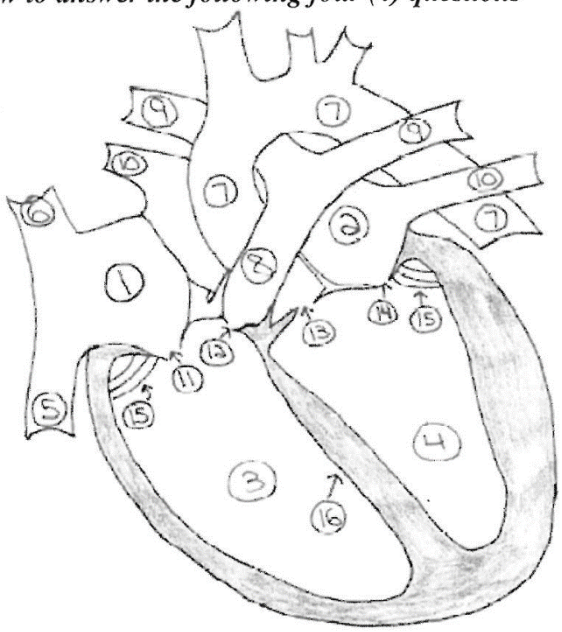
Use the diagram below to answer the following two (2) questions



105. Which area on the diagram below would be the AV node?
A) W B) X C) Y D) Z

106. Which area on the diagram below would be the SA node?
A) W B) X C) Y D) Z

Use the diagram below to answer the following four (4) questions



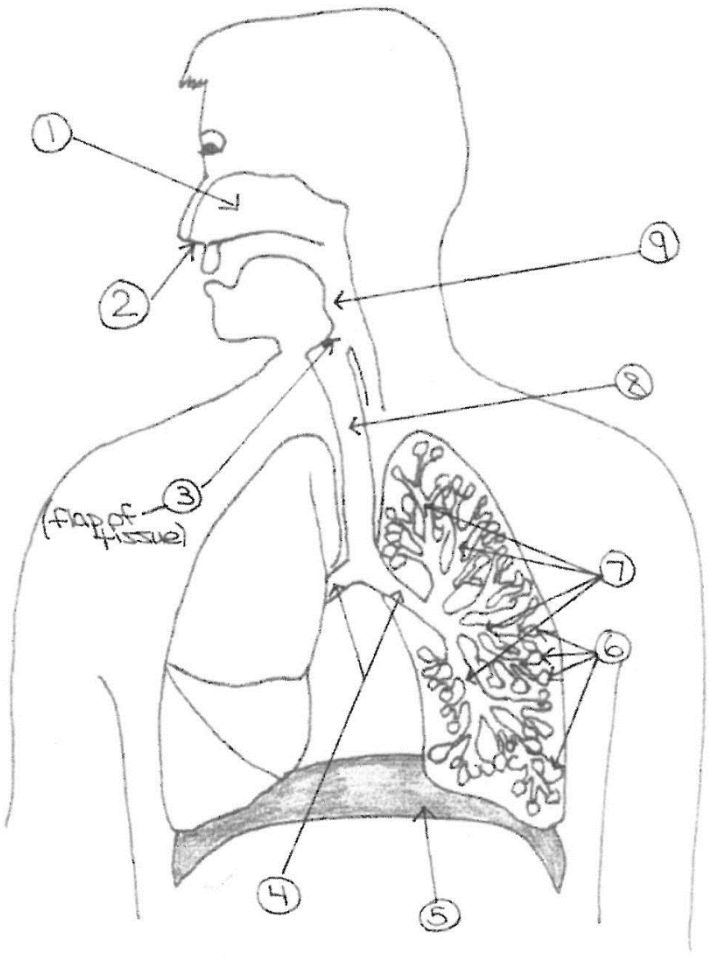
107. The blood vessel labeled #8 carries high levels of
   A) oxygen towards the heart
   B) oxygen away from the heart
   C) carbon dioxide towards the heart
   D) carbon dioxide away from the heart

108. Which structure prevents blood from re-entering the right atrium from the right ventricle?
   A) 11 B) 12 C) 13 D) 14

109. The function of structure #2 is
   A) pump low oxygen blood to the lungs
   B) receive high oxygen blood from the lungs
   C) pump high oxygen blood to the body tissues
   D) receive low oxygen blood from the body tissues

110. The mitral valve is structure #
   A) 11 B) 12 C) 13 D) 14

Use the diagram below to answer the following six (6) questions



111. The structure labeled #4 is the
A) larynx B) trachea C) bronchus D) diaphragm

112. Which number in the diagram below indicates the alveoli?
A) 9 B) 8 C) 4 D) 7 E) 6

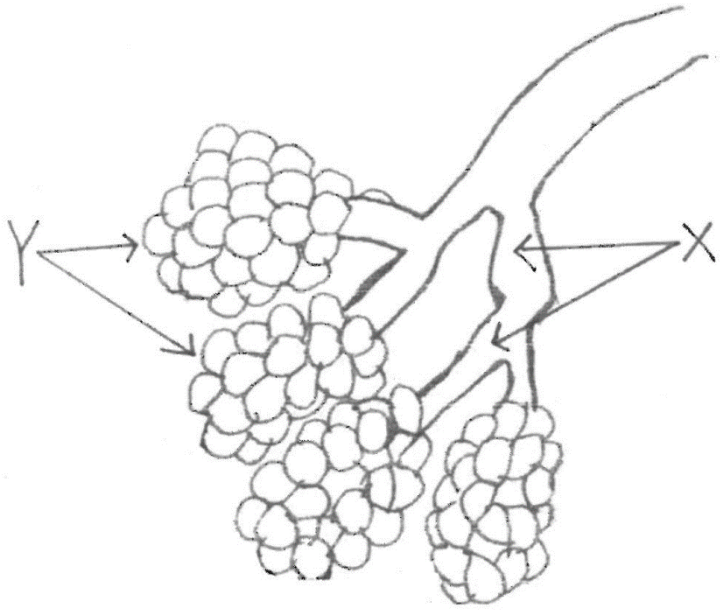
113. What is the structure labeled #7?
A) the larynx
B) the alveoli
C) the trachea
D) the bronchi
E) the bronchioles

114. When the structure labeled #5 contracts:
A) exhalation occurs
B) the epiglottis closes
C) the volume of the thoracic cavity increases
D) the pressure on the thoracic cavity increases

115. Which structure responds to nerve impulses from the medulla oblongata?
A) 1 B) 2 C) 9 D) 8 E) 5

116. Which reaction happens at structure #6?
A) $Hb + CO_2 \rightarrow HbCO_2$
B) $CO_2 + H_2O \rightarrow H^+ + HCO_3^-$
C) $HbO_2 \rightarrow Hb + O_2$
D) $H^+ + HCO_3^- \rightarrow CO_2 + H_2O$

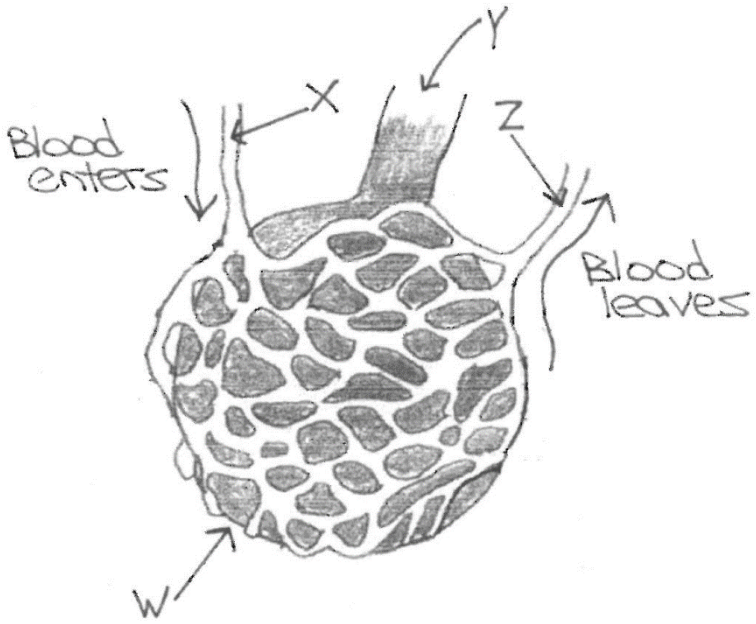
Use the diagram below to answer the following two (2) questions



117. The structure labeled X in the diagram is a(n)
A) trachea B) alveolus C) bronchus D) bronchiole

118. Which of the following pairs of reactions occurs most frequently in the blood surrounding the structure shown?
A) $Hb + O_2 \rightarrow HbO_2$ and $HHb \rightarrow Hb + H^+$
B) $HbO_2 \rightarrow Hb + O_2$ and $Hb + H^+ \rightarrow HHb$
C) $H^- + Hb \rightarrow HHb$ and $H_2CO_3 \rightarrow HCO_3^- + H^+$
D) $CO_2 + H_2O \rightarrow H_2CO_3$ and $H_2CO_3 \rightarrow HCO_3^- + H^+$

Use the diagram below to answer the following three (3) questions



119. At which area is the concentration of oxyhemoglobin the greatest?
A) W B) X C) Y D) Z

120. Which labeled structure contains the highest concentrations of HCO_3^- (bicarbonate ions)?
A) W B) X C) Y D) Z

121. Which of the following represents the composition of blood at X shown in the diagram above?

	OXYHEMOGLOBIN (HbO_2)	BICARBONATE ION (HCO_3^-)	REDUCED HEMOGLOBIN (HHb)
A	low	high	high
B	high	low	low
C	low	low	high
D	high	high	low

A) A B) B C) C D) D

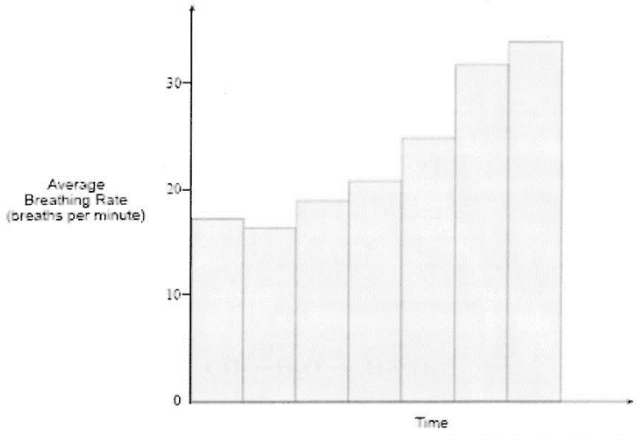
122. Consider the following reaction:

$$CO_2 + H_2O \rightarrow H_2CO_3^-$$

An enzyme found in red blood cells that catalyzes this reaction is

A) nuclease
B) peptidase
C) dehydrogenase
D) carbonic anhydrase

123. Which of the following would cause the effect shown in the graph below?



A) increased oxygen in the blood
B) increased numbers of red blood cells
C) increased carbon dioxide in the blood
D) decreased concentration of hydrogen ions

124. Which of the following reactions would occur in the capillary of a leg?

A) $Hb + H^+ \rightarrow HHb$
B) $HbCO_2 \rightarrow Hb + CO_2$
C) $Hb + O_2 \rightarrow HbO_2$
D) $H^+ + HCO_3^- \rightarrow H_2CO_3$

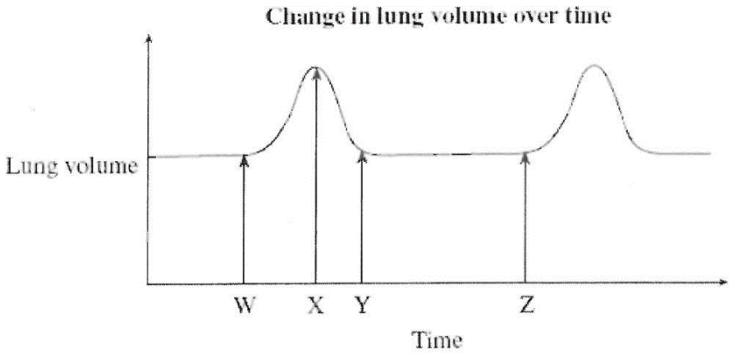
125. During the expiration of air, the diaphragm moves

A) up, resulting in a decrease in pressure in the thoracic cavity
B) up, resulting in an increase in pressure in the thoracic cavity
C) down, resulting in a decrease in pressure in the thoracic cavity
D) down, resulting in an increase in pressure in the thoracic cavity

126. When someone is exercising strenuously, breathing rate will increase because

A) the person has an increased need for oxygen to fuel working muscles
B) the person has a decreased need for oxygen to fuel working muscles
C) the muscles are burning more glucose, thus increasing carbon dioxide concentration in the blood
D) the muscles are burning less glucose, thus increasing carbon dioxide concentration in the blood

127. Using the diagram below, when does the diaphragm contract during breathing?



A) W → X B) X → Z C) X → Y D) Y → Z

128. What part of the brain controls inhalation?
A) cerebrum
B) cerebellum
C) corpus callosum
D) medulla oblongata

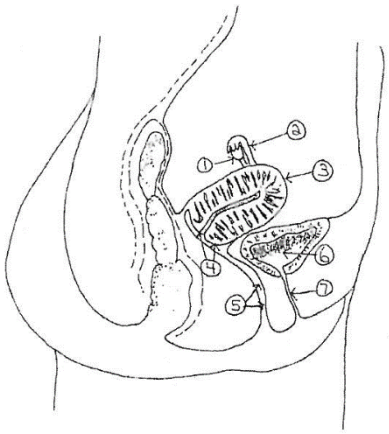
129. What structures increase the surface area of the lungs?
A) the villi
B) the alveoli
C) the bronchi
D) the pleural membranes

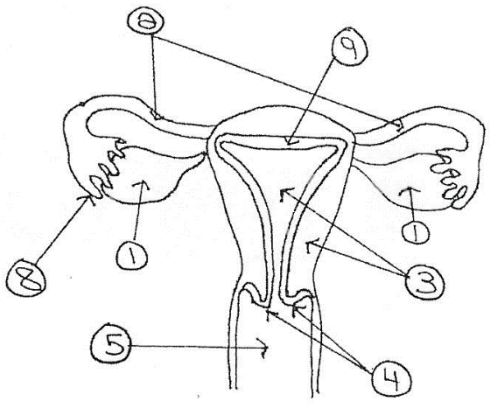
130. What is the correct order of the events below?

#1 - the volume of the thoracic cavity increases
#2 - the intercostal muscles contract
#3 - air enters the lungs
#4 - exhalation occurs
#5 - the diaphragm relaxes

A) 2 → 1→ 3→ 5→ 4
B) 2 → 3→ 5→ 1→ 4
C) 5 → 1→ 2→ 3→ 4
D) 5 → 1→ 3→ 4→ 2

Use the diagram below to answer the following three (3) questions



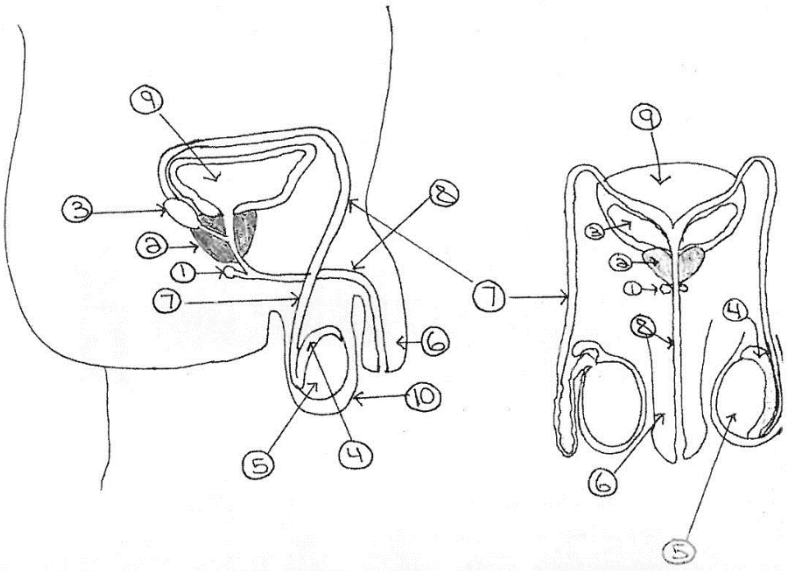


131. Structure #4 is the
A) ovary B) cervix C) vagina D) oviduct

132. In which structure does fertilization normally occur?
A) 1 B) 2 C) 3 D) 4 E) 5

133. Which labeled structure secretes hormones that cause the changes that occur in the female body during puberty?
A) 1 B) 2 C) 3 D) 4 E) 5

Use the diagram below to answer the following four (4) questions



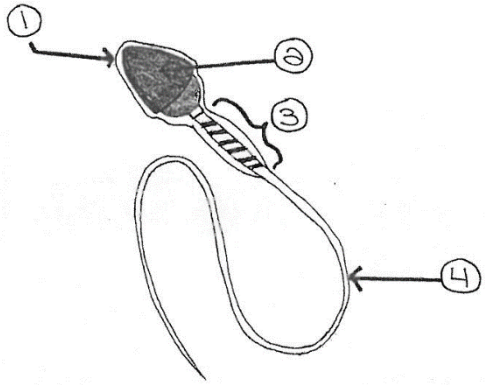
134. Which of the following is a function of the secretions from structure #5?
A) to buffer the pH of the semen
B) to cause beard growth at puberty
C) to cause rhythmic contractions of the uterus
D) to cause increased secretion of releasing hormones

135. Which labeled structure transfers semen to the female?
A) 6 B) 3 C) 9 D) 4 E) 5

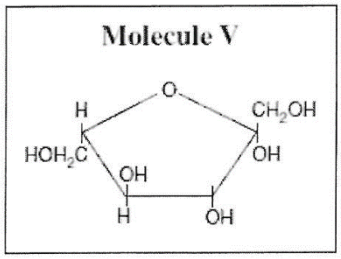
136. Which structure in the diagram is the target of follicle-stimulating hormone (FSH)?
A) 1 B) 2 C) 3 D) 4 E) 5

137. Which structure is responsible for producing a substance that causes contraction in the uterus of the female?
A) 1 B) 2 C) 3 D) 4 E) 5

Use the diagram below to answer the following two (2) questions



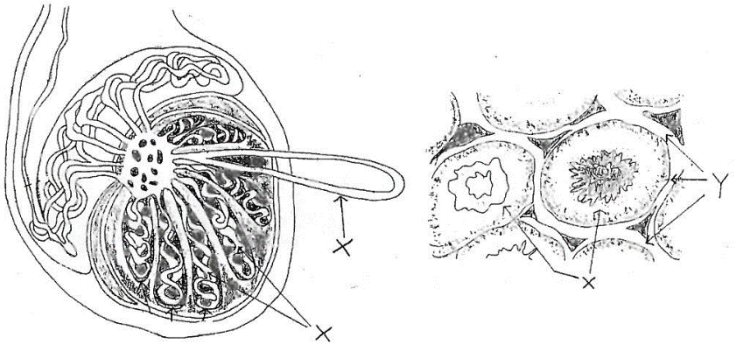
138. Where would molecules similar to V be used in this cell?



A) 1 B) 2 C) 3 D) 4

139. Which structure contains enzymes that help the sperm to penetrate the egg?
A) 1 B) 2 C) 3 D) 4

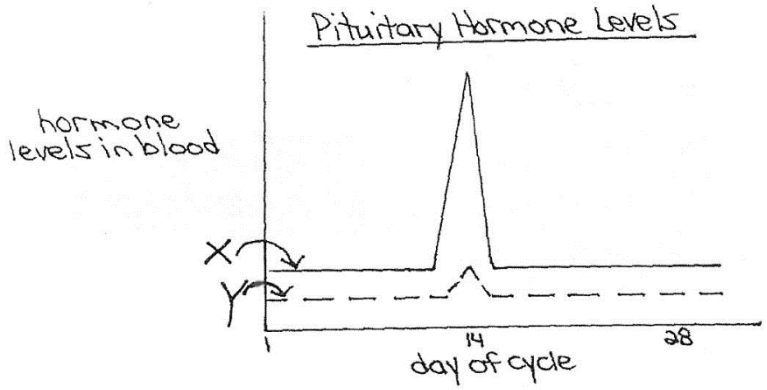
Use the diagram below to answer the following two (2) questions



140. Where do the cells stored in X move next?
A) urethra B) epididymis C) vas deferens D) seminal vesicle

141. The product(s) of structure Y
A) add fructose to semen
B) cause uterine contractions when placed in a female
C) lead to beard growth
D) fertilize eggs

Use the graph below to answer the following three (3) questions

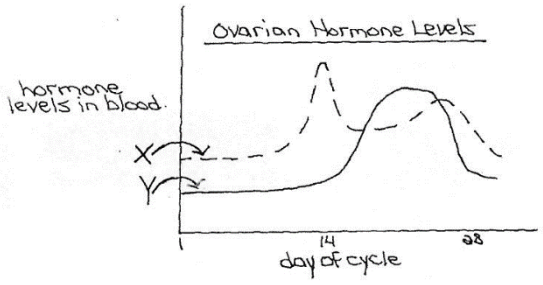


142. Hormone X is
   A) estrogen
   B) oxytocin
   C) follicle stimulating hormone (FSH)
   D) luteinizing hormone (LH)
   E) gonadotropin releasing hormone (GnRH)

143. Which of the following best describes the function(s) of hormone Y?
   A) trigger ovulation and help with development of primary oocyte
   B) develop the primary follicle and corpus luteum
   C) to trigger contractions of the uterus during child delivery
   D) trigger ovulation and help develop the corpus luteum
   E) aid in development of the follicle

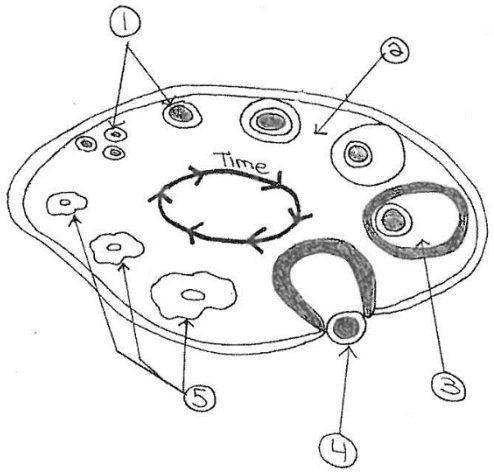
144. What effect does hormone X have during ***days 15-28*** in a 28 days female cycle?
   A) promotes the development of a follicle
   B) promotes ovulation
   C) promotes the development of a corpus luteum
   D) causes the endometrium lining to slough off

145. Hormone Y in the graph below is



A) estrogen B) progesterone C) LH D) FSH E) GnRH

Use the diagram below to answer the following two (2) questions

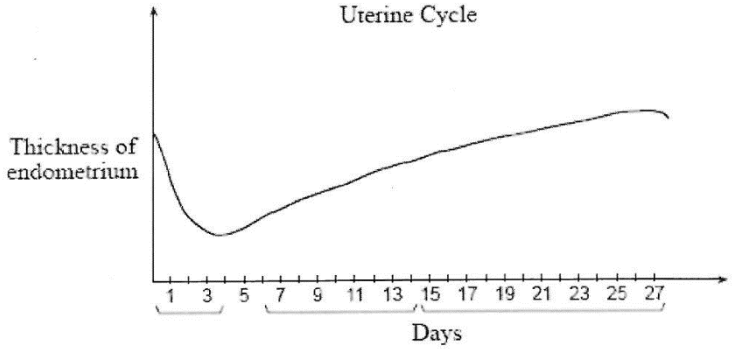


146. Using the diagram below, what is the next structure #4 will encounter after it leaves the ovary?

A) cervix
B) uterus
C) oviduct
D) endometrium
E) bladder

147. What do the secretions from structure #5 cause?
   A) uterine lining to slough off
   B) ovaries to produce a mature egg
   C) uterine lining to produce a thick mucus
   D) production of human chorionic gonadotropin (HCG)

Use the diagram below to answer the following two (2) questions

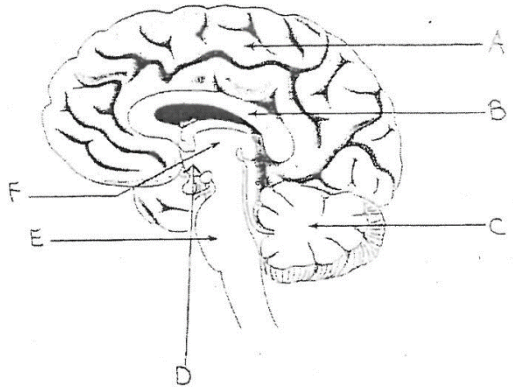


148. What hormone from the pituitary gland causes the changes shown following day 15 on the graph?
   A) gonadotropin releasing hormone (GnRH)
   B) estrogen
   C) progesterone
   D) luteinizing hormone (LH)
   E) follicle stimulating hormone (FSH)

149. What event happens in the days leading up to days 1-3 on the graph that leads to the changes seen on days 1-3?
   A) increased progesterone levels lead to decreased release of gonadotropin releasing hormone (GnRH) by the hypothalamus
   B) increased progesterone levels lead to increased release of gonadotropin releasing hormone (GnRH) by the hypothalamus
   C) decreased progesterone levels lead to increased release of gonadotropin releasing hormone (GnRH) by the hypothalamus
   D) decreased progesterone levels lead to decreased release of gonadotropin releasing hormone (GnRH) by the hypothalamus
   E) the pituitary decreases its release of follicle stimulating hormone (FSH)

150. What is an effect of oxytocin?
   A) release of an egg
   B) development of breasts
   C) loss of the endometrium
   D) production of milk
   E) contraction of the uterus

Use the diagram below to answer the following six (6) questions



151. Which structure sorts incoming information and channels it to the appropriate part of the brain?
A) B B) C C) D D) E E) F

152. Elevated body temperature due to a prolonged infection is due to a stimulation of which of the following structures?
A) A B) B C) C D) D E) E

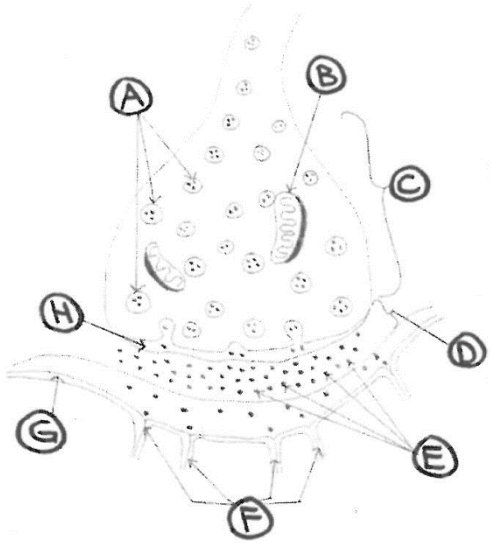
153. Studying for an exam would produce high activity in which structure?
A) A B) C C) D D) E E) F

154. The part of the brain responsible for muscle co-ordination is:
A) A B) C C) D D) E E) F

155. Level of carbon dioxide in the blood is monitored by
A) A B) C C) D D) E E) F

156. Which of the following activities accompanies high activity in structure C?
A) sleeping
B) swallowing
C) studying for an exam
D) performing a gymnastics routine

Use the diagram below to answer the following four (4) questions



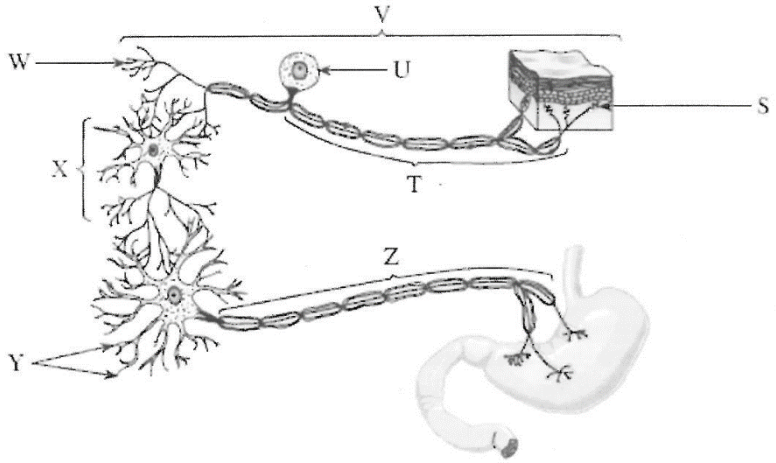
157. Structure A is
A) a synaptic vesicle
B) the pre-synaptic membrane
C) an axon
D) an axon bulb

158. If the diagram shows a synapse in the parasympathetic nervous system during the transmission of an impulse, what is the substance being released into the cleft?
A) sodium ions B) noradrenaline C) calcium ions D) acetylcholine

159. If molecule E causes depolarization at structure G, what could E be?
A) sodium ions
B) calcium ions
C) acetylcholine
D) all of these

160. Which processes are involved in the movement of molecule E from point A to point F?
A) exocytosis and diffusion
B) endocytosis and diffusion
C) exocytosis and facilitated transport
D) endocytosis and facilitated transport

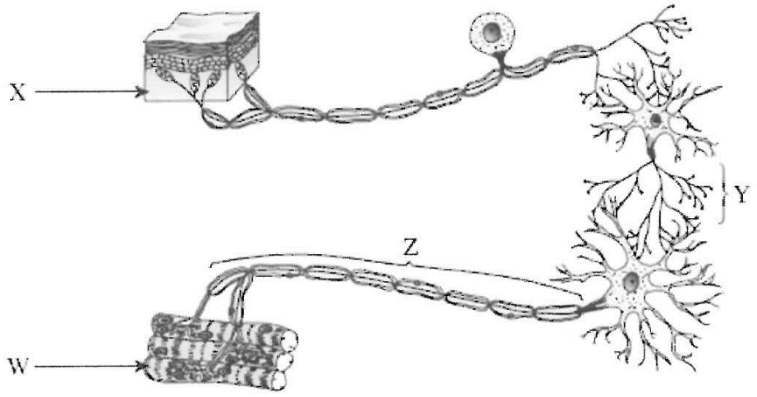
Use the diagram below to answer the following two (2) questions



161. Which letter indicates the interneuron?
A) V B) X C) Y D) Z

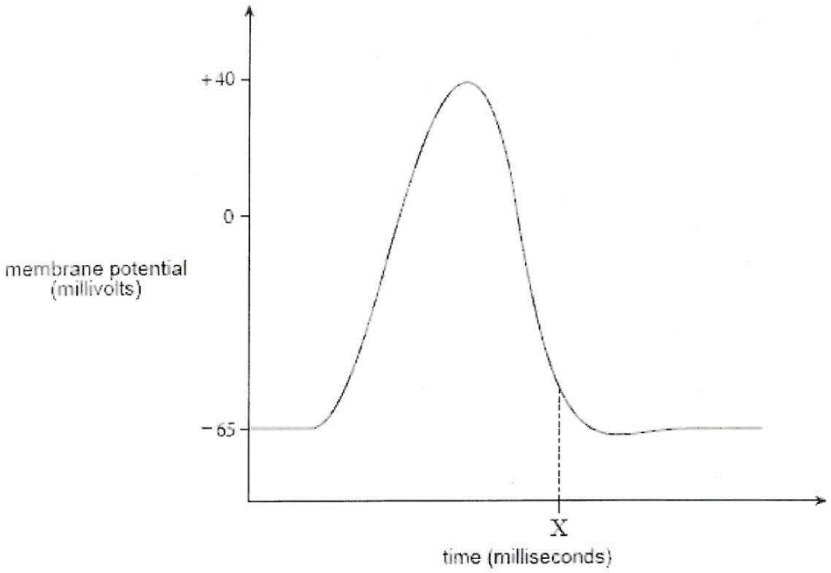
162. Which structure carries impulses away from the central nervous system?
A) U B) V C) W D) Z

163. To where does the nerve impulse travel after it leaves the axon of the motor neuron?



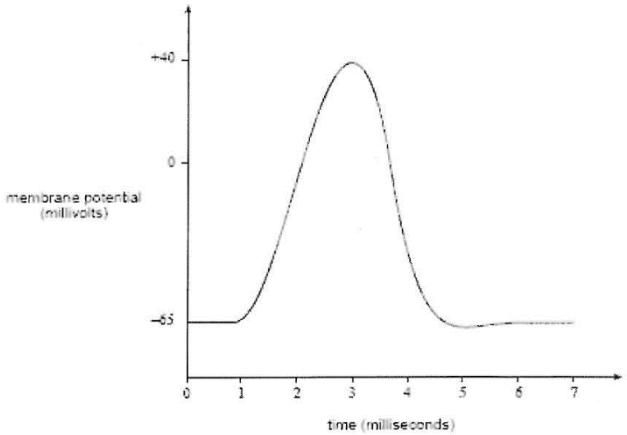
A) W B) X C) Y D) Z

164. Which of the following is a characteristic of the neuron at time X?



A) sodium ions are transported into the axon
B) the axon membrane is impermeable to potassium ions
C) there is a lower concentration of potassium ions inside than outside the axon
D) there is a net positive charge on the inside of the axon and a net negative charge on the outside

165. During which of the following times is the membrane's permeablility to sodium ions increasing?



A) 0 to 1 milliseconds
B) 1 to 3 milliseconds
C) 3 to 4 milliseconds
D) 4 to 5 milliseconds

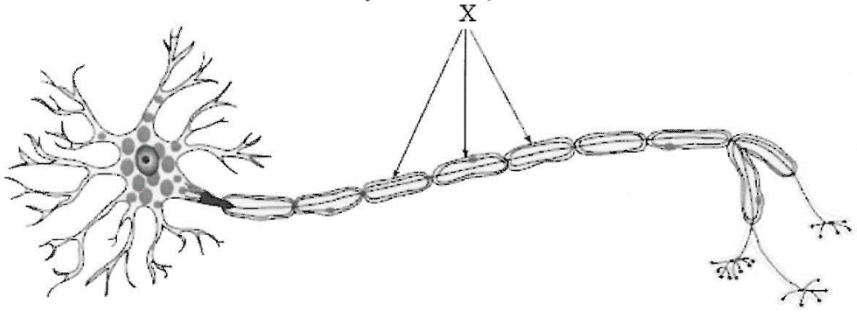
166. Short axon and long dendrites best describes
A) a motor neuron
B) a sensory neuron
C) an interneuron
D) a synaptic cleft
E) a sensory receptor

167. Control of skeletal muscle is a function of the
A) somatic nervous system
B) autonomic nervous system
C) sympathetic nervous system
D) parasympathetic nervous system
E) corpus callosum

168. In which of the following is ATP required?
A) initiation of the nerve impulse
B) establishment of the resting potential
C) repolarization of the neural membrane
D) depolarization of the neural membrane
E) all of the above

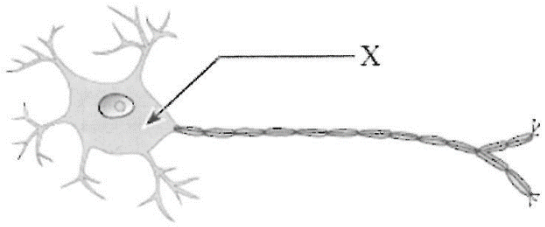
169. Following the "fight or flight" response, parasympathetic nervous stimulation would cause
A) peristalsis to decrease
B) the bronchioles to dilate
C) the heart rate to decrease
D) the liver to release glycogen

170. The structure made from the cells labeled X is destroyed. The ***likely*** result would be



A) blockage of receptor sites
B) slowing of the nerve impulse
C) continuous stimulation of a sensory receptor
D) an increase in the number of nodes of Ranvier

Use the diagram below to answer the following two (2) questions



171. What is the function of the neuron above?
A) to take an impulse to an interneuron
B) to send sensory information to the central nervous system
C) to take an impulse from a motor neuron to a sensory neuron
D) to carry a nerve impulse away from the central nervous system

172. What is the structure labeled X?
A) synapse
B) cell body
C) node of Ranvier
D) myelinated dendrite

173. The structure below carries impulses

A) from a receptor
B) to a muscle or a gland
C) away from the central nervous system
D) solely within the central nervous system

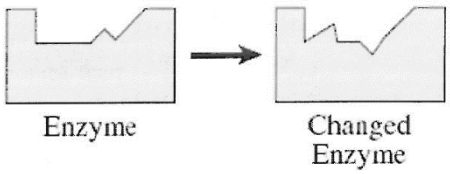
174. How do enzymes increase the rate of reaction?
A) they produce energy
B) they become denatured
C) they produce coenzymes
D) they decrease the energy of activation

175. How are coenzymes involved in enzymatic reactions?
A) they provide atoms for the reaction
B) they increase enzyme concentration
C) they provide energy for the reaction
D) they increase substrate concentration

176. What is the function of thyroxin?
A) to cause ovulation
B) to increase metabolic rate
C) to decrease the rate of digestion
D) to control the concentration of sodium ions in the blood

177. Which of the following substances will cause an enzyme to be denatured?
A) vitamins
B) a substrate
C) an inhibitor
D) heavy metal ions

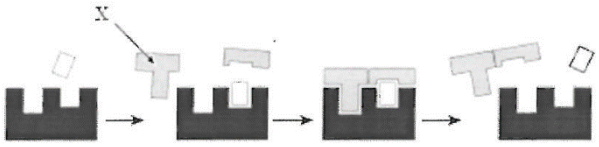
178. The changes shown in the diagram cause the rate of an enzyme-catalyzed reaction to decrease because



A) the enzyme denatures the substance
B) the substrate cannot bind to the active site
C) the co-enzyme is unable to bind to the substrate
D) the enzyme can no longer increase the activation energy

179. What conditions would decrease the ability of lipase to form an enzyme-substrate complex?
A) a pH of 8.5
B) the addition of lipids
C) the addition of lead ions
D) an increase in the amount of bile available

180. The structure labeled **X** in the diagram is a(n)



A) product B) enzyme C) complex D) substrate

ID: A

BIOLOGY 12 FINAL EXAM
Answer Section

MULTIPLE CHOICE

1. A
2. A
3. D
4. B
5. D
6. C
7. D
8. B
9. A
10. A
11. B
12. D
13. D
14. B
15. A
16. C
17. B
18. A
19. D
20. D
21. B
22. A
23. B
24. C
25. D
26. A
27. D
28. C
29. B
30. C
31. B
32. D
33. B
34. C
35. D
36. A
37. B

38. D
39. D
40. C
41. A
42. C
43. B
44. D
45. C
46. D
47. C
48. B
49. B
50. C
51. C
52. C
53. B
54. A
55. D
56. B
57. C
58. D
59. B
60. D
61. A
62. D
63. C
64. B
65. D
66. D
67. D
68. B
69. A
70. B
71. C
72. A
73. D
74. A
75. B
76. C
77. A
78. C
79. D
80. C
81. C
82. B

83. A
84. C
85. D
86. A
87. B
88. C
89. A
90. A
91. D
92. B
93. B
94. D
95. D
96. B
97. B
98. C
99. B
100. A
101. B
102. A
103. B
104. A
105. B
106. C
107. D
108. A
109. B
110. D
111. C
112. E
113. E
114. C
115. E
116. D
117. D
118. A
119. D
120. B
121. A
122. D
123. C
124. A
125. B
126. C
127. A

128. D
129. B
130. A
131. B
132. B
133. A
134. B
135. A
136. E
137. C
138. C
139. A
140. B
141. C
142. D
143. E
144. C
145. B
146. C
147. C
148. D
149. A
150. E
151. E
152. D
153. A
154. B
155. D
156. D
157. A
158. D
159. C
160. A
161. B
162. D
163. A
164. C
165. B
166. B
167. A
168. E
169. C
170. B
171. D
172. B

173. A
174. D
175. A
176. B
177. D
178. B
179. C
180. D

Appendix I – Old Provincial Exams

MINISTRY USE ONLY

MINISTRY USE ONLY

Place Personal Education Number (PEN) here.

Place Personal Education Number (PEN) here.

MINISTRY USE ONLY

BRITISH COLUMBIA

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Biology 12

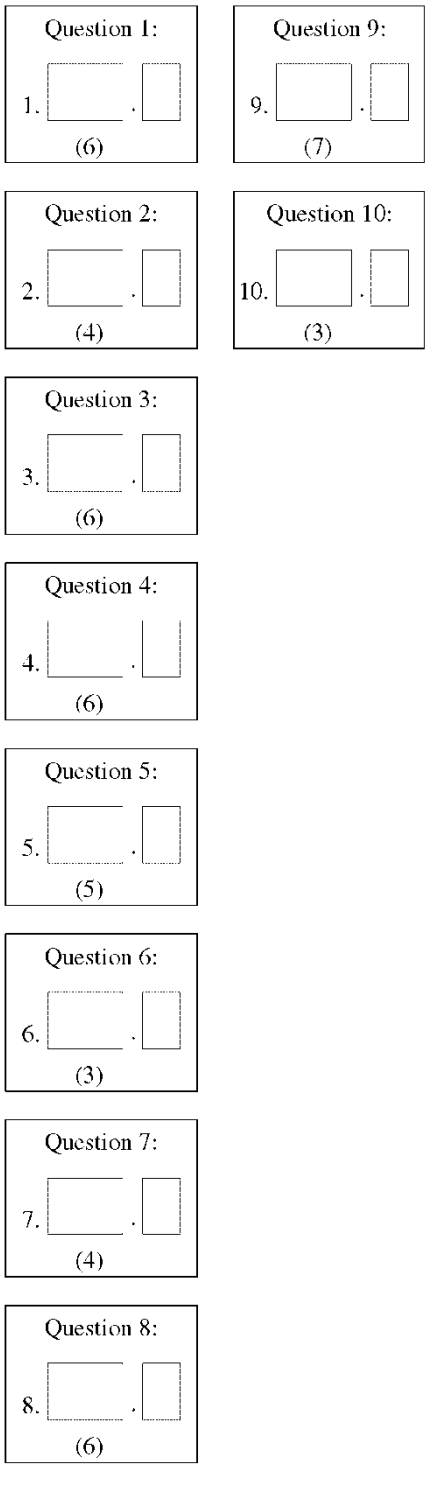
JUNE 2002

Course Code = BI

Student Instructions

1. Place the stickers with your Personal Education Number (PEN) in the allotted spaces above. **Under no circumstance is your name or identification, other than your Personal Education Number, to appear on this booklet.**
2. Ensure that in addition to this examination booklet, you have an **Examination Response Form**. Follow the directions on the front of the Response Form.
3. **Disqualification** from the examination will result if you bring books, paper, notes or unauthorized electronic devices into the examination room.
4. When instructed to open this booklet, **check the numbering of the pages** to ensure that they are numbered in sequence from page one to the last page, which is identified by

   END OF EXAMINATION.
5. At the end of the examination, place your Response Form inside the front cover of this booklet and return the booklet and your Response Form to the supervisor.


Question 1:
1. .
(6)
Question 9:
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Question 2:
2. .
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Question 10:
10. .
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Question 3:
3. .
(6)
Question 4:
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Question 5:
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Question 6:
6. .
(3)
Question 7:
7. .
(4)
Question 8:
8. .
(6)

BIOLOGY 12

JUNE 2002

COURSE CODE = BI

GENERAL INSTRUCTIONS

1. Electronic devices, including dictionaries and pagers, are **not** permitted in the examination room.

2. All multiple-choice answers must be entered on the Response Form using an **HB pencil**. Multiple-choice answers entered in this examination booklet will **not** be marked.

3. For each of the written-response questions, write your answer in **ink** unless otherwise instructed in the space provided in this booklet.

4. Ensure that you use language and content appropriate to the purpose and audience of this examination. Failure to comply may result in your paper being awarded a zero.

5. This examination is designed to be completed in **two hours**. *Students may, however, take up to 30 minutes of additional time to finish.*

BIOLOGY 12 PROVINCIAL EXAMINATION

	Value	Suggested Time
1. This examination consists of **two** parts:		
PART A: 50 multiple-choice questions	50	45
PART B: 10 written-response questions	50	75
Total:	**100 marks**	**120 minutes**

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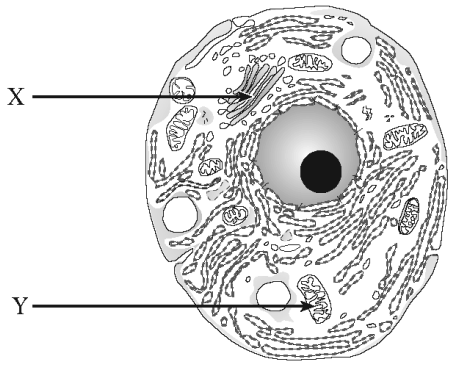
PART A: MULTIPLE CHOICE

Value: 50 marks **Suggested Time: 45 minutes**

INSTRUCTIONS:	For each question, select the **best** answer and record your choice on the Response Form provided. Using an HB pencil, completely fill in the circle that has the letter corresponding to your answer.

Use the following diagram to answer questions 1 and 2.



1. The structure labelled **X** is the

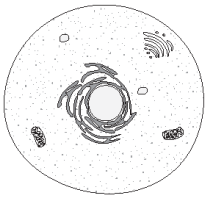
   A. ribosome.
   B. Golgi body.
   C. mitochondrion.
   D. endoplasmic reticulum.

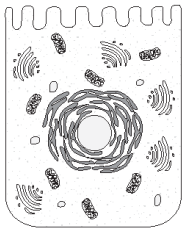
2. The function of the structure labelled **Y** is

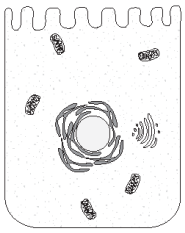
   A. phagocytosis.
   B. steroid synthesis.
   C. cellular respiration.
   D. selective re-absorption.

OVER

3. Which of the following cells of equal volume would be the most efficient at absorbing nutrients as well as synthesizing and secreting a product?

A. 

B. 

C. 

D.

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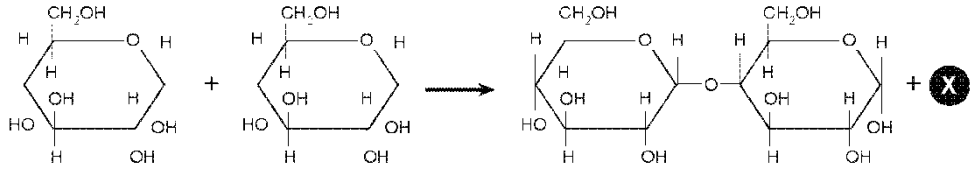
4. The products of reactions at the rough endoplasmic reticulum are transported in

   A. cilia.
   B. vesicles.
   C. nucleoli.
   D. mitochondria.

5. Translation occurs at which of the following organelles?

   A. nucleus
   B. vacuole
   C. ribosome
   D. nucleolus

Use the following diagram to answer question 6.



6. In the reaction above, what is molecule **X**?

   A. water
   B. an acid
   C. glucose
   D. an enzyme

---

7. Which of the following refers to primary protein structure?

   A. the helical shape of the protein
   B. the linear sequence of amino acids
   C. several protein molecules joined together
   D. the three-dimensional shape of the molecule

8. Which of the following is **not** a component of a nucleotide?

   A. sugar
   B. phospholipid
   C. phosphate group
   D. nitrogenous base

9. Which of the following correctly describes the number of bases in DNA?

   A. Adenine equals cytosine.
   B. Thymine equals guanine.
   C. Adenine and thymine equal guanine and cytosine.
   D. Adenine and cytosine equal thymine and guanine.

OVER

10. DNA from a wheat plant contains a gene that codes for the production of a bacterial enzyme. This is an example of

A. initiation.
B. promotion.
C. transfer RNA.
D. recombinant DNA.

11. Which of the following correctly contrasts RNA and DNA?

		RNA	DNA
A.	**sugar**	deoxyribose	ribose
B.	**structure**	single-stranded	double-stranded
C.	**location**	cytoplasm	nucleus and cytoplasm
D.	**shape**	helix	linear

12. Which of the following is a characteristic of cancerous cells?

A. flat shape
B. undifferentiated
C. large amount of cytoplasm
D. increased contact inhibition

13. Which of the following provides more oxygen to cancer cells?

A. metastasis
B. promotion
C. vascularization
D. abnormal nuclei

14. A virus can cause carcinogenesis in a human cell by

A. becoming a cancer cell.
B. inhibiting transcription.
C. introducing an oncogene.
D. converting oncogenes into proto-oncogenes.

15. According to the fluid-mosaic membrane model, phospholipids

A. form a single layer.
B. have the consistency of light oil.
C. actively transport potassium ions.
D. are only found on the outer layer of the membrane.

---

16. Four tissue samples were placed in four test tubes, each containing a sucrose solution of a different concentration. After a period of time, the final mass of each tissue sample was recorded.

Test Tube	Initial Mass of Tissue (g)	Final Mass of Tissue (g)
1	1.4	1.4
2	1.9	1.8
3	1.3	1.8
4	1.7	1.7

Given the results, which of the test tubes has a solution that is hypotonic to the tissue sample?

A. 1
B. 2
C. 3
D. 4

OVER

17. The function of the gallbladder is to

    A. store bile.
    B. store lipase.
    C. produce urea.
    D. produce trypsin.

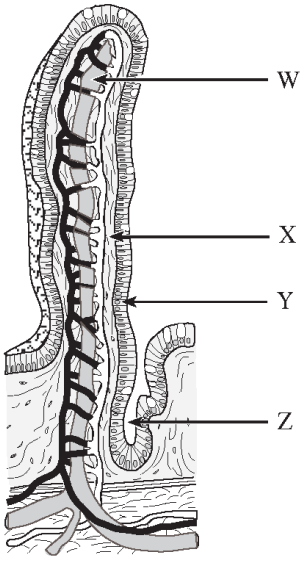
18. Starting in the esophagus, how many sphincters will an indigestible fibre molecule pass through on its way to the small intestine?

    A. one
    B. two
    C. three
    D. five

19. Which of the following enzymes produces a product that cannot be absorbed into the body?

    A. lipase
    B. maltase
    C. amylase
    D. nuclease

Use the following diagram to answer question 20.



20. Which letter indicates the area from which the products of lipid digestion are transported throughout the body?

A. W
B. X
C. Y
D. Z

---

21. Which of the following substances used by the body is produced by *E-coli* living in the digestive system?

A. minerals
B. vitamins
C. fatty acids
D. polysaccharides

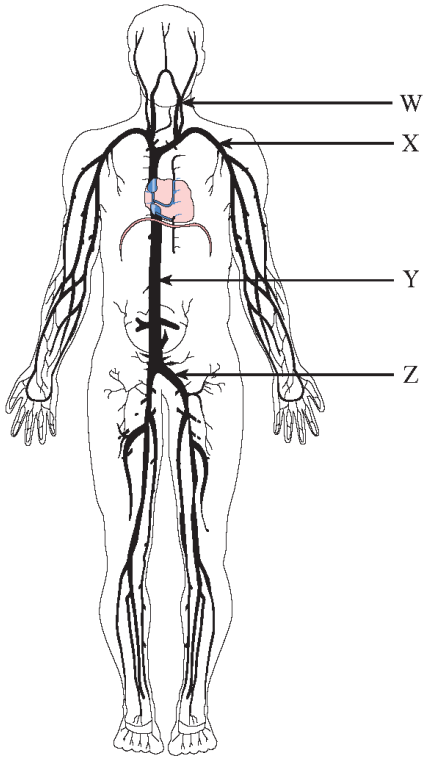
22. A function of an artery is to carry

A. blood to the small intestine.
B. blood from the head to the heart.
C. metabolic wastes away from the liver.
D. oxygenated blood from the lungs to the heart.

23. The blood vessels that carry blood to and from the head are the

A. aorta and pulmonary vein.
B. coronary artery and hepatic vein.
C. carotid arteries and jugular veins.
D. anterior vena cava and pulmonary artery.

Use the following diagram to answer question 24.



24. Which of the following represents the iliac vein?

A. W
B. X
C. Y
D. Z

---

25. Which two structures in the fetal circulatory system allow blood to bypass the lungs?

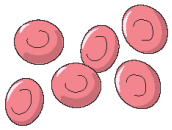
A. venous duct and oval opening
B. oval opening and arterial duct
C. pulmonary vein and arterial duct
D. umbilical artery and pulmonary vein

OVER

26. The lymphatic system consists of

A. vessels and valves.
B. AV and semilunar valves.
C. the pulmonary artery and the arterial duct.
D. the umbilical artery and the pulmonary vein.

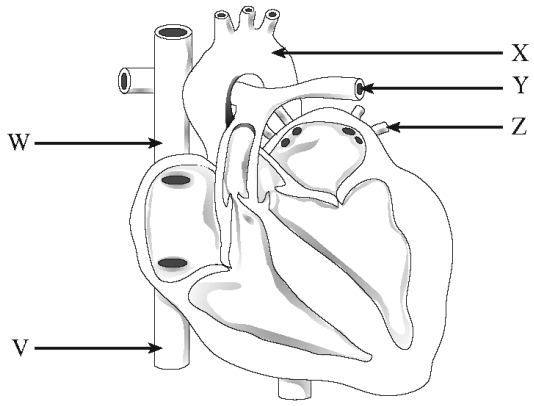
Use the following diagram to answer question 27.



27. What is the name of the blood components shown in the diagram?

A. platelets
B. red blood cells
C. plasma proteins
D. white blood cells

Use the following diagram to answer questions 28 and 29.



28. In which of the labelled structures would the highest blood pressure be measured?

A. V
B. W
C. X
D. Y

29. Which of the following correctly identifies structure **Z** in the diagram above and the composition of blood it contains?

	Structure Z	Composition of Blood
A.	vein	high concentration of oxyhemoglobin
B.	vein	low concentration of oxyhemoglobin
C.	artery	high concentration of reduced hemoglobin
D.	artery	low concentration of reduced hemoglobin

---

30. ~~As the blood moves through capillary beds from arteriole to venule, the osmotic pressure in the blood~~ **D E L E T E D**

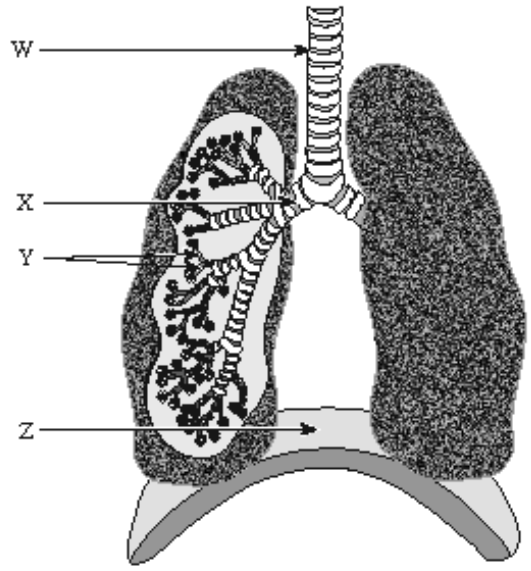
A. ~~increases.~~
B. ~~decreases.~~
C. ~~is lost entirely.~~
D. ~~stays the same.~~

OVER

31. Which of the following surrounds the lungs and the thoracic cavity and functions to reduce friction during inhalation and exhalation?

    A. cilia
    B. alveoli
    C. diaphragm
    D. pleural membranes

Use the following diagram to answer questions 32 and 33.



32. The bronchus is labelled

    A. W.
    B. X.
    C. Y.
    D. Z.

33. The structure labelled **Z** functions to

    A. filter dust from the air.
    B. exchange oxygen and carbon dioxide.
    C. move blood into the inferior vena cava.
    D. change the volume of the thoracic cavity.

Use the following information to answer question 34.

1. The diaphragm flattens.
2. The rib cage moves down and in.
3. The volume of the thoracic cavity increases.
4. The medulla oblongata signals the rib muscles to contract.

34. Which sequence correctly shows the order of events during breathing?

A. 1, 2, 4, 3
B. 2, 4, 3, 1
C. 3, 1, 2, 4
D. 4, 1, 3, 2

---

35. A small amount of carbon dioxide is transported in the pulmonary artery as

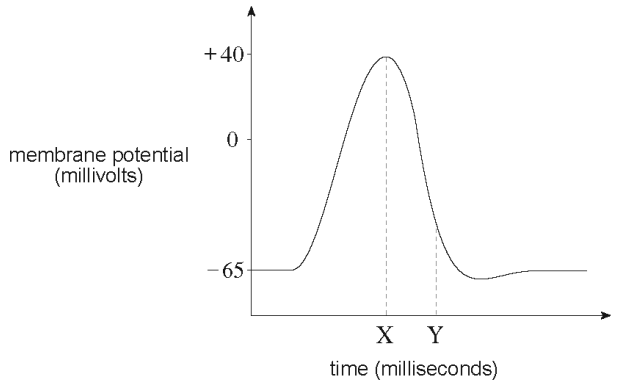
A. bicarbonate ion.
B. carbonic anhydrase.
C. reduced hemoglobin.
D. carbaminohemoglobin.

36. Which of the following carries a nerve impulse toward the spinal cord?

A. interneuron
B. synaptic cleft
C. motor neuron
D. sensory neuron

OVER

Use the following graph to answer question 37.



37. Which of the following events is causing the change within the neuron between time **X** and time **Y**?

    A. Sodium ions are moving into the axon.
    B. Sodium ions are moving out of the axon.
    C. Potassium ions are moving out of the axon.
    D. Large, organic, negative ions are moving into the axon.

---

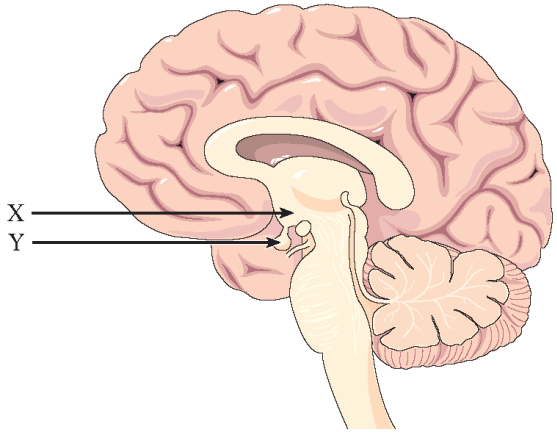
38. Movement of which of the following ions causes depolarization?

    A. sodium
    B. calcium
    C. hydrogen
    D. potassium

39. Which substance causes the microfilaments to contract and pull the synaptic vesicles to the presynaptic membrane?

    A. sodium ions
    B. calcium ions
    C. noradrenalin
    D. acetylcholine

Use the following diagram to answer questions 40 and 41.



40. The structure labelled **X** is the

A. pituitary.
B. cerebellum.
C. hypothalamus.
D. medulla oblongata.

41. Increased activity in structures **X** and **Y** is associated with which of the following?

A. rebuilding of the endometrium
B. decreased coordination of skeletal muscle
C. contraction of smooth muscle in the intestines
D. reabsorption of neurotransmitters in the synaptic cleft

---

42. What is the pathway for urine leaving the body?

A. collecting duct → renal pelvis → bladder → ureter
B. collecting duct → renal pelvis → ureter → bladder
C. renal pelvis → collecting duct → ureter → bladder
D. renal pelvis → bladder → ureter → collecting duct

OVER

43. Which of the following is less concentrated in blood plasma than it is in urine?

A. urea
B. insulin
C. glucose
D. carbon dioxide

Use the following information to answer question 44.

Water lost from the body (mL per day) on two different days		
From	**Day 1**	**Day 2**
Evaporation	900	1 200
Urine	1 500	1 200
Feces	100	100

44. Homeostasis is maintained on **day 2** by a hormone that is produced in the

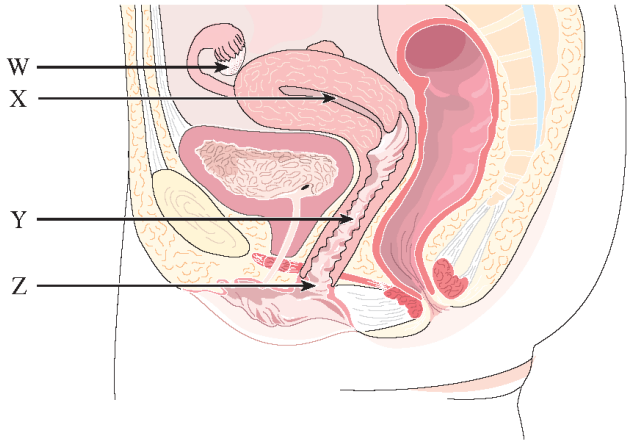
A. hypothalamus and acts on the collecting duct.
B. adrenal cortex and acts on the collecting duct.
C. posterior pituitary and acts on the loop of Henle.
D. anterior pituitary and acts on the distal convoluted tubule.

---

45. What is the function of the mid-piece of the sperm?

A. to propel the sperm
B. to protect the sperm
C. to produce ATP energy
D. to carry genetic material

Use the following diagram to answer questions 46 and 47.



46. Structure **W** contains the

A. cervix.
B. oviduct.
C. endometrium.
D. corpus luteum.

47. At which of the labelled structures is human chorionic gonadotropin (HCG) released?

A. W
B. X
C. Y
D. Z

---

48. Which hormone is released by the anterior pituitary that triggers the production of egg or sperm cells?

A. estrogen
B. progesterone
C. luteinizing hormone (LH)
D. follicle-stimulating hormone (FSH)

OVER

49. On which day of a typical 28-day menstrual cycle will luteinizing hormone (LH) be the highest?

A. day 2
B. day 7
C. day 13
D. day 28

50. Which of the following substances stimulates uterine contractions?

A. estrogen and calcium
B. oxytocin and prostaglandins
C. progesterone and human chorionic gonadotropin (HCG)
D. acrosomal enzymes and follicle-stimulating hormone (FSH)

This is the end of the multiple-choice section.
Answer the remaining questions directly in this examination booklet.

PART B: WRITTEN RESPONSE

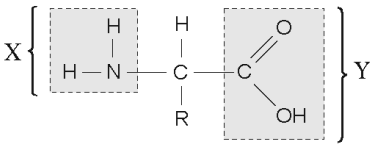
Value: 50 marks **Suggested Time: 75 minutes**

INSTRUCTIONS:

1. Use a **pen** for this part of the examination unless otherwise instructed.
2. Write your answers in the space below the questions.
3. Organization and planning space has been incorporated into the space allowed for answering each question.
4. You may not need all of the space provided to answer each question.

OVER

Use the following diagram to answer question 1.



1. a) Identify each of the following parts of the molecule. **(2 marks: 1 mark each)**

Part **X**:

_____

Part **Y**:

_____

b) State **two** different polymers that are synthesized from the molecule and give a function of each. **(4 marks: 1 mark each for polymer; 1 mark each for function)**

Polymer	Function

2. Describe how the following are related in terms of their function in protein synthesis.

DNA and mRNA: **(2 marks)**

tRNA and ribosomes: **(2 marks)**

OVER

3. The cells of the thyroid gland are able to take in iodine atoms and may contain iodine concentrations up to 25 times that of the surrounding tissue fluid. In an experiment designed to study factors affecting the rate of iodine intake, thyroid cells were cultured and placed in a medium containing normal blood concentrations of iodine. Temperature and glucose concentrations were varied and the effects recorded. The results of the study are shown in the table below.

Sample	Glucose Concentration (%)	Temperature (°C)	Increase in Iodine Concentration (X)
normal conditions	0.20	38	22
A	0.01	38	12
B	0.20	60	8

a) Explain the observed results for sample **A**. **(2 marks)**

b) Explain the observed results for sample **B**. **(2 marks)**

c) Explain how the movement of amino acids into the cells would be affected by the conditions in sample **B**. **(2 marks)**

4. Describe the pH in each of the following regions along the digestive tract. Identify the secretion which determines the pH of the region and give the source of the secretion.

stomach: **(3 marks)**

pH: _____

secretion: _____

source of secretion: _____

small intestine: **(3 marks)**

pH: _____

secretion:

source of secretion: _____

OVER

5. For each of the following processes, describe how the small intestine functions to digest food and absorb nutrients.

digestion: **(3 marks)**

absorption: **(2 marks)**

Use the following diagram to answer question 6.

6. a) Identify the type of blood vessel shown in the diagram. **(1 mark)**

_____

b) State **two** functions of the blood vessel in the diagram. **(2 marks)**

i) _____

_____

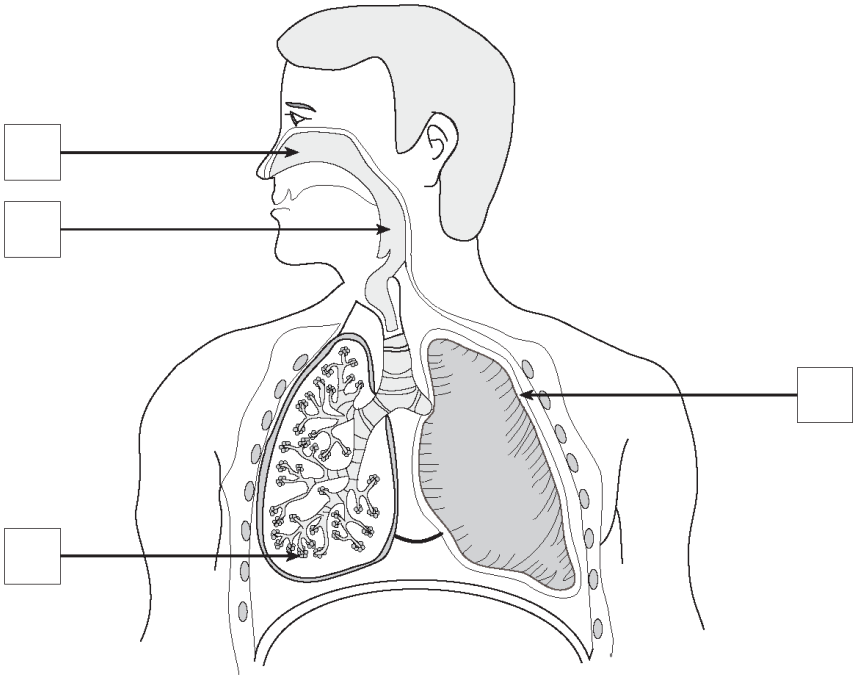
ii) _____

_____

OVER

7. Place the correct number for each of the following characteristics in the appropriate box at the locations in the diagram. (Only put one number per box. Not all of the characteristics will be used.) **(4 marks)**

    1. has stretch receptors
    2. prevents collapse of the lungs
    3. filters, warms and moistens air
    4. stops food from entering the lungs
    5. allows food and air to pass through
    6. has cilia, cartilaginous rings and mucous membranes



8. a) In what type of situation does the sympathetic nervous system respond? **(1 mark)**

b) What division is the sympathetic system part of? **(1 mark)**

c) State **four** effects on the body when the sympathetic nervous system is active. **(4 marks)**

i)

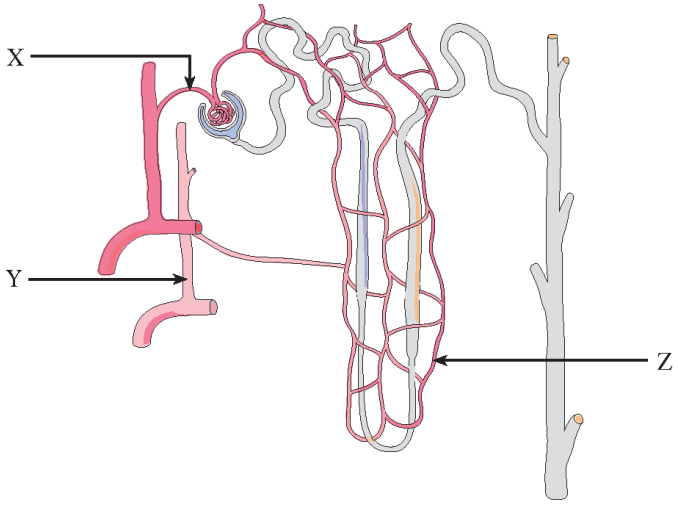
ii)

iii)

iv)

OVER

Use the following diagram to answer question 9 a) and b).



9. a) Identify the following structures. **(2 marks: 1 mark each)**

Structure **X**:

_____

Structure **Z**:

_____

b) In an experiment, fluids were removed at point **X** and at point **Y** and the composition of each sample was analyzed. Describe **three** ways in which the fluid obtained at point **X** is different from the fluid obtained at point **Y**. **(3 marks)**

i) _____

_____

ii) _____

_____

iii) _____

_____

c) Explain how an increase in blood pressure from 120/80 to 160/100 would increase the volume of urine produced. **(2 marks)**

_____

_____

_____

_____

OVER

10. Give **one** function for each of the following substances found in seminal fluid.

(3 marks: 1 mark each)

Substance	Function
fructose	
prostaglandins	
alkaline (basic) fluid	

END OF EXAMINATION

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Chemistry 12

JANUARY 2002

Course Code = CH

Student Instructions

1. Place the stickers with your Personal Education Number (PEN) in the allotted spaces above. **Under no circumstance is your name or identification, other than your Personal Education Number, to appear on this booklet.**
2. Ensure that in addition to this examination booklet, you have a **Data Booklet** and an **Examination Response Form**. Follow the directions on the front of the Response Form.
3. **Disqualification** from the examination will result if you bring books, paper, notes or unauthorized electronic devices into the examination room.
4. When instructed to open this booklet, **check the numbering of the pages** to ensure that they are numbered in sequence from page one to the last page, which is identified by

   END OF EXAMINATION.
5. At the end of the examination, place your Response Form inside the front cover of this booklet and return the booklet and your Response Form to the supervisor.

PART A: MULTIPLE CHOICE

Value: 60 marks **Suggested Time: 70 minutes**

INSTRUCTIONS: For each question, select the **best** answer and record your choice on the Response Form provided. Using an HB pencil, completely fill in the circle that has the letter corresponding to your answer.

Selected multiple-choice questions are worth 2 marks.

1. Which of the following has the greatest reaction rate? **(1 mark)**

   A. $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$
   B. $2H_2O_{2(\ell)} \rightarrow 2H_2O_{(\ell)} + O_{2(g)}$
   C. $2Al_{(s)} + 3CuCl_{2(aq)} \rightarrow 2AlCl_{3(aq)} + 3Cu_{(s)}$
   D. $NaCl_{(aq)} + AgNO_{3(aq)} \rightarrow AgCl_{(s)} + NaNO_{3(aq)}$

2. Which factor explains why potassium generally reacts faster than sodium? **(1 mark)**

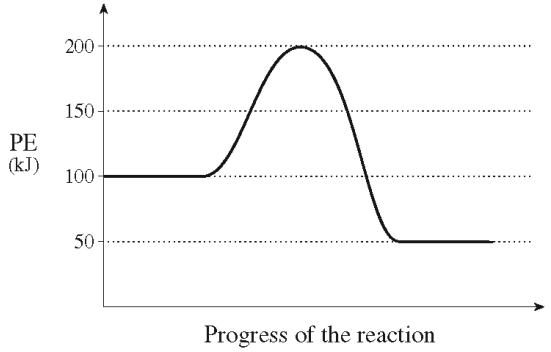
   A. surface area
   B. temperature
   C. concentration
   D. nature of reactants

3. What happens to the PE and KE of the reactant particles as the activated complex is formed? **(1 mark)**

	PE	KE
A.	increases	decreases
B.	increases	increases
C.	decreases	decreases
D.	decreases	increases

OVER

4. Consider the following PE diagram: **(2 marks)**



What are the values of ΔH and activation energy (E_a) for the forward reaction?

	ΔH (kJ)	E_a (kJ)
A.	–50	100
B.	–50	200
C.	+50	100
D.	+50	200

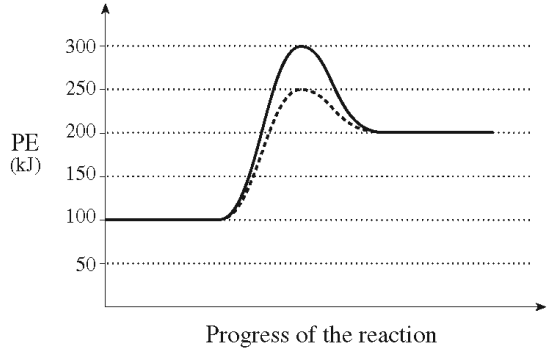
5. Consider the following reaction mechanism: **(1 mark)**

Step 1	$Cl_2 \rightarrow 2Cl$
Step 2	$CHCl_3 + Cl \rightarrow HCl + CCl_3$
Step 3	$CCl_3 + Cl \rightarrow CCl_4$

Which of the following is a reactant in the overall reaction?

A. Cl
B. HCl
C. CCl_3
D. $CHCl_3$

6. Consider the following PE diagram for a catalyzed and uncatalyzed reaction: **(2 marks)**



Which of the following describes the **reverse** reaction?

	Reverse Reaction	Activation Energy (kJ)	ΔH (kJ)
A.	catalyzed	50	−100
B.	uncatalyzed	50	−100
C.	catalyzed	50	+100
D.	uncatalyzed	50	+100

7. Consider the following: **(1 mark)**

$$2SO_{2(g)} + O_{2(g)} \rightleftarrows 2SO_{3(g)}$$

Initially, SO_3 is added to an empty flask. How do the rate of the forward reaction and $[SO_3]$ change as the system proceeds to equilibrium?

	Forward Rate	$[SO_3]$
A.	decreases	increases
B.	decreases	decreases
C.	increases	increases
D.	increases	decreases

OVER

8. Consider the following reaction: **(2 marks)**

$$N_{2(g)} + 3H_{2(g)} \rightleftarrows 2NH_{3(g)} + \text{energy}$$

What positions do minimum enthalpy and maximum entropy tend toward?

	Minimum Enthalpy	Maximum Entropy
A.	reactants	products
B.	reactants	reactants
C.	products	products
D.	products	reactants

Use the following equilibrium equation to answer questions 9 and 10.

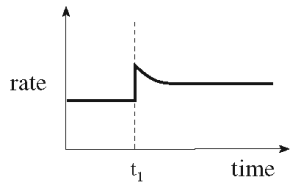
$$\mathbf{CO_{2(g)} + H_{2(g)} \rightleftarrows H_2O_{(g)} + CO_{(g)}}$$

9. Which two stresses will each cause the equilibrium to shift to the left? **(1 mark)**

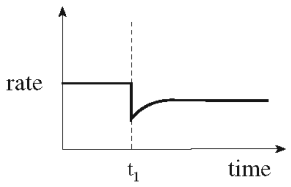
A. increase $[H_2]$, increase $[CO]$
B. decrease $[H_2]$, increase $[H_2O]$
C. increase $[CO_2]$, decrease $[CO]$
D. decrease $[CO_2]$, decrease $[H_2O]$

10. Which of the following graphs represents the forward rate of reaction when $H_2O_{(g)}$ is added to the above equilibrium at time = t_1 ? **(1 mark)**

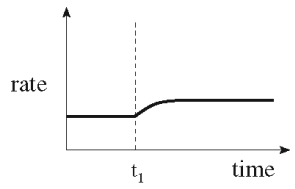
A.



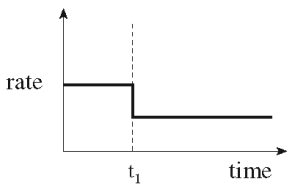
B.



C.



D.



11. Consider the following: **(1 mark)**

$$2NH_{3(g)} \rightleftarrows N_{2(g)} + 3H_{2(g)}$$

Initially, some NH_3 is placed into a 1.0 L container. At equilibrium there is 0.030 mol N_2 present. What is the $[H_2]$ at this equilibrium?

A. 0.010 mol/L
B. 0.030 mol/L
C. 0.060 mol/L
D. 0.090 mol/L

12. Which reaction has the following equilibrium expression? **(1 mark)**

$$K_{eq} = \frac{[NO_2]^4[H_2O]^6}{[NH_3]^4[O_2]^7}$$

A. $4NH_{3(g)} + 7O_{2(g)} \rightleftarrows 4NO_{2(g)} + 6H_2O_{(g)}$
B. $4NH_{3(aq)} + 7O_{2(g)} \rightleftarrows 4NO_{2(aq)} + 6H_2O_{(\ell)}$
C. $4NO_{2(aq)} + 6H_2O_{(\ell)} \rightleftarrows 4NH_{3(g)} + 7O_{2(g)}$
D. $4NO_{2(g)} + 6H_2O_{(g)} \rightleftarrows 4NH_{3(g)} + 7O_{2(g)}$

13. What will cause the K_{eq} for an exothermic reaction to increase? **(1 mark)**

A. increasing [reactants]
B. decreasing [products]
C. increasing the temperature
D. decreasing the temperature

OVER

14. Consider the following equilibrium: **(1 mark)**

$$PCl_{5(g)} \rightleftarrows PCl_{3(g)} + Cl_{2(g)} \qquad K_{eq} = 9.0 \times 10^{-2}$$

In a 1.0 L container an equilibrium mixture contains 6.0×10^{-3} mol PCl_5 and 1.0×10^{-2} mol PCl_3. How many moles of Cl_2 are also present at equilibrium?

A. 5.4×10^{-6} mol
B. 6.7×10^{-4} mol
C. 5.4×10^{-2} mol
D. 1.5×10^{-1} mol

15. The equation that describes the solubility equilibrium of $Ca_3(PO_4)_2$ is **(1 mark)**

A. $Ca_3(PO_4)_{2(s)} \rightleftarrows Ca_{3\,(aq)}^{6+} + 2PO_4^{\,3}{}_{(aq)}$
B. $Ca_3(PO_4)_{2(s)} \rightleftarrows 3Ca^{2+}_{(aq)} + 2PO_4^{\,3-}{}_{(aq)}$
C. $Ca_3(PO_4)_{2(s)} \rightleftarrows 2Ca^{3+}_{(aq)} + 3PO_4^{\,2-}{}_{(aq)}$
D. $Ca_3(PO_4)_{2(s)} \rightleftarrows \left(Ca^{2+}\right)_{3(aq)} + \left(PO_4^{\,3-}\right)_{2(aq)}$

16. In a saturated solution of $Ag_2C_2O_4$, the $\left[Ag^+\right] = 2.2 \times 10^{-4}$ M.
What is the solubility of $Ag_2C_2O_4$ in this solution? **(1 mark)**

A. 4.3×10^{-11} M
B. 1.1×10^{-4} M
C. 2.2×10^{-4} M
D. 4.4×10^{-4} M

17. When equal volumes of 0.2 M solutions are mixed, which of the following combinations forms a precipitate? **(1 mark)**

A. CaS and $Sr(OH)_2$
B. H_2SO_4 and $MgCl_2$
C. $(NH_4)_2SO_4$ and K_2CO_3
D. H_2SO_3 and $NaCH_3COO$

18. A solution contains 0.2 M Zn^{2+} and 0.2 M Sr^{2+}. An equal volume of a second solution was added, forming a precipitate with Sr^{2+} but not with Zn^{2-}. What is present in the second solution? **(1 mark)**

A 0.2 M Cl^-
B. 0.2 M OH^-
C. 0.2 M SO_4^{2-}
D. 0.2 M PO_4^{3-}

19. The K_{sp} expression for a saturated solution of $Ba_3(AsO_4)_2$ is **(1 mark)**

A. $K_{sp} = [Ba^{2+}][AsO_4^{3-}]$
B. $K_{sp} = [Ba^{2+}]^3[AsO_4^{3}]^2$
C. $K_{sp} = [3Ba^{2+}][2AsO_4^{3-}]$
D. $K_{sp} = [3Ba^{2+}]^3[2AsO_4^{3-}]^2$

20. The solubility of $NiCO_3$ is 4.4×10^{-2} g/L . Determine the K_{sp} value of $NiCO_3$. **(2 marks)**

A. 1.4×10^{-7}
B. 3.7×10^{4}
C. 1.9×10^{-3}
D. 2.1×10^{-1}

OVER

21. Calculate the solubility of $PbSO_4$. **(1 mark)**

A. 3.2×10^{-16} M
B. 1.8×10^{-8} M
C. 3.6×10^{-8} M
D. 1.3×10^{-4} M

22. When a solution containing Ag^{1} is mixed with a solution containing BrO_3 , the trial ion product is determined to be 2.5×10^{-7} . What would be observed? **(2 marks)**

A. A precipitate would form since trial ion product < K_{sp} .
B. A precipitate would form since trial ion product > K_{sp} .
C. A precipitate would not form since trial ion product < K_{sp} .
D. A precipitate would not form since trial ion product > K_{sp} .

23. Which of the following represents the complete neutralization of H_3PO_4 by NaOH? **(1 mark)**

A. $H_3PO_4 + NaOH \rightarrow NaH_2PO_4 + H_2O$
B. $H_3PO_4 + 3NaOH \rightarrow Na_3PO_4 + 3H_2O$
C. $H_3PO_4 + 2NaOH \rightarrow Na_2HPO_4 + 2H_2O$
D. $H_3PO_4 + NaOH \rightarrow NaH + HPO_4 + H_2O$

24. The conjugate base of HBO_3^{2-} is **(1 mark)**

A. BO_3^{2-}
B. BO_3^{3}
C. $IIBO_3^{-}$
D. $H_2BO_3^{-}$

25. When comparing equal volumes of 0.10 M HNO_3 with 0.10 M HNO_2 , what would be observed? **(1 mark)**

A. The pH values would be the same.
B. The electrical conductivities would be different.
C. The effects on blue litmus paper would be different.
D. The volumes of 0.10 M NaOH needed for neutralization would be different.

26. Consider the equilibrium: **(2 marks)**

$$HF_{(aq)} + HPO_4^{2-}{}_{(aq)} \rightleftarrows F^-_{(aq)} + H_2PO_4^-{}_{(aq)}$$

For the above equilibrium, identify the weaker acid and determine whether reactants or products are favoured.

	Weaker Acid	Side Favoured
A.	HF	products
B.	HF	reactants
C.	$H_2PO_4^-$	products
D.	$H_2PO_4^-$	reactants

27. The ionization of water can be represented by **(1 mark)**

A. $2H_2O_{(\ell)} \rightarrow 2H_{2(g)} + O_{2(g)}$
B. $H_2O_{(\ell)} \rightarrow 2H^+_{(aq)} + O^{2-}_{(aq)}$
C. $H_2O_{(\ell)} \rightarrow H_3O_{(aq)} + OH_{(aq)}$
D. $2H_2O_{(\ell)} \rightarrow H_3O^+_{(aq)} + OH^-_{(aq)}$

28. Calculate the pOH of a 0.050 M HBr solution. **(1 mark)**

A. 0.30
B. 1.30
C. 12.70
D. 13.70

OVER

29. Calculate the value of K_b for HPO_4^{2-}. **(1 mark)**

A. 4.5×10^{-2}
B. 1.6×10^{-7}
C. 2.2×10^{-27}
D. 6.2×10^{-22}

30. Which of the following is the net ionic equation describing the hydrolysis of $KCN_{(aq)}$? **(1 mark)**

A. $K^+_{(aq)} + H_2O_{(\ell)} \rightleftarrows KOH_{(aq)} + H^+_{(aq)}$
B. $KCN_{(aq)} + H_2O_{(\ell)} \rightleftarrows K^+_{(aq)} + CN^-_{(aq)}$
C. $CN^-_{(aq)} + H_2O_{(\ell)} \rightleftarrows HCN_{(aq)} + OH^-_{(aq)}$
D. $CN^-_{(aq)} + H_2O_{(\ell)} \rightleftarrows 2H^+_{(aq)} + CNO^-_{(aq)}$

31. Which of the following 1.0 M salt solutions will be acidic? **(2 marks)**

A. $NaNO_3$
B. $NaHCO_3$
C. $NaHSO_4$
D. $NaHPO_4$

32. The pH at which an indicator changes colour is known as its **(1 mark)**

A. standard point.
B. transition point.
C. equivalence point.
D. stoichiometric point.

33. An indicator is blue at a pH of 12.0 and colourless at a pH of 1.0 .
Identify the indicator and determine its K_a value. **(2 marks)**

	Indicator	K_a
A.	thymolphthalein	1×10^{-10}
B.	thymolphthalein	3×10^{-7}
C.	bromthymol blue	2×10^{-7}
D.	bromthymol blue	3×10^{-7}

34. A 10.0 mL sample of H_2SO_3 is completely neutralized by titration with 18.6 mL of 0.10 M NaOH . Calculate the concentration of the acid. **(2 marks)**

A. 0.093 M
B. 0.19 M
C. 0.37 M
D. 0.74 M

35. A common source of NO_2 is **(1 mark)**

A. a fuel cell.
B. a lead smelter.
C. an aluminum smelter.
D. an automobile engine.

36. The pH at the stoichiometric point for the complete neutralization of a strong acid by a weak base will be **(1 mark)**

A. equal to 7.0
B. equal to 7.2
C. less than 7.0
D. greater than 7.2

OVER

37. A buffer solution can be prepared by dissolving equal moles of **(1 mark)**

A. a weak base and a strong base.
B. a weak acid and its conjugate base.
C. a strong base and its conjugate acid.
D. a strong acid and its conjugate base.

38. A reducing agent **(2 marks)**

A. loses electrons and is reduced.
B. gains electrons and is reduced.
C. loses electrons and is oxidized.
D. gains electrons and is oxidized.

39. Which of the following could be produced by the reduction of NO_2 ? **(1 mark)**

A. NO
B. N_2O_4
C. N_2O_5
D. HNO_3

40. Consider the following redox equation: **(1 mark)**

$$3NO + SO_4^{2-} + Fe^{3+} + 2H_2O \rightarrow FeS + 3NO_3^- + 4H^-$$

Which of the following is being oxidized?

A. NO
B. Fe^{3+}
C. H_2O
D. SO_4^{2-}

41. What is the oxidation number of Cr in $Cr_2O_7^{2-}$? **(1 mark)**

A. +6
B. +7
C. +12
D. +14

42. Which of the following represents a spontaneous redox reaction? **(1 mark)**

A. $2Br^- + Hg^{2-} \rightarrow Br_2 + Hg$
B. $Cu + Sn^{4+} \rightarrow Cu^{2+} + Sn^{2+}$
C. $HCl + NaOH \rightarrow NaCl + H_2O$
D. $AuCl_4^- + 3Ag \rightarrow Au + 4Cl^- + 3Ag^+$

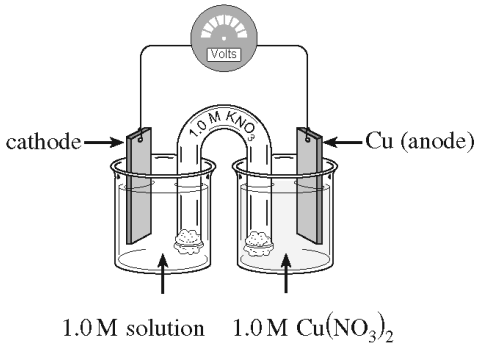
43. Which of the following is the balanced half-reaction for **(1 mark)**

$$N_2O \rightarrow NH_3OH^+ \qquad \text{(acidic)}$$

A. $N_2O + 4H^+ + 3e^- \rightarrow NH_3OH^+$
B. $N_2O + 3H^+ + H_2O \rightarrow NH_3OH^+ + 2e^-$
C. $N_2O + 6H^+ + H_2O \rightarrow 2NH_3OH^+ + 4e^-$
D. $N_2O + 6H^+ + H_2O + 4e^- \rightarrow 2NH_3OH^+$

OVER

Use the following diagram to answer questions 44 to 46.



44. Which material could be used as the cathode to produce an $E^{\circ}_{cell} = +0.46\,V$? **(1 mark)**

A. Pb
B. Co
C. Ag
D. MnO_2

45. In what directions do the electrons and cations move? **(2 marks)**

	Direction of Electrons	Direction of Cations
A.	toward the cathode	toward the anode
B.	toward the cathode	toward the cathode
C.	toward the anode	toward the anode
D.	toward the anode	toward the cathode

46. The concentration of Cu^{2+} in the copper half-cell will **(2 marks)**

A. increase as Cu loses electrons and is reduced.
B. increase as Cu loses electrons and is oxidized.
C. decrease as Cu gains electrons and is reduced.
D. decrease as Cu gains electrons and is oxidized.

47. Which of the following metals could be used to cathodically protect iron? **(1 mark)**

A. tin
B. lead
C. zinc
D. copper

48. Which of the following is formed at the anode during the electrolysis of 1.0 M KF ? **(1 mark)**

A. K
B. F_2
C. H_2
D. O_2

This is the end of the multiple-choice section.
Answer the remaining questions directly in this examination booklet.

OVER

PART B: WRITTEN RESPONSE

Value: 40 marks **Suggested Time: 50 minutes**

INSTRUCTIONS:	You will be expected to communicate your knowledge and understanding of chemical principles in a clear and logical manner. Your steps and assumptions leading to a solution must be written in the spaces below the questions. Answers must include units where appropriate and be given to the correct number of significant figures. **For questions involving calculations, full marks will NOT be given for providing only an answer.**

1. Consider the following reaction: **(3 marks)**

$$C_{12}H_{22}O_{11(s)} \rightarrow 11\ H_2O_{(g)} + 12C_{(s)}$$

The rate of decomposition of $C_{12}H_{22}O_{11}$ is 0.75 mol/min .
What mass of C is produced in 10.0 seconds?

2. Define the term *activation energy*. **(2 marks)**

3. Consider the following equilibrium: **(2 marks)**

$$2NF_{2(g)} \rightleftarrows N_2F_{4(g)}$$

Equilibrium shifts to the right when volume is decreased. Describe the changes in reaction rates that cause this shift to the right.

4. Consider the following: **(4 marks)**

$$H_{2(g)} + I_{2(g)} \rightleftarrows 2HI_{(g)}$$

Initially, 0.200 mol H_2 and 0.200 mol I_2 are added to an empty 2.00 L container. At equilibrium, the $[I_2] = 0.020$ mol/L . What is the value of K_{eq} ?

OVER

5. When equal volumes of 0.20 M $Pb(NO_3)_2$ and 0.20 M KCl are mixed, a precipitate of $PbCl_2$ forms.

   a) Write the formula equation for the above reaction. **(1 mark)**

   b) Write the complete ionic equation for the above reaction. **(1 mark)**

   c) Write the net ionic equation for the above reaction. **(1 mark)**

6. Calculate the maximum $[CO_3^{2-}]$ that can exist in 0.0010 M $Mg(NO_3)_2$. **(3 marks)**

7. The two reactants in an acid-base reaction are $HNO_{2(aq)}$ and $HCO_3^-{}_{(aq)}$.

a) Write the equation for the above reaction. **(2 marks)**

b) Define the term *conjugate acid-base pair.* **(1 mark)**

c) Write the formulas for a conjugate acid-base pair for the above reaction. **(1 mark)**

8. At 10.0°C, $K_w = 2.95 \times 10^{-15}$ for pure water.

   a) Calculate the pII of water at 10.0°C. **(3 marks)**

   b) A mixture of the indicators phenolphthalein and bromcresol green is added to the water. What is the resulting colour of the mixture? Explain. **(2 marks)**

   Resulting colour: _____

   Explanation: _____

   _____

9. At a particular temperature a 1.0 M H_2S solution has a pH = 3.75 . Calculate the value of K_a at this temperature. **(4 marks)**

10. What is the main function of a buffer solution? **(1 mark)**

_____

_____

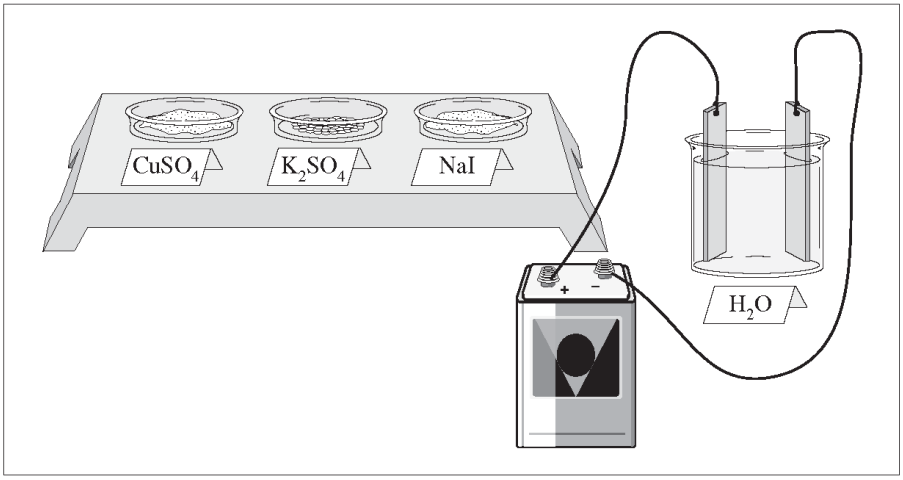
OVER

11. A titration is performed to determine the concentration of Fe^{2+} in 25.00 mL of an $FeSO_4$ solution. It requires 22.52 mL of 0.015 M $KMnO_4$ to reach the equivalence point according to the following equation:

$$MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$$

Calculate the $\left[Fe^{2+}\right]$. **(4 marks)**

12. Consider the following diagram:



Students are asked to produce hydrogen and oxygen gas by the electrolysis of water. They are given three substances $(CuSO_4, K_2SO_4$ and $NaI)$ to choose from to prepare an electrolytic solution that will only produce hydrogen and oxygen.

a) Which substance should be selected? Explain why. **(3 marks)**

Substance: _____

Explanation: _____

_____

b) Write the equation for the half-reaction that occurs at the anode in the electrolytic cell. **(1 mark)**

c) Explain why it would **not** be acceptable to use a copper anode in this cell. **(1 mark)**

_____

_____

END OF EXAMINATION

INSERT STUDENT I.D. NUMBER

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JANUARY 1995

PROVINCIAL EXAMINATION

MINISTRY OF EDUCATION

PHYSICS 12

GENERAL INSTRUCTIONS

1. Insert the stickers with your Student I.D. Number (PEN) in the allotted spaces above. **Under no circumstance is your name or identification, other than your Student I.D. Number, to appear on this paper.**
2. Take the separate Answer Sheet and follow the directions on its front page.
3. Be sure you have an HB pencil and an eraser for completing your Answer Sheet. Follow the directions on the Answer Sheet when answering multiple-choice questions.
4. For each of the written-response questions, write your answer in the space provided.
5. When instructed to open this booklet, **check the numbering of the pages** to ensure that they are numbered in sequence from page one to the last page, which is identified by

   END OF EXAMINATION.
6. At the end of the examination, place your Answer Sheet inside the front cover of this booklet and return the booklet and your Answer Sheet to the supervisor.

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FOR OFFICE USE ONLY

INSERT STUDENT I.D. NUMBER

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_____ – _____

PHYSICS 12 JANUARY 1995 PROVINCIAL
(PHP)

1. _____ (7)

2. _____ (7)

3. _____ (7)

4. _____ (5)

5. _____ (4)

6. _____ (7)

7. _____ (7)

8. _____ (4)

Score **only one** of the following optional sections.

SECTION I		SECTION II		SECTION III
9. _____ (3)		12. _____ (3)		15. _____ (3)
10. _____ (4)	**OR**	13. _____ (4)	**OR**	16. _____ (4)
11. _____ (5)		14. _____ (5)		17. _____ (5)

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PHYSICS 12 PROVINCIAL EXAMINATION

1. This examination consists of **three** parts:

		Value	Suggested Time
PART A:	30 multiple-choice questions worth two marks each	60	60
PART B:	7 written-response questions	48	48
PART C:	Three sections from which **one** section **only** must be chosen.	12	12
	Total	**120 marks**	**120 minutes**

2. The last **three** pages inside the back cover contain the **Data Table**, **Trigonometric and Other Equations**, **Equations,** and **Rough Work for Multiple-Choice**. These pages may be detached for convenient reference prior to writing this examination.

3. Rough-work space has been incorporated into the space allowed for answering each written-response question. You may not need all of the space provided to answer each question.

4. An approved scientific calculator is essential for the examination. The calculator must be a hand-held device designed **only** for mathematical computations such as logarithmic and trigonometric functions. It **can be** programmable, but **must not** contain any graphing capabilities. You **must not** bring into the examination room any devices to support calculators such as manuals, printed or electronic cards, printers, memory expansion chips or cards, or keyboards.

5. You are permitted to use rulers, compasses and protractors.

6. a) Final answers must include appropriate **units**.
   b) Marks will not be deducted for answers expressed to **two** or **three** significant figures.
   c) In this examination the zero in a number such as 30 shall be considered to be a significant zero.

7. You are expected to communicate your knowledge and understanding of physics principles in a clear and logical manner. Partial marks will be awarded for steps and assumptions leading to a solution. Full marks will **not** be awarded for providing **only** a final answer.

   If you are unable to determine the value of a quantity required in order to proceed, you may assume a reasonable value and continue toward the solution. Such a solution, however, may not be eligible for full marks.

8. You have **two hours** to complete this examination.

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PART A: MULTIPLE-CHOICE

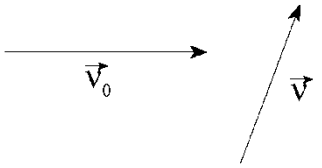
Value: 60 marks (2 marks per question) **Suggested Time: 60 minutes**

INSTRUCTIONS: For each question, select the **best** answer and record your choice on the answer sheet provided. Using an HB pencil, completely fill in the circle that has the letter corresponding to your answer.

1. Which of the following is a vector quantity?

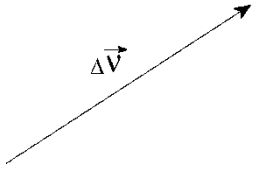
   A. work
   B. speed
   C. acceleration
   D. kinetic energy

2. Initial velocity vector $\vec{v}_0$ and final velocity vector $\vec{v}$ are shown below.



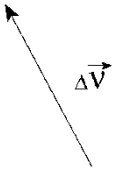
Which of the following represents the change in velocity $\Delta\vec{v}$?

A.

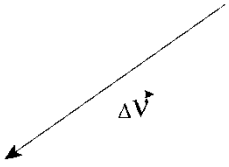


B.

C.



D.

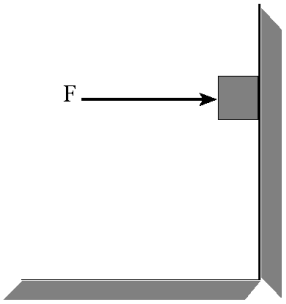


OVER

3. A projectile is launched over level ground with a speed of 240 m/s at 35° to the horizontal. If friction is negligible, what is the height of the projectile 17 s after launch?

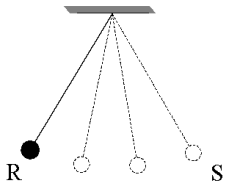
   A. 9.2×10^2 m
   B. 1.9×10^3 m
   C. 2.7×10^3 m
   D. 5.5×10^3 m

4. What minimum horizontal force F will **just** prevent the 5.0 kg block from sliding if the coefficient of friction between the wall and the block is 0.65?



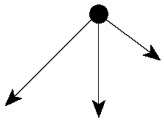
   A. 6.4 N
   B. 32 N
   C. 49 N
   D. 75 N

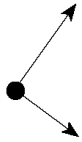
5. A pendulum is swinging freely between points R and S as shown in the diagram below.

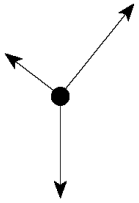


Which of the following diagrams **best** represents the forces acting on the pendulum bob at point R?

A.

B. 

C. 

D. 

6. Impulse is measured in which units?

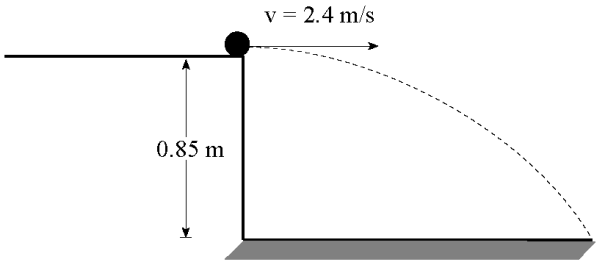
A. J
B. N
C. $N \cdot m$
D. $N \cdot s$

7. How much work must be done to stop an 1 800 kg vehicle travelling at 30 m/s?

A. 1.8×10^4 J
B. 5.4×10^4 J
C. 5.3×10^5 J
D. 8.1×10^5 J

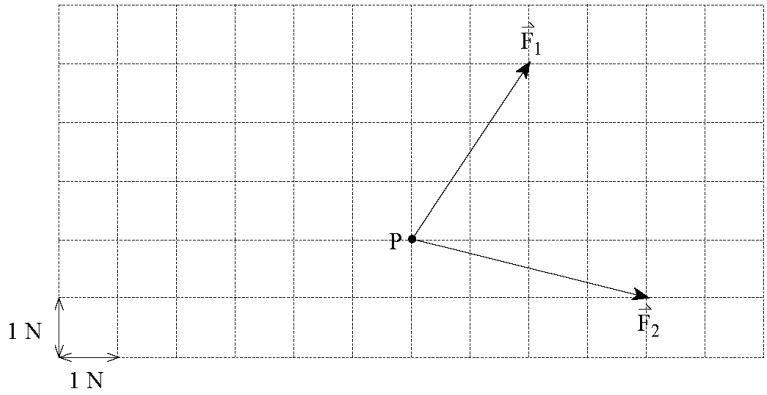
OVER

8. A 0.15 kg ball rolls off a bench at 2.4 m/s as shown in the diagram below. What is the vertical component of the ball's momentum when it strikes the floor 0.85 m below?



A. $0.36\ \text{kg}\cdot\text{m/s}$
B. $0.61\ \text{kg}\cdot\text{m/s}$
C. $0.71\ \text{kg}\cdot\text{m/s}$
D. $1.2\ \text{kg}\cdot\text{m/s}$

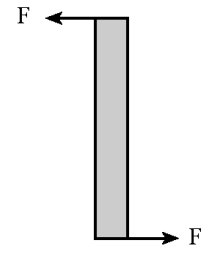
9. Two forces act at point P as shown below.

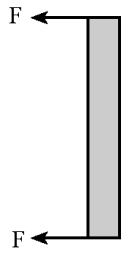


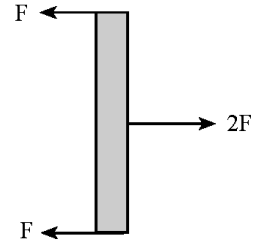
Find the magnitude of the third force required to achieve equilibrium.

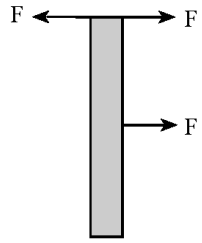
A. 4.5 N
B. 5.5 N
C. 6.3 N
D. 7.2 N

10. Which of the following shows a uniform beam which is in rotational equilibrium but **not** translational equilibrium?

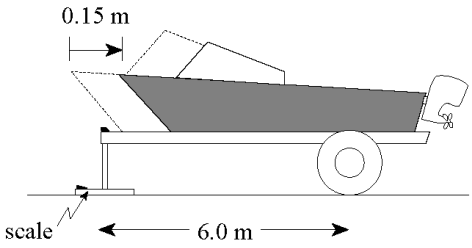
A.


B.


C.


D.


11. A trailer carrying a boat is supported by a scale which initially reads 48 kg. The boat (and therefore its centre of gravity) is moved 0.15 m further back on the trailer. The scale now reads 37 kg. Find the mass of the boat.



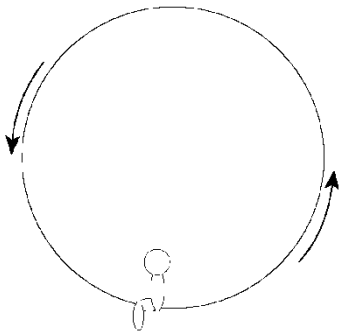
A. 440 kg
B. 1 600 kg
C. 1 700 kg
D. 3 400 kg

12. The work required to move an object in a planet's gravitational field can be determined graphically by calculating

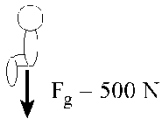
A. the slope of a graph of gravitational force versus separation distance.
B. the area under a graph of gravitational force versus separation distance.
C. the slope of a graph of gravitational potential energy versus separation distance.
D. the area under a graph of gravitational potential energy versus separation distance.

OVER

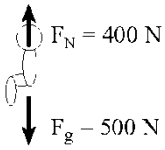
13. A 500 N child travels in a circular path on a ferris wheel. Which free body diagram **best** shows the forces which could act on the child as she passes the lowest point?



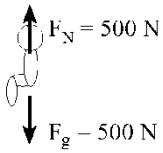
A.



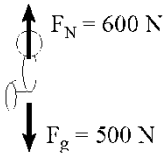
B.



C.



D.



14. A satellite orbits a planet of mass 4.0×10^{25} kg at a velocity of 5.8×10^{3} m/s. What is the radius of this orbit?

A. 6.4×10^{6} m
B. 7.9×10^{7} m
C. 1.6×10^{8} m
D. 1.2×10^{19} m

15. What minimum kinetic energy would a spacecraft of mass 1.2×10^{4} kg need at the surface of the Earth so that it could escape to infinity?

A. 1.1×10^{4} J
B. 1.2×10^{5} J
C. 7.5×10^{11} J
D. An infinite amount

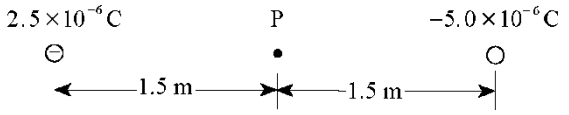
16. A negative charge in an electric field experiences a force accelerating it due south. What is the direction of the electric field?

A. east
B. west
C. north
D. south

17. A -2.3×10^{-6} C charge exerts a repulsive force of magnitude 0.35 N on an unknown charge 0.20 m away. What are the magnitude and polarity of the unknown charge?

	MAGNITUDE	POLARITY
A.	6.8×10^{-7} C	Negative
B.	6.8×10^{7} C	Positive
C.	1.2×10^{-6} C	Negative
D.	1.2×10^{-6} C	Positive

18. Two point charges, 2.5×10^{-6} C and -5.0×10^{-6} C, are placed 3.0 m apart as shown below.

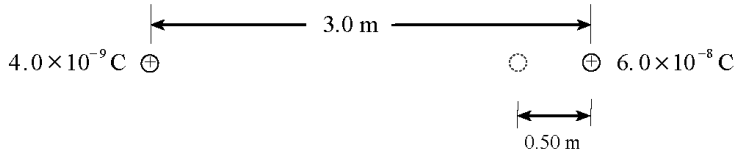


What is the magnitude of the electric field at point P, midway between the two charges?

A. 0 N/C
B. 1.0×10^{4} N/C
C. 2.0×10^{4} N/C
D. 3.0×10^{4} N/C

OVER

19. A 4.0×10^{-9} C charge is initially located 3.0 m from a stationary 6.0×10^{-8} C charge. How much work is required to move the 4.0×10^{-9} C charge to a point 0.50 m from the stationary charge?

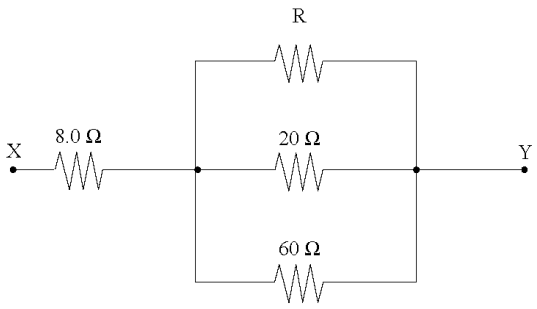


A. 6.0×10^{-7} J
B. 8.6×10^{-7} J
C. 3.6×10^{-6} J
D. 4.3×10^{-6} J

20. Two parallel plates 4.0×10^{-2} m apart have a potential difference of 1 000 V. An electron is released from the negative plate at the same instant that a proton is released from the positive plate. Which of the following **best** compares their speed and kinetic energy as they strike the opposite plate?

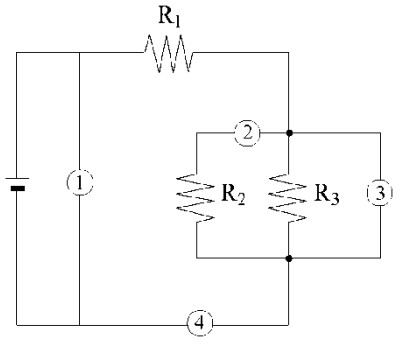
	SPEED OF ELECTRON AND PROTON	KINETIC ENERGY OF ELECTRON AND PROTON
A.	same	same
B.	same	different
C.	different	same
D.	different	different

21. The total resistance between points X and Y is 14.0 Ω. What is the value of R?



A. 6.0 Ω
B. 8.3 Ω
C. 10 Ω
D. 210 Ω

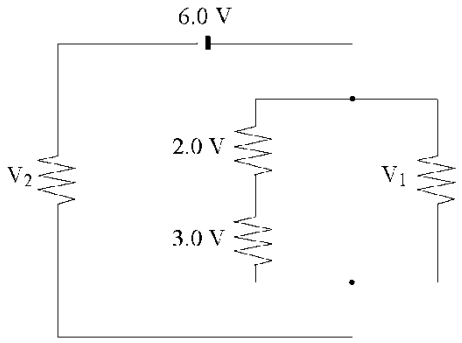
22. The diagram below shows a circuit with four possible meter locations.



In which locations should an ammeter and voltmeter be connected to correctly measure the current through R_2 and the voltage drop across R_2 ?

	CURRENT THROUGH R_2	VOLTAGE DROP ACROSS R_2
A.	2	1
B.	2	3
C.	4	1
D.	4	3

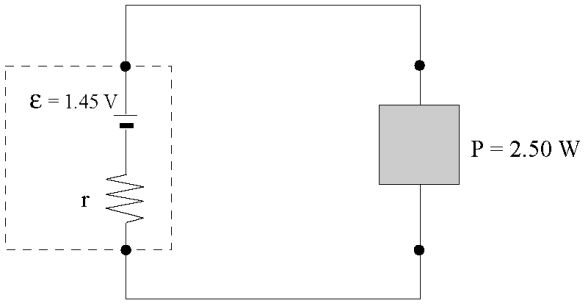
23. What are the potential differences, V_1 and V_2, in the circuit shown below?



	Potential Difference V_1	Potential Difference V_2
A.	1.0 V	5.0 V
B.	1.0 V	6.0 V
C.	5.0 V	1.0 V
D.	5.0 V	5.0 V

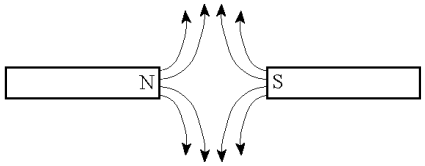
OVER

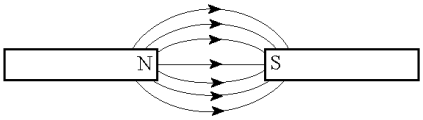
24. A 2.50 W device requires 1.20 V to operate properly. A 1.45 V cell, with internal resistance r, is used to power this device. What value of r enables the cell to provide 1.20 V to the device?

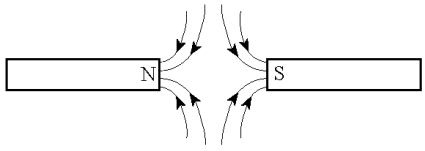


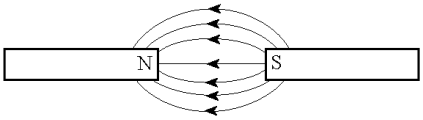
A. 0.120 Ω
B. 0.145 Ω
C. 0.576 Ω
D. 0.841 Ω

25. Which of the following correctly shows the magnetic field between two opposite, magnetic poles?

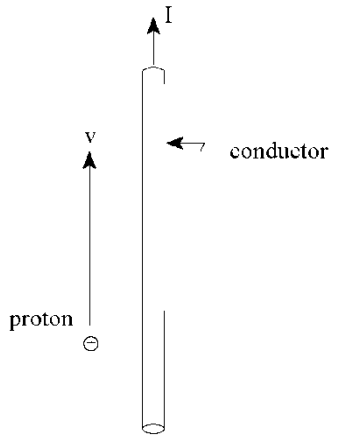
A.


B.


C.


D.


26. A proton moving parallel to a current-carrying wire will experience a force in what direction? (The proton and the wire are both in the plane of the page.)



A. into the page
B. out of the page
C. toward the conductor (to the right)
D. away from the conductor (to the left)

27. A particle with a charge of 3.2×10^{-19} C is moving at 1.2×10^{6} m/s. This particle enters a 0.25 T magnetic field at right angles and travels in a circular path of 0.80 m radius. What is the mass of this particle?

A. 6.7×10^{-27} kg
B. 5.3×10^{-26} kg
C. 6.4×10^{-20} kg
D. 7.7×10^{-14} kg

28. Which of the following is a statement of Lenz's law?

A. The number of magnetic lines perpendicular to the surface area enclosed by a circuit is equal to the flux.

B. An induced current in a closed conducting loop will appear in such a direction that it opposes the change that created it.

C. An emf is produced between the ends of a straight wire when the wire is moving perpendicularly through a uniform magnetic field.

D. The average emf induced in a circuit is proportional to the rate of change of the magnetic flux through that circuit.

OVER

29. A 2.5 m wire moves 77 m/s perpendicular to a uniform 3.8×10^{-6} T magnetic field. What potential difference is induced across the ends of this wire?

A. 0 V
B. 1.6×10^{-19} V
C. 2.0×10^{-8} V
D. 7.3×10^{-4} V

30. A transformer has four times as many turns on the secondary as on the primary. If the primary voltage is 120 V ac, which of the following describes the transformer?

	SECONDARY VOLTAGE	TYPE
A.	30 V ac	step down
B.	30 V ac	step up
C.	480 V ac	step down
D.	480 V ac	step up

This is the end of the multiple-choice section.
Answer the remaining questions directly in this examination booklet.

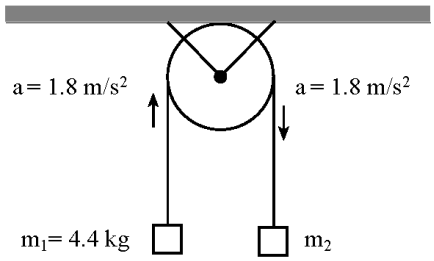
PART B: WRITTEN-RESPONSE

Value: 48 marks **Suggested Time: 48 minutes**

INSTRUCTIONS:	Rough-work space has been incorporated into the space allowed for answering each question. You may not need all of the space provided to answer each question. Your numerical answers to problems must contain correct units where appropriate, and must be calculated to two or three significant figures. Since partial marks will be awarded for a partial solution, it is important that you provide a clear indication of the steps leading to your answer. **Full marks will NOT be given for providing only a final answer.**

OVER

1. The diagram shows a 4.4 kg mass connected by a string to an unknown mass over a frictionless pulley. The system accelerates at 1.8 m/s^2 in the direction shown.



a) Draw and label a free body diagram for the 4.4 kg mass. **(2 marks)**

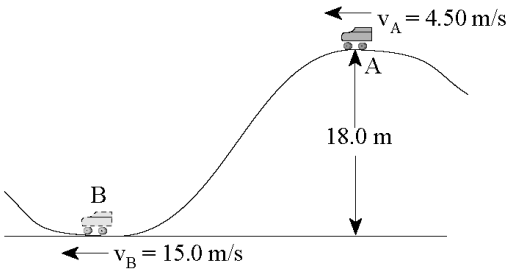
b) Calculate the tension in the string. **(2 marks)**

c) Find mass m_2. **(3 marks)**

ANSWERS:	Score for Question 1:
b) tension _____	1. _____ (7)
c) mass _____	

OVER

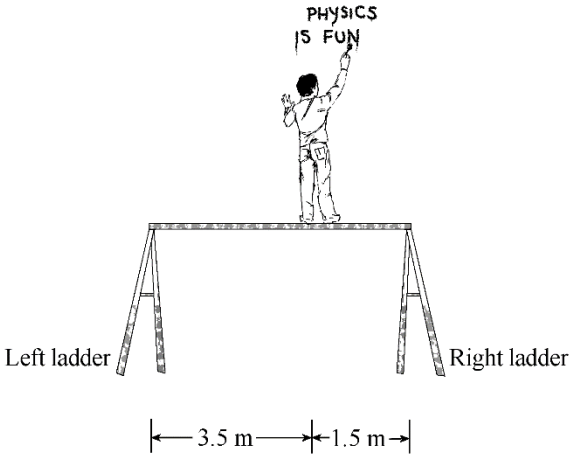
2. A 250 kg roller coaster car travels past points A and B with speeds shown in the diagram below. How much heat energy is produced between these points? **(7 marks)**



ANSWER:	Score for Question 2:
heat energy: _____	2. _____ (7)

OVER

3. A 75 kg painter stands on a uniform 5.0 m board of mass 16 kg supported horizontally by two ladders. Find the forces exerted by each ladder on the board. **(7 marks)**



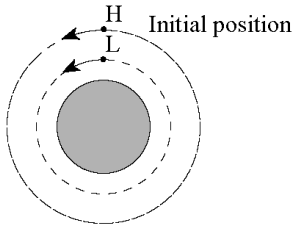
ANSWER:	Score for Question 3:
forces: _____ _____	3. _____ (7)

OVER

4. a) A satellite is placed in circular orbit at an altitude of 4.8×10^5 m above Earth's surface. What is the satellite's orbital period? **(5 marks)**

ANSWER:	Score for Question 4a:
orbital period: _____	4. _____ (5)

b) (i) As shown in the diagram below, two satellites pass over the same point on Earth's surface. Satellite H is in a higher orbit than satellite L.



Which satellite, H or L, completes one orbit first? (Circle one) **(1 mark)**

A. satellite H

B. satellite L

(ii) Using principles of physics, explain your answer. **(3 marks)**

_____

_____

_____

_____

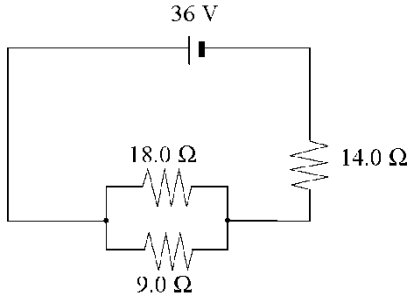
_____

_____

Score for Question 4b:
5. _____ (4)

OVER

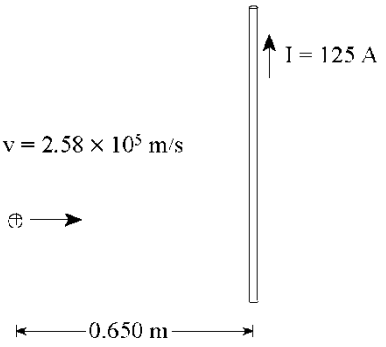
5. What is the power dissipated in the 9.0 Ω resistor in the following circuit? **(7 marks)**



ANSWER:	Score for Question 5:
power dissipated : _____	6. _____ (7)

OVER

6. A proton is traveling at 2.58×10^5 m/s towards a conductor carrying a current of 125 A. What is the magnitude of the magnetic force acting on the proton 0.650 m from the conductor? **(7 marks)**



ANSWER:	Score for Question 6:
magnetic force: _____	7. _____ (7)

OVER

7. When an electric drill turns at normal operating speeds, there is little heat produced in the motor windings. When drilling harder material, the drill motor turns much slower than normal and overheats. Using principles of physics, give an explanation for the increased heat in the windings.
(4 marks)

Score for Question 7:

8. _____
(4)

PART C: ELECTED TOPICS

Value: 12 marks **Suggested Time: 12 minutes**

INSTRUCTIONS

1. Choose **only one** section from the three sections in this part of the examination.

   SECTION I: Quantum Mechanics (p. 28 to 30)

   or

   SECTION II: Fluid Theory (p. 31 to 33)

   or

   SECTION III: AC Circuitry and Electronics (p. 34 to 36)

2. If you answer questions in more than one section, only the answers in the first section chosen will be marked.

3. Do **all** of the questions in the section that you choose. **Write your answers in the space provided in this booklet.**

4. Rough-work space has been incorporated into the space allowed for answering each question. You may not need all of the space provided to answer each question.

5. Your numerical answers to problems must contain correct units where appropriate, and must be calculated to two or three significant figures.

6. Since partial marks will be awarded for a partial solution, it is important that you provide a clear indication of the steps leading to your answer.

   Full marks will not be given for providing only a final answer.

I have selected SECTION _____.

OVER

SECTION I: Quantum Mechanics

1. What is the wavelength of a proton traveling at 2.70×10^5 m/s ? **(3 marks)**

ANSWER:	Score for Question 1:
wavelength: _____	9. _____ (3)

SECTION I: Continued

2. An ionized lithium atom has one electron and a nucleus with three protons and four neutrons. What is the energy of an electron in the first excited state (n = 2) ? **(4 marks)**

ANSWER:	Score for Question 2:
energy:	10. (4)

OVER

SECTION I: Continued

3. Light shines on a metal surface that has a work function of 2.60 eV . The light has a wavelength of 400 nm . What is the maximum speed of photoelectrons ejected from the surface by this light?
(5 marks)

ANSWER:	Score for Question 3:
maximum speed: _____	11. _____ (5)

END OF SECTION I: Quantum Mechanics

SECTION II: Fluid Theory

1. A block of wood floats in water with $1.71\,m^3$ of its volume submerged. Find the buoyant force acting on the block of wood. **(3 marks)**

ANSWER:	Score for Question 1:
force: _____	12. _____ (3)

OVER

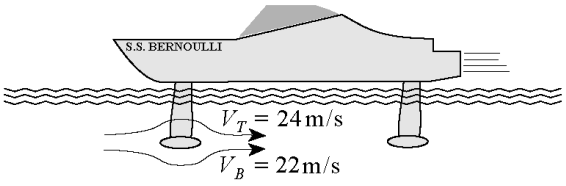
SECTION II: Continued

2. A sealed cylinder contains $0.82\,m^3$ of an ideal gas at $18°C$. When the cylinder is heated, a piston allows the gas to expand at constant pressure to a new volume of $0.93\,m^3$. Find the new temperature of the gas. **(4 marks)**

ANSWER:	Score for Question 2:
temperature: _____	13. _____ (4)

SECTION II: Continued

3. The diagram shows a hydrofoil, a vessel supported by an underwater "wing". Water flows over the top surface of the wing at 24 m/s and under the bottom surface at 22 m/s. Find the pressure difference between the surfaces of the wing. **(5 marks)**



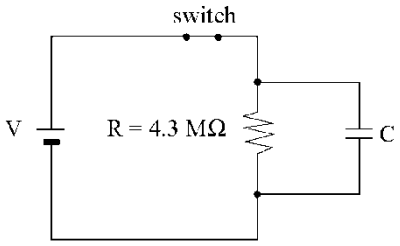
ANSWER:	Score for Question 3:
pressure difference: _____	14. _____ (5)

END OF SECTION II: Fluid Theory

OVER

SECTION III: AC Circuitry and Electronics

1. The diagram below shows a circuit in which the switch has been closed for a long time.

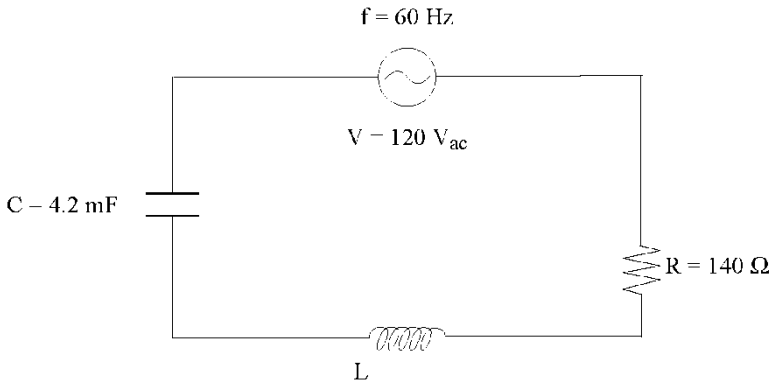


When the switch is opened, it takes 8.0 s for the voltage across the capacitor to drop to 37% of the battery voltage V. What is the capacitance, C, of the capacitor? **(3 marks)**

ANSWER:	Score for Question 1:
capacitance: _____	15. _____ (3)

SECTION III: Continued

2. The diagram below shows an LRC circuit that has a resonant frequency of 60 Hz.



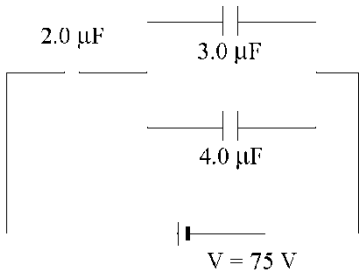
What is the inductive reactance for this circuit at the resonant frequency? **(4 marks)**

ANSWER:	Score for Question 2:
inductive reactance: _____	16. _____ (4)

OVER

SECTION III: Continued

3. What is the maximum charge on the 3.0 μF capacitor? **(5 marks)**



ANSWER:	Score for Question 3:
maximum charge: _____	17. _____ (5)

END OF SECTION III: AC Circuitry and Electronics

END OF EXAMINATION

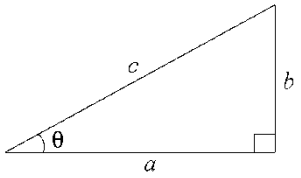
REFERENCE SHEET OF CONSTANTS

Gravitational constant	G	$= 6.67 \times 10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2$
Acceleration due to gravity at the surface of Earth (for the purposes of this examination)	g	$= 9.80\ \text{m/s}^2$
Earth		
radius		$= 6.38 \times 10^{6}\ \text{m}$
radius of orbit about Sun		$= 1.50 \times 10^{11}\ \text{m}$
period of rotation		$= 8.61 \times 10^{4}\ \text{s}$
period of revolution about Sun		$= 3.16 \times 10^{7}\ \text{s}$
mass		$= 5.98 \times 10^{24}\ \text{kg}$
Moon		
radius		$= 1.74 \times 10^{6}\ \text{m}$
radius of orbit about Earth		$= 3.84 \times 10^{8}\ \text{m}$
period of rotation		$= 2.36 \times 10^{6}\ \text{s}$
period of revolution about Earth		$= 2.36 \times 10^{6}\ \text{s}$
mass		$= 7.35 \times 10^{22}\ \text{kg}$
Sun		
mass		$= 1.98 \times 10^{30}\ \text{kg}$
Constant in Coulomb's Law	k	$= 9.00 \times 10^{9}\ \text{N}\cdot\text{m}^2/\text{C}^2$
Elementary charge	e	$= 1.60 \times 10^{-19}\ \text{C}$
Mass of electron	m_e	$= 9.11 \times 10^{-31}\ \text{kg}$
Mass of proton	m_p	$= 1.67 \times 10^{-27}\ \text{kg}$
Mass of neutron	m_n	$= 1.68 \times 10^{-27}\ \text{kg}$
Permeability of free space	μ_o	$= 4\pi \times 10^{-7}\ \text{T}\cdot\text{m/A}$
Planck's constant	h	$= 6.63 \times 10^{-34}\ \text{J}\cdot\text{s}$
	h	$= 4.14 \times 10^{-15}\ \text{eV}\cdot\text{s}$
Speed of light	c	$= 3.00 \times 10^{8}\ \text{m/s}$
Rydberg's constant	R	$= 1.097 \times 10^{7}\ \text{m}^{-1}$
Unified atomic mass unit	u	$= 1.66 \times 10^{-27}\ \text{kg}$
Boltzmann's constant	k	$= 1.38 \times 10^{-23}\ \text{J/K}$
Gas constant	R	$= 8.31\ \text{J/mol}\cdot\text{K}$
Density of water		$= 1.00 \times 10^{3}\ \text{kg/m}^3$
Density of air		$= 1.29\ \text{kg/m}^3$
Standard atmospheric pressure		$= 1.01 \times 10^{5}\ \text{Pa}$
Volume of one mole of gas at STP		$= 22.4\ \text{L}\ (2.24 \times 10^{-2}\ \text{m}^3)$
Avogadro's number	N	$= 6.02 \times 10^{23}$ particles/mol
Absolute zero		$= -273\ ^\circ\text{C}$

You may detach this page for convenient reference.
Exercise care when tearing along perforations.

TRIGONOMETRIC AND OTHER EQUATIONS

For Right-angled Triangles:

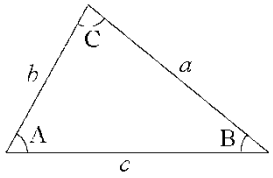


$$a^2 + b^2 = c^2$$

$$\sin\theta = \frac{b}{c} \quad \cos\theta = \frac{a}{c} \quad \tan\theta = \frac{b}{a}$$

$$\text{area} = \frac{1}{2}ab$$

For All Triangles:



$$\text{area} = \frac{1}{2}\ \text{base} \times \text{height}$$

$$\sin 2A = 2\sin A \cos A$$

Sine Law: $\dfrac{\sin A}{a} = \dfrac{\sin B}{b} = \dfrac{\sin C}{c}$

Cosine Law: $c^2 = a^2 + b^2 - 2ab\ \cos C$

Circle:

$$\text{Circumference} = 2\pi r$$

$$\text{Area} = \pi r^2$$

Sphere:

$$\text{Surface area} = 4\pi r^2$$

$$\text{Volume} = \frac{4}{3}\pi r^3$$

Quadratic Equation:

$$\text{If } ax^2 + bx + c = 0, \quad \text{then } x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

EQUATIONS

Note: Vector quantities have not been indicated.

1. **Kinematics:** (for constant acceleration)

$$v = v_0 + at \qquad v_{av} = \frac{v + v_0}{2} \qquad v^2 = v_0{}^2 + 2ad$$

$$d = v_0 t + \frac{1}{2} at^2$$

2. **Dynamics:**

$$F_f = \mu F_N \qquad F_{net} = ma$$

3. **Mechanical Energy and Momentum:**

$$W = Fd \qquad E_p = mgh \qquad E_k = \frac{1}{2} mv^2$$

$$P = \frac{W}{t} \qquad p = mv \qquad \Delta p = F_{net} \Delta t$$

4. **Equilibrium:**

$$\tau = Fd$$

5. **Circular Motion and Gravitation:**

$$a_c = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2} \qquad F = G\frac{m_1 m_2}{r^2}$$

$$E_p = -G\frac{m_1 m_2}{r} \qquad r^3 \propto T^2$$

6. **Electrostatics:**

$$F = k\frac{Q_1 Q_2}{r^2} \qquad E = \frac{V}{d} \qquad V = \frac{kQ}{r}$$

$$E_p = k\frac{Q_1 Q_2}{r} \qquad F = QE \qquad V = \frac{\Delta E_p}{Q}$$

7. **Circuitry:**

$$Q = It \qquad V = IR \qquad P = VI$$

You may detach this page for convenient reference.
Exercise care when tearing along perforations.

EQUATIONS CONTINUED

8. Electromagnetism:

$F = IlB$ $\quad B = \frac{\mu_0 I}{2\pi d}$ $\quad \tau = NIAB$

$F = QvB$ $\quad B = \mu_0 n I \left(where\ n = \frac{N}{l} \right)$ $\quad \Phi = BA$

$\mathcal{E} = -N\frac{\Delta\Phi}{\Delta t}$ $\quad \mathcal{E} = Blv$ $\quad \frac{V_s}{V_p} = \frac{N_s}{N_p}$

9. Quantum Mechanics: (Section I)

$E = hf$ $\quad c = f\lambda$ $\quad E_n = (-13.6eV)\frac{Z^2}{n^2}$

$E_{k_{max}} = hf - W_0$ $\quad \lambda = \frac{h}{p}$

10. Fluid Theory: (Section II)

$\rho = \frac{m}{V}$ $\quad PV = NkT$ $\quad PV = \frac{1}{3}Nmv^2$

$F = \rho Vg$ $\quad P = \frac{F}{A}$ $\quad P = P_G + P_a$

$PV = nRT$ $\quad P + \frac{1}{2}\rho v^2 + \rho gh = \text{constant}$ $\quad E_k = \frac{3}{2}kT$

$Av = \text{constant}$

11. AC Circuits and Electronics: (Section III)

$Q = CV$ $\quad E_p = \frac{1}{2}CV^2$ $\quad \tau = RC$

$X_C = \frac{1}{2\pi fC}$ $\quad Z = \sqrt{R^2 + (X_L - X_C)^2}$ $\quad X_L = 2\pi fL$

$f_0 = \frac{1}{2\pi\sqrt{LC}}$ $\quad \beta\ (\text{current gain}) = \frac{\Delta I_C}{\Delta I_B}$ $\quad A_f = \frac{A}{1 - \beta A}$

(where β = feedback ratio)

ROUGH WORK FOR MULTIPLE-CHOICE

You may detach this page for convenient reference.
Exercise care when tearing along perforations.

ROUGH WORK FOR MULTIPLE-CHOICE

Appendix J – Curriculum Guides

This document represents an updating of the 1996 IRP. This updating has been undertaken for the purpose of

- clarifying the Prescribed Learning Outcomes
- introducing Suggested Achievement Indicators
- addressing content overload

Resources previously recommended for the 1996 version of the curriculum, where still valid, continue to support this updated IRP. (See the Learning Resources section in this IRP for additional information.)

BIOLOGY 11 AND 12

Integrated Resource Package 2006

BRITISH COLUMBIA
The Best Place on Earth

Ministry of Education

IRP 140

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Acknowledgments

This document has been updated from the 1996 IRP to include suggested achievement indicators, a more clear and succinct set of prescribed learning outcomes, a snapshot of the course's key elements, and other minor refinements, while maintaining the original intent and essence of the 1996 curricular content.

Many people contributed their expertise to the Biology 11-12 IRP. The Project Manager (2005-2006) was Mr. Waël Afifi of the Ministry of Education, working with other ministry personnel and our partners in education. We would like to thank all who participated in this process, including the teams of educators who developed the 1996 Biology 11-12 IRP, and the following individuals who contributed to the 2005-2006 updating of this document:

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Preface

This Integrated Resource Package (IRP) provides basic information teachers will require in order to implement Biology 11 and 12. This document supersedes the *Biology 11 and 12 Integrated Resource Package* (1996).

The information contained in this document is also available on the Internet at www.bced.gov.bc.ca/irp/irp.htm

The following paragraphs provide brief descriptions of the components of the IRP.

Introduction

The Introduction provides general information about Biology 11 and 12, including special features and requirements.

Included in this section are

- a rationale for teaching Biology 11 and 12 in BC schools
- information about graduation program requirements and provincial examinations
- listings of each course's curriculum organizers and suborganizers – groupings for prescribed learning outcomes that share a common focus
- suggested time allotments for each course

Considerations for Program Delivery

This section of the IRP contains additional information to help educators develop their school practices and plan their program delivery to meet the needs of all learners.

Prescribed Learning Outcomes

This section contains the *prescribed learning outcomes*, the legally required content standards for the provincial education system. The learning outcomes define the required knowledge, skills, and attitudes for each subject. They are statements of what students are expected to know and be able to do by the end of the course.

Student Achievement

This section of the IRP contains information about classroom assessment and measuring student achievement, including sets of specific achievement indicators for each prescribed learning outcome. Achievement indicators are statements that describe what students should be able to do in order to demonstrate that they fully meet the expectations set out by the prescribed learning outcomes. Achievement indicators are not mandatory; they are provided to assist in the assessment of how well students achieve the prescribed learning outcomes.

Also included in this section are key elements – descriptions of content that help determine the intended depth and breadth of the prescribed learning outcomes.

Learning Resources

This section contains general information on learning resources, and provides a link to titles, descriptions, and ordering information for the recommended learning resources in the Biology 11 and 12 Grade Collections.

INTRODUCTION

Biology 11 and 12

This Integrated Resource Package (IRP) sets out the provincially prescribed curriculum for Biology 11 and 12. The development of this IRP has been guided by the principles of learning:

- Learning requires the active participation of the student.
- People learn in a variety of ways and at different rates.
- Learning is both an individual and a group process.

In addition to these three principles, this document recognizes that British Columbia's schools include young people of varied backgrounds, interests, abilities, and needs. Wherever appropriate for this curriculum, ways to meet these needs and to ensure equity and access for all learners have been integrated as much as possible into the learning outcomes and achievement indicators.

This document represents an updating of the 1996 IRP. This updating has been undertaken for the purpose of

- clarifying the prescribed learning outcomes
- introducing suggested achievement indicators
- addressing content overload

Resources previously recommended for the 1996 version of the curriculum, where still valid, continue to support this updated IRP. (See the Learning Resources section later in this IRP for additional information.)

Biology 11 and 12, in draft form, was available for public review and response from November to December, 2005. Feedback from educators, students, parents, and other educational partners informed the development of this updated IRP.

RATIONALE

The science curriculum of British Columbia provides a foundation for the scientific literacy of citizens, for the development of a highly skilled and adaptable work force, and for the development of new technologies. It is a foundation on which teachers can develop a science program that provides a comprehensive set of knowledge, skills, and experiences related to science.

School science programs that are planned to develop scientifically literate students provide experiences that

- help students become flexible and adaptable while acquiring specialized knowledge
- develop the capacity to think critically
- call for a wide range of knowledge, methods, and approaches that enable students to analyse personal and societal issues critically
- encourage students to examine the impact of scientific knowledge on their lives, society, and the environment
- develop a positive attitude toward science
- cultivate students' appreciation of the scientific endeavour and their potential to contribute to it

The science curricula of British Columbia provide a framework of opportunities for students to become scientifically literate by

- examining basic concepts, principles, laws, and theories through scientific inquiry
- actively gaining knowledge, skills, and attitudes that provide the basis for sound and ethical problem solving and decision making
- developing an understanding of the place of science in society and history and its relationships to other disciplines
- making informed and responsible decisions about themselves, their homes, workplaces, and the global community

REQUIREMENTS AND GRADUATION CREDITS

Biology 11 and 12 are two of the courses available for students to satisfy the Grade 11-12 Graduation Program science requirement.

Biology 11 and 12 are each designated as four-credit courses, and must be reported as such to the Ministry of Education for transcript purposes. Letter grades and percentages must be reported for these courses. It is not possible to obtain partial credit for these courses.

The course codes for Biology 11 and 12 are BI 11 and BI 12. These courses are also available in French (Biologie 11, Biologie 12: course codes BIOSR 11, BIOSR 12).

Introduction to Biology 11 and 12

Graduation Program Examination

Biology 12 has an optional Graduation Program examination, worth 40% of the final course mark for students who choose to write it. Although students are not required to take this exam to receive credit for the course, they should be advised that some post-secondary institutions require Grade 12 exams to meet entrance requirements, and that writing Grade 12 exams also provides opportunities for provincial scholarships.

For more information, refer to the Ministry of Education examinations web site: www.bced.gov.bc.ca/exams/

Biology 11

Biology is a scientific discipline that studies a great variety of organisms. It is widely accepted that a few major themes exist in biology, and the use of these can provide an organizational framework for studying biology. The three themes for Biology 11 are as follows:

- Unity and Diversity
- Evolutionary Relationships
- Ecological Relationships

Teachers should provide laboratory and field opportunities for students to examine a wide variety of organisms to develop their understanding of the three major themes of Biology 11.

The prescribed learning outcomes for Biology 11 are grouped under the following curriculum organizers and suborganizers:

Biology 11						
Processes of Science	**Taxonomy**	**Evolution**	**Ecology**	**Microbiology** • Viruses • Kingdom Monera	**Plant Biology**	**Animal Biology**

A curriculum organizer consists of a set of prescribed learning outcomes that share a common focus. Note that the ordering of organizers, suborganizers, and outcomes in the Biology 11 curriculum is not intended to imply an order of instruction.

The prescribed learning outcomes related to Processes of Science support the development of knowledge, skills, and attitudes essential for an understanding of science. These learning outcomes should not be taught in isolation, but should be integrated with activities related to the other six curriculum organizers.

BIOLOGY 12

Biology 12 focusses on human biology, allowing students to develop an interest in and understanding of science by looking at themselves and seeing how the diverse body systems are integrated to maintain homeostasis.

Laboratory skills are essential to students of Biology 12. These skills are developed in lab activities that focus on the hypothetical as well as the practical. An emphasis on the processes of science is integral to the complete study of Biology 12 and should be integrated throughout the course.

The order of learning outcomes follows a sequence from cell structure and simple, biochemical processes to the organ systems themselves. However, this order does not imply a required sequence of instruction.

The prescribed learning outcomes for Biology 12 are grouped under the following curriculum organizers and suborganizers:

Biology 12		
Processes of Science	**Cell Biology** • Cell Structure • Cell Compounds and Biological Molecules • DNA Replication • Protein Synthesis • Transport across Cell Membrane • Enzymes	**Human Biology** • Digestive System • Circulatory System • Respiratory System • Nervous System • Urinary System • Reproductive System

A curriculum organizer consists of a set of prescribed learning outcomes that share a common focus. Note that the ordering of organizers, suborganizers, and outcomes in the Biology 12 curriculum does not imply an order of instruction.

The prescribed learning outcomes related to Processes of Science support the development of knowledge, skills, and attitudes essential for an understanding of science. These learning outcomes should not be taught in isolation, but should be integrated with activities related to the other two curriculum organizers.

SUGGESTED TIMEFRAME

Provincial curricula are developed in accordance with the amount of instructional time recommended by the Ministry of Education for each subject area. Teachers may choose to combine various curricula to enable students to integrate ideas and make meaningful connections.

Biology 11 and 12 each require approximately 90–110 hours of instructional time. Although a four-credit course is typically equivalent to 120 hours, this timeframe allows for flexibility to address local needs. The Student Achievement section of this IRP provides a suggested breakdown of this suggested time allotment by curriculum organizer.

Considerations for Program Delivery

Biology 11 and 12

This section of the IRP contains additional information to help educators develop their school practices and plan their program delivery to meet the needs of all learners. Included in this section is information about

- Alternative Delivery policy
- addressing local contexts
- involving parents and guardians
- course requirements respecting beliefs
- safety considerations
- confidentiality
- inclusion, equity, and accessibility for all learners
- working with the school and community
- working with the Aboriginal community
- information and communications technology
- copyright and responsibility

Alternative Delivery Policy

The Alternative Delivery policy does not apply to Biology 11 and 12.

The Alternative Delivery policy outlines how students, and their parents or guardians, in consultation with their local school authority, may choose means other than instruction by a teacher within the regular classroom setting for addressing prescribed learning outcomes contained in the Health curriculum organizer of the following curriculum documents:

- Health and Career Education K to 7, and Personal Planning K to 7 Personal Development curriculum organizer (until September 2008)
- Health and Career Education 8 and 9
- Planning 10

The policy recognizes the family as the primary educator in the development of children's attitudes, standards, and values, but the policy still requires that all prescribed learning outcomes be addressed and assessed in the agreed-upon alternative manner of delivery.

It is important to note the significance of the term "alternative delivery" as it relates to the Alternative Delivery Policy. The policy does not permit schools to omit addressing or assessing any of the prescribed learning outcomes within the health and career education curriculum. Neither does it allow students to be excused from meeting any learning outcomes related to health. It is expected that students who arrange for alternative delivery will address the health-related learning outcomes and will be able to demonstrate their understanding of these learning outcomes.

For more information about policy relating to alternative delivery, refer to www.bced.gov.bc.ca/policy/

Addressing Local Contexts

There is some flexibility in the Biology 11 and 12 curriculum, providing opportunities for individual teacher and student choice in the selection of topics to meet learning outcomes. This flexibility enables educators to plan their programs by using topics and examples that are relevant to their local context and to the particular interests of their students. When selecting topics it may be appropriate to incorporate student input.

In particular, Biology 11 teachers may wish to customize the curriculum to take advantage of opportunities to study the seasonal flora and fauna of their region. The prescribed learning outcomes offer a variety of organisms to choose from. It is important, however, that teachers recognize the importance of choosing life activities (such as energy acquisition) as a thread that relates each organism studied to those previously studied and those yet to be studied.

Involving Parents and Guardians

The family is the primary educator in the development of students' attitudes and values. The school plays a supportive role by focussing on the prescribed learning outcomes in the Biology 11 and 12 curriculum. Parents and guardians can support, enrich, and extend the curriculum at home.

It is highly recommended that schools inform parents and guardians about the Biology 11 and 12 curriculum, and teachers (along with school and district administrators) may choose to do so by

- informing parents/guardians and students of the prescribed learning outcomes for the subject by sending home class letters, providing an overview during parent-teacher interviews, etc.
- responding to parent and guardian requests to discuss course unit plans, learning resources, etc.

Course Requirements Respecting Beliefs

For many students and teachers, the study of some science concepts may lead to issues and questions that go beyond the immediate scope of curriculum (e.g., science is used to meet many industrial requirements, but industrial decision makers must consider factors other than scientific feasibility before adopting a particular process). The technological application of science in areas such as genetic engineering, human reproduction, and medical technology raises questions of ethics and values. Because these social questions arise, in part, from capabilities that science makes possible, they should be addressed. It must be made clear to students, however, that science only provides the background for what is hoped will be informed personal and social decisions. Teachers must handle these questions objectively and with sensitivity.

Reconciling scientific discoveries (for example, in genetic engineering) and religious faith poses a particular challenge for some students. While respecting the personal beliefs of students, teachers should be careful to distinguish between knowledge based on the application of scientific methods, and religious teachings and associated beliefs such as creationism, theory of divine creation, or intelligent design theory.

Safety Considerations

Science education is an activity-based process that provides an exciting method of teaching and learning. However, experiments and demonstrations may involve inherent risks for both the teacher and the student.

Safety guidelines must be discussed with students. These safety guidelines must support and encourage the investigative approach generally and laboratory instruction specifically, while at the same time promoting safety in the classroom and laboratory.

Encouraging a positive safety attitude is a responsibility shared among the board, school administrators, teachers, and students in every school district. The co-operation of all these groups helps develop a strong safety consciousness both inside and outside our schools.

Field work and field trips require special vigilance with respect to traffic and road safety, safe practices in study areas and when obtaining samples, and an awareness of changes in weather. Teachers are also reminded of the potential risks associated with activities that involve extraction and analysis of human fluids or tissue.

Another important aspect of in-school safety is the Workplace Hazardous Materials Information Systems (WHMIS). Through labelling, material safety data sheets, and education and training, WHMIS is designed to ensure that those using hazardous materials have sufficient information to handle them safely. Each school district should have an individual trained in WHMIS who can work with teachers to establish safe, well-ventilated classroom and laboratory working conditions.

To assist teachers in providing a safe science-learning environment, the Ministry of Education publishes the *Science Safety Resource Manual*, which has been distributed to every school.

The *Science Safety Resource Manual* is available online at www.bced.gov.bc.ca/irp/resdocs/scisafety.htm

Confidentiality

The Freedom of Information and Protection of Privacy Act (FOIPPA) applies to students, to school districts, and to all curricula. Teachers, administrators, and district staff should consider the following:

- Be aware of district and school guidelines regarding the provisions of FOIPPA and how it applies to all subjects, including Biology 11 and 12.
- Do not use students' Personal Education Numbers (PEN) on any assignments that students wish to keep confidential.

- Ensure students are aware that if they disclose personal information that indicates they are at risk for harm, then that information cannot be kept confidential.
- Inform students of their rights under FOIPPA, especially the right to have access to their own personal information in their school records. Inform parents of their rights to access their children's school records.
- Minimize the type and amount of personal information collected, and ensure that it is used only for purposes that relate directly to the reason for which it is collected.
- Inform students that they will be the only ones recording personal information about themselves unless they, or their parents, have consented to teachers collecting that information from other people (including parents).
- Provide students and their parents with the reason(s) they are being asked to provide personal information in the context of the Biology 11 and 12 curriculum.
- Inform students and their parents that they can ask the school to correct or annotate any of the personal information held by the school, in accordance with Section 29 of FOIPPA.
- Ensure students are aware that their parents may have access to the schoolwork they create only insofar as it pertains to students' progress.
- Ensure that any information used in assessing students' progress is up-to-date, accurate, and complete.

For more information about confidentiality, refer to www.mser.gov.bc.ca/FOI_POP/index.htm

Inclusion, Equity, and Accessibility for All Learners

British Columbia's schools include students of varied backgrounds, interests, and abilities. The Kindergarten to Grade 12 school system focuses on meeting the needs of all students. When selecting specific topics, activities, and resources to support the implementation of Biology 11 and 12, teachers are encouraged to ensure that these choices support inclusion, equity, and accessibility for all students. In particular, teachers should ensure that classroom instruction, assessment, and resources reflect sensitivity to diversity and incorporate positive role portrayals, relevant issues, and themes such as inclusion, respect, and acceptance.

Government policy supports the principles of integration and inclusion of students for whom English is a second language and of students with special needs. Most of the prescribed learning outcomes and suggested achievement indicators in this IRP can be met by all students, including those with special needs and/or ESL needs. Some strategies may require adaptations to ensure that those with special and/or ESL needs can successfully achieve the learning outcomes. Where necessary, modifications can be made to the prescribed learning outcomes for students with Individual Education Plans.

For more information about resources and support for students with special needs, refer to www.bced.gov.bc.ca/specialed/

For more information about resources and support for ESL students, refer to www.bced.gov.bc.ca/esl/

Working with the School and Community

This curriculum addresses a wide range of skills and understandings that students are developing in other areas of their lives. It is important to recognize that learning related to this curriculum extends beyond the biology classroom.

School and district-wide programs support and extend learning in Biology 11 and 12. Community organizations may also support the curriculum with locally developed learning resources, guest speakers, workshops, and field studies. Teachers may wish to draw on the expertise of these community organizations and members.

Working with the Aboriginal Community

The Ministry of Education is dedicated to ensuring that the cultures and contributions of Aboriginal peoples in BC are reflected in all provincial curricula. To address these topics in the classroom in a way that is accurate and that respectfully

reflects Aboriginal concepts of teaching and learning, teachers are strongly encouraged to seek the advice and support of local Aboriginal communities. Aboriginal communities are diverse in terms of language, culture, and available resources, and each community will have its own unique protocol to gain support for integration of local knowledge and expertise. To begin discussion of possible instructional and assessment activities, teachers should first contact Aboriginal education co-ordinators, teachers, support workers, and counsellors in their district who will be able to facilitate the identification of local resources and contacts such as elders, chiefs, tribal or band councils, Aboriginal cultural centres, Aboriginal Friendship Centres, and Métis or Inuit organizations.

In addition, teachers may wish to consult the various Ministry of Education publications available, including the "Planning Your Program" section of the resource, *Shared Learnings*. This resource was developed to help all teachers provide students with knowledge of, and opportunities to share experiences with, Aboriginal peoples in BC.

For more information about these documents, consult the Aboriginal Education web site: www.bced.gov.bc.ca/abed/welcome.htm

Information and Communications Technology

The study of information and communications technology is increasingly important in our society. Students need to be able to acquire and analyse information, to reason and communicate, to make informed decisions, and to understand and use information and communications technology for a variety of purposes. Development of these skills is important for students in their education, their future careers, and their everyday lives.

Literacy in the area of information and communications technology can be defined as the ability to obtain and share knowledge through investigation, study, instruction, or transmission of information by means of media technology. Becoming literate in this area involves finding, gathering, assessing, and communicating information using electronic means, as well as developing the knowledge and skills to use and solve problems effectively with the technology. Literacy also involves a critical examination and understanding of the ethical and social issues related to the use of information and communications technology. When planning for instruction and assessment in Biology 11 and 12, teachers should provides opportunities for students to develop literacy in relation to information and communications technology sources, and to reflect critically on the role of these technologies in society.

Copyright and Responsibility

Copyright is the legal protection of literary, dramatic, artistic, and musical works; sound recordings; performances; and communications signals. Copyright provides creators with the legal right to be paid for their work and the right to say how their work is to be used. The law permits certain exceptions for schools (i.e., specific things permitted) but these are very limited, such as copying for private study or research. The copyright law determines how resources can be used in the classroom and by students at home.

In order to respect copyright it is necessary to understand the law. It is unlawful to do the following, unless permission has been given by a copyright owner:

- photocopy copyrighted material to avoid purchasing the original resource for any reason
- photocopy or perform copyrighted material beyond a very small part – in some cases the copyright law considers it "fair" to copy whole works, such as an article in a journal or a photograph, for purposes of research and private study, criticism, and review
- show recorded television or radio programs to students in the classroom unless these are cleared for copyright for educational use (there are exceptions such as for news and news commentary taped within one year of broadcast that by law have record-keeping requirements – see the web site at the end of this section for more details)

- photocopy print music, workbooks, instructional materials, instruction manuals, teacher guides, and commercially available tests and examinations
- show videorecordings at schools that are not cleared for public performance
- perform music or do performances of copyrighted material for entertainment (i.e., for purposes other than a specific educational objective)
- copy work from the Internet without an express message that the work can be copied

Permission from or on behalf of the copyright owner must be given in writing. Permission may also be given to copy or use all or some portion of copyrighted work through a licence or agreement. Many creators, publishers, and producers have formed groups or "collectives" to negotiate royalty payments and copying conditions for educational institutions. It is important to know what licences are in place and how these affect the activities schools are involved in. Some licences may also require royalty payments that are determined by the quantity of photocopying or the length of performances. In these cases, it is important to assess the educational value and merits of copying or performing certain works to protect the school's financial exposure (i.e., only copy or use that portion that is absolutely necessary to meet an educational objective).

It is important for education professionals, parents, and students to respect the value of original thinking and the importance of not plagiarizing the work of others. The works of others should not be used without their permission.

For more information about copyright, refer to www.cmec.ca/copyright/indexe.stm

Prescribed Learning Outcomes

Biology 11 and 12

Prescribed learning outcomes are content standards for the provincial education system; they are the prescribed curriculum. Clearly stated and expressed in measurable and observable terms, learning outcomes set out the required knowledge, skills, and attitudes – what students are expected to know and be able to do – by the end of the specified course.

Schools have the responsibility to ensure that all prescribed learning outcomes in this curriculum are met; however, schools have flexibility in determining how delivery of the curriculum can best take place.

It is expected that student achievement will vary in relation to the learning outcomes. Evaluation, reporting, and student placement with respect to these outcomes are dependent on the professional judgment and experience of teachers, guided by provincial policy.

Prescribed learning outcomes for Biology 11 and 12 are presented by grade and by curriculum organizer and suborganizer, and are coded alphanumerically for ease of reference; however, this arrangement is not intended to imply a required instructional sequence.

WORDING OF PRESCRIBED LEARNING OUTCOMES

All learning outcomes complete the stem, "It is expected that students will…."

When used in a prescribed learning outcome, the word "**including**" indicates that any ensuing item **must be addressed**. Lists of items introduced by the word "including" represent a set of minimum requirements associated with the general requirement set out by the outcome. The lists are not necessarily exhaustive, however, and teachers may choose to address additional items that also fall under the general requirement set out by the outcome.

DOMAINS OF LEARNING

Prescribed learning outcomes in BC curricula identify required learning in relation to one or more of the three domains of learning: cognitive, psychomotor, and affective. The following definitions of the three domains are based on Bloom's taxonomy.

The **cognitive domain** deals with the recall or recognition of knowledge and the development of intellectual abilities. The cognitive domain can be further specified as including three cognitive levels: knowledge, understanding and application, and higher mental processes. These levels are determined by the verb used in the learning outcome, and illustrate how student learning develops over time.

- *Knowledge* includes those behaviours that emphasize the recognition or recall of ideas, material, or phenomena.
- *Understanding and application* represents a comprehension of the literal message contained in a communication, and the ability to apply an appropriate theory, principle, idea, or method to a new situation.
- *Higher mental processes* include analysis, synthesis, and evaluation. The higher mental processes level subsumes both the knowledge and the understanding and application levels.

The **affective domain** concerns attitudes, beliefs, and the spectrum of values and value systems.

The **psychomotor domain** includes those aspects of learning associated with movement and skill demonstration, and integrates the cognitive and affective consequences with physical performances.

Domains of learning and, particularly, cognitive levels, inform the design and development of the Graduation Program examination for Biology 12.

Prescribed Learning Outcomes

Prescribed Learning Outcomes: Biology 11
It is expected that students will:
Processes of Science
A1 demonstrate safe and correct technique for a variety of laboratory procedures
A2 design an experiment using the scientific method
A3 interpret data from a variety of text and visual sources
Taxonomy
B1 apply the Kingdom system of classification to study the diversity of organisms
Evolution
C1 describe the process of evolution
Ecology
D1 analyse the functional inter-relationships of organisms within an ecosystem
Microbiology
Viruses
E1 evaluate the evidence used to classify viruses as living or non-living
E2 evaluate the effects of viruses on human health
Kingdom Monera
E3 analyse monerans as a lifeform at the prokaryotic level of organization
E4 evaluate the effectiveness of various antibiotics, disinfectants, or antiseptics on bacterial cultures
Plant Biology
F1 analyse how the increasing complexity of algae, mosses, and ferns represent an evolutionary continuum of adaptation to a land environment
F2 analyse how the increasing complexity of gymnosperms and angiosperms contribute to survival in a land environment
Animal Biology
G1 analyse how the increasing complexity of animal phyla represents an evolutionary continuum
G2 analyse the increasing complexity of the Phylum Porifera and the Phylum Cnidaria
G3 analyse the increasing complexity of the Phylum Platyhelminthes, the Phylum Nematoda, and the Phylum Annelida
G4 analyse the increasing complexity of the Phylum Mollusca, the Phylum Echinodermata, and the Phylum Arthropoda
G5 relate the complexity of the form and function of vertebrates to the evolutionary continuum of animals

Prescribed Learning Outcomes: Biology 12

It is expected that students will:

PROCESSES OF SCIENCE

A1 demonstrate safe and correct technique for a variety of laboratory procedures
A2 design an experiment using the scientific method
A3 interpret data from a variety of text and visual sources

CELL BIOLOGY

Cell Structure

B1 analyse the functional inter-relationships of cell structures

Cell Compounds and Biological Molecules

B2 describe the characteristics of water and its role in biological systems
B3 describe the role of acids, bases, and buffers in biological systems in the human body
B4 analyse the structure and function of biological molecules in living systems, including
- carbohydrates
- lipids
- proteins
- nucleic acids

DNA Replication

B5 describe DNA replication
B6 describe recombinant DNA

Protein Synthesis

B7 demonstrate an understanding of the process of protein synthesis
B8 explain how mutations in DNA affect protein synthesis

Transport across Cell Membrane

B9 analyse the structure and function of the cell membrane
B10 explain why cells divide when they reach a particular surface area-to-volume ratio

Enzymes

B11 analyse the roles of enzymes in biochemical reactions

Biology 12 Prescribed Learning Outcomes continued on page 20

Prescribed Learning Outcomes

Prescribed Learning Outcomes: Biology 12

Biology 12 Prescribed Learning Outcomes continued from page 19

Human Biology

Digestive System

C1 analyse the functional inter-relationships of the structures of the digestive system
C2 describe the components, pH, and digestive actions of salivary, gastric, pancreatic, and intestinal juices

Circulatory System

C3 describe the inter-relationships of the structures the heart
C4 analyse the relationship between heart rate and blood pressure
C5 analyse the functional inter-relationships of the vessels of the circulatory system
C6 describe the components of blood
C7 describe the inter-relationships of the structures of the lymphatic system

Respiratory System

C8 analyse the functional inter-relationships of the structures of the respiratory system
C9 analyse the processes of breathing
C10 analyse internal and external respiration

Nervous System

C11 analyse the transmission of nerve impulses
C12 analyse the functional inter-relationships of the divisions of the nervous system

Urinary System

C13 analyse the functional inter-relationships of the structures of the urinary system

Reproductive System

C14 analyse the functional inter-relationships of the structures of the male reproductive system
C15 analyse the functional inter-relationships of the structures of the female reproductive system

Student Achievement

Biology 11 and 12

This section of the IRP contains information about classroom assessment and student achievement, including specific achievement indicators to assist in the assessment of student achievement in relation to each prescribed learning outcome. Also included in this section are key elements – descriptions of content that help determine the intended depth and breadth of prescribed learning outcomes.

CLASSROOM ASSESSMENT AND EVALUATION

Assessment is the systematic gathering of information about what students know, are able to do, and are working toward. Assessment evidence can be collected using a wide variety of methods, such as

- observation
- student self-assessments and peer assessments
- quizzes and tests (written, oral, practical)
- samples of student work
- projects and presentations
- oral and written reports
- journals and learning logs
- performance reviews
- portfolio assessments

Assessment of student performance is based on the information collected through assessment activities. Teachers use their insight, knowledge about learning, and experience with students, along with the specific criteria they establish, to make judgments about student performance in relation to prescribed learning outcomes.

Three major types of assessment can be used in conjunction to support student achievement.

- Assessment **for** learning is assessment for purposes of greater learning achievement.
- Assessment **as** learning is assessment as a process of developing and supporting students' active participation in their own learning.
- Assessment **of** learning is assessment for purposes of providing evidence of achievement for reporting.

Assessment for Learning

Classroom assessment for learning provides ways to engage and encourage students to become involved in their own day-to-day assessment – to acquire the skills of thoughtful self-assessment and to promote their own achievement.

This type of assessment serves to answer the following questions:

- What do students need to learn to be successful?
- What does the evidence of this learning look like?

Assessment for learning is criterion-referenced, in which a student's achievement is compared to established criteria rather than to the performance of other students. Criteria are based on prescribed learning outcomes, as well as on suggested achievement indicators or other learning expectations.

Students benefit most when assessment feedback is provided on a regular, ongoing basis. When assessment is seen as an opportunity to promote learning rather than as a final judgment, it shows students their strengths and suggests how they can develop further. Students can use this information to redirect their efforts, make plans, communicate with others (e.g., peers, teachers, parents) about their growth, and set future learning goals.

Assessment for learning also provides an opportunity for teachers to review what their students are learning and what areas need further attention. This information can be used to inform teaching and create a direct link between assessment and instruction. Using assessment as a way of obtaining feedback on instruction supports student achievement by informing teacher planning and classroom practice.

Student Achievement

Assessment as Learning

Assessment as learning actively involves students in their own learning processes. With support and guidance from their teacher, students take responsibility for their own learning, constructing meaning for themselves. Through a process of continuous self-assessment, students develop the ability to take stock of what they have already learned, determine what they have not yet learned, and decide how they can best improve their own achievement.

Although assessment as learning is student-driven, teachers can play a key role in facilitating how this assessment takes place. By providing regular opportunities for reflection and self-assessment, teachers can help students develop, practise, and become comfortable with critical analysis of their own learning.

Assessment of Learning

Assessment of learning can be addressed through summative assessment, including large-scale assessments and teacher assessments. These summative assessments can occur at the end of the year or at periodic stages in the instructional process.

Large-scale assessments, such as Foundation Skills Assessment (FSA) and Graduation Program exams, gather information on student performance throughout the province and provide information for the development and revision of curriculum. These assessments are used to make judgments about students' achievement in relation to provincial and national standards. There is no large-scale provincial assessment for Biology 11. The large-scale provincial assessment for Biology 12 is the optional graduation program examination, worth 40% of the final course mark for students who choose to write it.

Assessment of learning is also used to inform formal reporting of student achievement.

For Ministry of Education reporting policy, refer to www.bced.gov.bc.ca/policy/policies/student_reporting.htm

Assessment *for* Learning	Assessment *as* Learning	Assessment *of* Learning
Formative assessment is ***ongoing in the classroom***	**Formative assessment is** ***ongoing in the classroom***	**Summative assessment occurs** ***at end of year or at key stages***
• teacher assessment, student self-assessment, and/or student peer assessment • criterion-referenced – criteria based on prescribed learning outcomes identified in the provincial curriculum, reflecting performance in relation to a specific learning task • involves both teacher and student in a process of continual reflection and review about progress • teachers adjust their plans and engage in corrective teaching in response to formative assessment	• self-assessment • provides students with information on their own achievement and prompts them to consider how they can continue to improve their learning • student-determined criteria based on previous learning and personal learning goals • students use assessment information to make adaptations to their learning process and to develop new understandings	• teacher assessment • may be either criterion-referenced (based on prescribed learning outcomes) or norm-referenced (comparing student achievement to that of others) • information on student performance can be shared with parents/guardians, school and district staff, and other education professionals (e.g., for the purposes of curriculum development) • used to make judgments about students' performance in relation to provincial standards

For more information about assessment for, as, and of learning, refer to the following resource developed by the Western and Northern Canadian Protocol (WNCP): *Rethinking Assessment with Purpose in Mind.*

This resource is available online at www.wncp.ca/

Criterion-Referenced Assessment and Evaluation

In criterion-referenced evaluation, a student's performance is compared to established criteria rather than to the performance of other students. Evaluation in relation to prescribed curriculum requires that criteria be established based on the learning outcomes.

Criteria are the basis for evaluating student progress. They identify, in specific terms, the critical aspects of a performance or a product that indicate how well the student is meeting the prescribed learning outcomes. For example, weighted criteria, rating scales, or scoring guides (reference sets) are ways that student performance can be evaluated using criteria.

Wherever possible, students should be involved in setting the assessment criteria. This helps students develop an understanding of what high-quality work or performance looks like.

Criterion-referenced assessment and evaluation may involve these steps:

Step 1	Identify the prescribed learning outcomes and suggested achievement indicators (as articulated in this IRP) that will be used as the basis for assessment.
Step 2	Establish criteria. When appropriate, involve students in establishing criteria.
Step 3	Plan learning activities that will help students gain the knowledge, skills, and attitudes outlined in the criteria.
Step 4	Prior to the learning activity, inform students of the criteria against which their work will be evaluated.
Step 5	Provide examples of the desired levels of performance.
Step 6	Conduct the learning activities.
Step 7	Use appropriate assessment instruments (e.g., rating scale, checklist, scoring guide) and methods (e.g., observation, collection, self-assessment) based on the particular assignment and student.
Step 8	Review the assessment data and evaluate each student's level of performance or quality of work in relation to criteria.
Step 9	Where appropriate, provide feedback and/or a letter grade to indicate how well the criteria are met.
Step 10	Communicate the results of the assessment and evaluation to students and parents/guardians.

Student Achievement

Key Elements

Key elements provide an overview of content in each curriculum organizer and suborganizer. They can be used to determine the expected depth and breadth of the prescribed learning outcomes.

Achievement Indicators

To support the assessment of provincially prescribed curricula, this IRP includes sets of achievement indicators in relation to each learning outcome.

Achievement indicators, taken together as a set, define the specific level of knowledge acquired, skills applied, or attitudes demonstrated by the student in relation to a corresponding prescribed learning outcome. They describe what evidence to look for to determine whether or not the student has fully met the intent of the learning outcome. Since each achievement indicator defines only one aspect of the corresponding learning outcome, the entire set of achievement indicators should be considered when determining whether students have fully met the learning outcome.

In some cases, achievement indicators may also include suggestions as to the type of task that would provide evidence of having met the learning outcome (e.g., a constructed response such as a list, comparison, analysis, or chart; a product created and presented such as a report, drama presentation, poster, letter, or model; a particular skill demonstrated such as microscope use).

Achievement indicators support the principles of assessment *for* learning, assessment *as* learning, and assessment *of* learning. They provide teachers and parents with tools that can be used to reflect on what students are learning, as well as provide students with a means of self-assessment and ways of defining how they can improve their own achievement.

Achievement indicators are not mandatory; they are suggestions only, provided to assist in the assessment of how well students achieve the prescribed learning outcomes.

Achievement indicators may be useful to provincial examination development teams and inform the development of exam items. However, examination questions, item formats, exemplars, rubrics, or scoring guides will not necessarily be limited to the achievement indicators as outlined in the Integrated Resource Packages.

Specifications for provincial examinations are available online at www.bced.gov.bc.ca/exams/specs/

The following pages contain the suggested achievement indicators corresponding to each prescribed learning outcome for the Biology 11 and 12 curriculum. The achievement indicators are arranged by curriculum organizer and suborganizer for each grade; however, this order is not intended to imply a required sequence of instruction and assessment.

Student Achievement

Biology 11

Key Elements: Processes of Science

Estimated Time: integrated throughout

The prescribed learning outcomes related to Processes of Science support the development of knowledge, skills, and attitudes essential for an understanding of science. These learning outcomes should not be taught in isolation, but should be integrated with activities related to the other curriculum organizers.

Vocabulary

conclusion, control, control group, controlled variable, dependent variable, experimental group, experimental variable, independent variable, repeatable procedure, sample size, scientific method, testable hypothesis

Knowledge

- independent and dependent variables
- controlled and experimental variables
- control group, experimental group

Skills and Attitudes

- demonstrate safe and correct lab technique (e.g., use of dissection and compound microscopes, preparation of wet-mount slides, sterile technique, safe dissection technique)
- apply the scientific method to design and carry out experiments
- make inferences and generalizations
- interpret data from a variety of types of sources
- draw conclusions
- communicate information and results (e.g., graphs, diagrams, models, formulae)

PROCESSES OF SCIENCE

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
A1 demonstrate safe and correct technique for a variety of laboratory procedures	❑ demonstrate the correct use of a dissection microscope ❑ prepare wet-mount slides ❑ demonstrate safe and correct dissection technique ❑ demonstrate the correct use of a compound microscope ❑ demonstrate sterile technique while preparing a streak plate
A2 design an experiment using the scientific method	❑ formulate a testable hypothesis to investigate a scientific problem (e.g., determining the effectiveness of antibacterial agents on bacteria, determining the rate of fermentation in yeast) ❑ formulate and carry out a repeatable, controlled procedure to test the hypothesis: – identify controlled versus experimental variables – identify the independent and dependent variables – use control and experimental groups, as appropriate – use a control as appropriate – use appropriate sample size ❑ observe, measure, and record data ❑ interpret results to draw conclusions ❑ determine whether the conclusions support or reject the hypothesis ❑ determine whether the experiment is reliable ❑ use results and conclusions as a basis for further comparisons, investigations, or analyses
A3 interpret data from a variety of text and visual sources	❑ use data from a variety of representations (e.g., diagrams, electron micrographs, graphs, photographs) to make inferences and generalizations ❑ draw and present conclusions, applying the most appropriate means to communicate (e.g., graph, diagram, model, formula, map, visual)

Key Elements: Taxonomy

Estimated Time: 3–5 hours

By the end of this course, students will have an understanding of the applications of taxonomy.

Vocabulary

binomial nomenclature, biochemical relationship, class, embryological relationship, eukaryotic cell, evolutionary relationship, family, genus, homologous structure, kingdom, order, phylum, prokaryotic cell, species, sub-phylum, taxonomy/taxon

Knowledge

- principles of taxonomy
- Kingdom system of classification, taxons, binomial nomenclature
- characteristics of the kingdoms Monera, Protista, Fungi, Plantae, and Animalia

Skills and Attitudes

- use classification keys
- demonstrate correct use of a compound microscope
- observe organisms to recognize common characteristics
- demonstrate ethical, responsible, co-operative behaviour
- show respect for living things

TAXONOMY

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
B1 apply the Kingdom system of classification to study the diversity of organisms	❑ explain how the following principles are used in taxonomy to classify organisms: – evolutionary relationships – biochemical relationships – homologous structures – embryological relationships ❑ compare characteristics of a prokaryotic cell with those of a eukaryotic cell ❑ describe the unifying characteristics of organisms in each of the following kingdoms: – Monera – Protista – Fungi – Plantae – Animalia ❑ classify selected organisms using the following taxons: kingdom, phylum (and sub-phylum), class, order, family, genus, species ❑ apply binomial nomenclature to name selected organisms

Key Elements: Evolution

Estimated Time: 5–10 hours

By the end of this course, students will have an understanding of the mechanics of evolution.

Vocabulary

complementary base pairing, convergent evolution, divergent evolution, deoxyribonucleic acid (DNA), double helix, evolutionary change, gene flow, genetic drift, gradual change model, mutation, natural selection, nitrogenous base, non-random mating, punctuated equilibrium model, speciation, sugar-phosphate backbone

Knowledge

- basic structure of DNA
- role of DNA in evolution
- agents of evolutionary change
- patterns of evolution
- tempo of evolutionary change

Skills and Attitudes

- create models (e.g., agents of evolutionary change, DNA)
- gather data to study variation within a population
- communicate results (e.g., using graphs, tables, diagrams, lab reports)
- demonstrate ethical, responsible, co-operative behaviour

EVOLUTION

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
C1 describe the process of evolution	❑ describe the basic structure of deoxyribonucleic acid (DNA) with reference to the following terms: – double helix – sugar-phosphate backbone – nitrogenous bases (A, T, C, G) – complementary base pairing (A-T, C-G) ❑ explain the role of DNA in evolution ❑ describe the five agents of evolutionary change: mutation, genetic drift, gene flow, non-random mating, and natural selection ❑ differentiate among and give examples of convergent evolution, divergent evolution, and speciation ❑ compare the gradual change model with the punctuated equilibrium model of evolution

Key Elements: Ecology

Estimated Time: 10–12 hours

By the end of this course, students will have an understanding of the role various organisms play in an ecosystem.

Vocabulary

carrying capacity, cellular respiration, chemical equations, climax community, commensalism, consumer, cyclic growth, decomposer, density-dependent factors, density-independent factors, ecological succession, energy flow, exponential growth, logistic growth, mutualism, parasitism, photosynthesis, pioneer species, population, producer, products, pyramid of energy, reactants, steady state, symbiosis

Knowledge

- interdependent roles of organisms in ecosystems
- energy flow and energy pyramids
- photosynthesis and cellular respiration
- factors affecting population growth

Skills and Attitudes

- create bar graphs, line graphs, pie charts, tables, and diagrams to extract and convey information
- create models to represent a given type of data (e.g., populations)
- conduct experiments (e.g., quadrat study)
- relate cause to effect
- assess human impacts on an ecosystem
- demonstrate ethical, responsible, co-operative behaviour
- show respect and sensitivity for the environment

ECOLOGY

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
D1 analyse the functional inter-relationships of organisms within an ecosystem	❑ describe the process of ecological succession, with reference to terms such as pioneer species and climax community ❑ explain the roles of producers, consumers, and decomposers in ecosystems ❑ describe a pyramid of energy in terms of energy flow through an ecosystem ❑ describe the roles of photosynthesis and cellular respiration within a pyramid of energy ❑ compare photosynthesis and cellular respiration in terms of the reactants, products, and chemical equations ❑ describe the stages a population goes through as it increases in size, with reference to terms such as exponential growth, logistic growth, cyclic growth, carrying capacity, steady state ❑ describe density-dependent and density-independent factors that limit and control population growth ❑ define *symbiosis* and types of symbiosis: *parasitism*, *commensalism*, and *mutualism*

Key Elements: Microbiology

Estimated Time: 20–25 hours

By the end of this course, students will have an understanding of characteristics and functions of viruses and bacteria.

Vocabulary

Viruses: antibody, antigen, DNA, host cell, lymphocyte, lysogenic cycle, lytic cycle, membranous envelope, mucous membrane, nucleic acid core, phagocytic white blood cell, primary line of defence, protein capsid, RNA, secondary line of defence, tertiary line of defence, viral specificity, white blood cell

Monera: aerobic respiration, antibiotic, antiseptic, bacteria, binary fission, classification, conjugation, disinfectant, ecological role, fermentation, motility, mutate/mutation, photosynthesis, prokaryote, resistant/resistance

Knowledge

Viruses
- definitions of living vs. non-living
- structure of viruses
- viral reproduction
- effects of viruses on humans

Monera
- characteristics of prokaryotic cells
- structure and function of bacteria
- moneran diversity
- roles and effects of bacteria
- effects of antibacterial agents

Skills and Attitudes

- demonstrate proper techniques for handling and disposing of laboratory materials involving bacteria
- use personal protective equipment
- demonstrate emergency response procedures
- demonstrate safe and correct use of a Bunsen burner
- observe organisms to recognize common characteristics
- communicate results (e.g., using graphs, tables, diagrams, lab reports)
- create models (e.g., life cycle of a virus)
- conduct experiments (e.g., antibiotic sensitivity of bacteria)
- demonstrate ethical, responsible, co-operative behaviour
- show respect for living things

MICROBIOLOGY

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
Viruses E1 evaluate the evidence used to classify viruses as living or non-living	❑ identify criteria for classifying organisms as living ❑ describe the basic structure of a virus, including the antigens, the membranous envelope, the protein capsid, and the nucleic acid core (DNA or RNA) ❑ identify the role of the host cell in viral reproduction ❑ compare the lytic and lysogenic cycles
E2 evaluate the effects of viruses on human health	❑ define and give examples of viral specificity ❑ describe the body's basic lines of defence against a viral attack, including – primary line of defence (e.g., skin, mucous membranes, tears) – secondary line of defence (e.g., phagocytic white blood cells engulf viruses) – tertiary line of defence (e.g., white blood cells called lymphocytes produce antibodies) ❑ give examples of ways to reduce the spread of viral diseases
Kingdom Monera E3 analyse monerans as a lifeform at the prokaryotic level of organization	❑ examine monerans and identify the characteristics that unify them ❑ use examples to illustrate moneran diversity with respect to the following: – classification – shape and grouping of cells – motility – ecological role – nutrition (fermentation, aerobic respiration, photosynthesis) – reproduction (binary fission, conjugation) – human diseases ❑ give examples of the beneficial roles of bacteria
E4 evaluate the effectiveness of various antibiotics, disinfectants, or antiseptics on bacterial cultures	❑ conduct an experiment using sterile technique to test the effects of various antibacterial agents (e.g., antibiotics, disinfectants, and antiseptics) on bacterial cultures ❑ analyse and interpret data from experiments to draw conclusions about the effectiveness of particular agents on specific bacteria ❑ explain how bacteria mutate to become resistant to antibiotics

Key Elements: Plant Biology

Estimated Time: 20–23 hours

By the end of this course, students will have an understanding of the increasing complexity of phyla within the Kingdom Plantae and the characteristics that place organisms within each phylum.

Vocabulary

adaptation, alternation of generations, colonial, dicots, enclosed seeds, flowers, fruit, leaves, monocots, multicellular, pollen, roots, seeds, stems, unicellular, vascular tissue

Knowledge

- trends of increasing complexity in plant lifeforms
- characteristics of algae, mosses, ferns, gymnosperms, and angiosperms
- adaptations of plants to a land environment

Skills and Attitudes

- observe plants to recognize common characteristics
- communicate results (e.g., using graphs, tables, diagrams, lab reports)
- create models (e.g., vascular tissue of a plant)
- conduct experiments (e.g., plant dissection, water transport in vascular tissue)
- demonstrate ethical, responsible, co-operative behaviour
- show respect and sensitivity for the environment

PLANT BIOLOGY

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
F1 analyse how the increasing complexity of algae, mosses, and ferns represent an evolutionary continuum of adaptation to a land environment	❑ examine green algae and describe the characteristics that unify them ❑ use examples of unicellular, colonial, and multicellular green algae to illustrate their increasing complexity ❑ examine mosses and describe the characteristics that unify them ❑ examine ferns and describe the characteristics that unify them ❑ describe alternation of generations in algae, mosses, and ferns ❑ describe features of mosses and ferns that have enabled adaptation to a land environment
F2 analyse how the increasing complexity of gymnosperms and angiosperms contribute to survival in a land environment	❑ examine gymnosperms and describe the characteristics that unify them ❑ explain how gymnosperms are adapted for survival in a land environment with respect to the following: alternation of generations, roots, stems, leaves, seeds, pollen, vascular tissue ❑ examine angiosperms and describe characteristics that unify them ❑ use specimens to differentiate between monocots and dicots ❑ describe how angiosperms are adapted for survival in a land environment, with respect to alternation of generations, flowers, pollen, enclosed seeds, fruit, roots, stems, leaves, vascular tissue ❑ compare the ways in which mosses, ferns, gymnosperms, and angiosperms have adapted to a land environment

Key Elements: Animal Biology

Estimated Time: 32–35 hours

By the end of this course, students will have an understanding of the increasing complexity within the Kingdom Animalia and the characteristics that place organisms within each phylum.

Vocabulary

asexual reproduction, cell, cephalization, closed circulatory system, coelom, colonial, fluid feeding, endoskeleton, excretion, exoskeleton, filter feeding, free-living, internal transport, invertebrates, levels of organization, life functions, medusa, motility, motility/motile, multicellular, niche, open circulatory system, organ, organ system, parasite/parasitic, polyp, reproduction, respiration, response, sessile, sexual reproduction, symmetry, tissue, vertebral column

Knowledge

- trends of increasing complexity in animal lifeforms
- characteristics of Phylum Porifera, Phylum Cnidaria, Phylum Platyhelminthes, Phylum Nematoda, Phylum Annelida, Phylum Mollusca, Phylum Echinodermata, Phylum Arthropoda, and Subphylum Vertebrata (Phylum Chordata)
- how animals in each phylum carry out their life functions
- ecological significance of various animal phyla

Skills and Attitudes

- demonstrate proper techniques for handling and disposing of laboratory materials involving preserved specimens
- use personal protective equipment
- demonstrate safe and correct dissection technique
- observe organisms to recognize common characteristics
- communicate results (e.g., using graphs, tables, diagrams, lab reports)
- create models (e.g., of a sponge)
- conduct experiments (e.g., light sensitivity in planaria)
- demonstrate ethical, responsible, co-operative behaviour
- show respect for living things

ANIMAL BIOLOGY

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
G1 analyse how the increasing complexity of animal phyla represents an evolutionary continuum	❑ compare phyla in terms of – levels of organization – cell, tissue, organ, organ system – cephalization – development of a coelom – symmetry – reproduction ❑ describe the life functions animals need to survive, including – feeding – respiration – internal transport – excretion – reproduction – response and motility ❑ compare the advantages and disadvantages of different ways animals carry out their life functions (e.g., filter feeding vs. fluid feeding, parasitic vs. free-living, asexual vs. sexual reproduction, sessile vs. motile)
G2 analyse the increasing complexity of the Phylum Porifera and the Phylum Cnidaria *Organizer 'Animal Biology'* *continued on page 42*	❑ examine members of the Phylum Porifera and identify their unifying characteristics ❑ describe how poriferans carry out their life functions ❑ examine members of the Phylum Cnidaria and identify their unifying characteristics ❑ describe how cnidarians carry out their life functions ❑ compare polyp and medusa with respect to structure, general function, and motility ❑ suggest the advantages of a motile form in the life cycle of a cnidarian ❑ explain the evolutionary significance of colonial (poriferan) versus multicellular (cnidarian) lifeforms ❑ describe the ecological roles of sponges and cnidarians

Prescribed Learning Outcomes	Suggested Achievement Indicators
Organizer 'Animal Biology' continued from page 41	
G3 analyse the increasing complexity of the Phylum Platyhelminthes, the Phylum Nematoda, and the Phylum Annelida	❑ examine members of the Phylum Platyhelminthes and describe their unifying characteristics ❑ describe how platyhelminthes carry out their life functions ❑ examine members of the Phylum Nematoda and describe their unifying characteristics ❑ describe how nematodes carry out their life functions ❑ examine members of the Phylum Annelida and describe their unifying characteristics ❑ describe how annelids carry out their life functions ❑ describe the physical changes that were necessary for flatworms and roundworms to become parasitic ❑ evaluate the characteristics of a successful parasite ❑ describe human disorders that are caused by non-segmented worms ❑ compare platyhelminthes, nematodes, and annelids with respect to evolutionary changes ❑ describe the ecological roles of platyhelminthes, nematodes, and annelids
G4 analyse the increasing complexity of the Phylum Mollusca, the Phylum Echinodermata, and the Phylum Arthropoda	❑ examine members of the Phylum Mollusca and describe their unifying characteristics ❑ describe how molluscs carry out their life functions ❑ examine members of the Phylum Echinodermata and describe their unifying characteristics ❑ describe how echinoderms carry out their life functions ❑ examine members of the Phylum Arthropoda and describe their unifying characteristics ❑ describe how arthropods carry out their life functions ❑ compare how molluscs, echinoderms, and arthropods have evolved to adapt to different niches ❑ demonstrate a knowledge of the diverse ecological roles of molluscs, echinoderms, and arthropods
G5 relate the complexity of the form and function of vertebrates to the evolutionary continuum of animals	❑ examine members of the Subphylum Vertebrata and describe their unifying characteristics ❑ compare members of two or more classes of vertebrates ❑ compare the vertebrates and invertebrates in terms of increasing complexity, with reference to characteristics including – endoskeleton vs. exoskeleton – presence or absence of vertebral column – closed vs. open circulatory system ❑ describe the diverse ecological role of vertebrates

Student Achievement

Biology 12

Key Elements: Processes of Science

Estimated Time: integrated throughout

The prescribed learning outcomes related to Processes of Science support the development of knowledge, skills, and attitudes essential for an understanding of science. These learning outcomes should not be taught in isolation, but should be integrated with activities related to the other curriculum organizers.

Vocabulary

conclusion, control, control group, controlled variable, dependent variable, electron micrograph, experimental group, experimental variable, independent variable, reliable, repeatable procedure, sample size, scientific method, testable hypothesis

Knowledge

- distinguish between independent and dependent variables
- distinguish between controlled and experimental variables
- distinguish between control group and experimental group

Skills and Attitudes

- safe and correct lab technique (e.g., use of dissection and compound microscopes, dissection technique)
- applying the scientific method to design and carry out experiments
- making inferences and generalizations
- interpreting data from a variety of types of sources (e.g., electron micrographs)
- drawing conclusions
- communicating information and results (e.g., graphs, diagrams, models, formulae)

PROCESSES OF SCIENCE

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
A1 demonstrate safe and correct technique for a variety of laboratory procedures	❑ demonstrate the correct use of a dissection microscope ❑ demonstrate safe and correct dissection technique ❑ demonstrate the correct use of a compound microscope
A2 design an experiment using the scientific method	❑ formulate a testable hypothesis to investigate a scientific problem (e.g., factors affecting enzyme activity, tonicity of various cells) ❑ formulate and carry out a repeatable, controlled procedure to test the hypothesis: – identify controlled versus experimental variables – identify the independent and dependent variables – use control and experimental groups, as appropriate – use a control as appropriate – use appropriate sample size ❑ observe, measure, and record data ❑ interpret results to draw conclusions ❑ determine whether the conclusions support or reject the hypothesis ❑ determine whether the experiment is reliable ❑ use information and conclusions as a basis for further comparisons, investigations, or analyses
A3 interpret data from a variety of text and visual sources	❑ use data from a variety of representations (e.g., diagrams, electron micrographs, graphs, photographs) to make inferences and generalizations ❑ draw and present conclusions, applying the most appropriate means to communicate (e.g., graph, diagram, model, formula, map, visual)

Key Elements: Cell Biology (Cell Structure)

Estimated Time: 5–6 hours

By the end of this course, students will have an understanding of the structure of cells.

Vocabulary

cell membrane, cell wall, cellular respiration, chloroplast, chromatin, chromosome, cristae, cytoplasm, cytoskeleton, Golgi bodies, lysosome, matrix, mitochondria, nuclear envelope, nuclear pore, nucleolus, nucleus, organelle, polysome, ribosome, rough endoplasmic reticulum, smooth endoplasmic reticulum, vacuole, vesicle

Knowledge

- functional inter-relationships of cell structures
- how cell compartmentalization assists in the production and distribution of molecules

Skills and Attitudes

- demonstrate correct use of a compound microscope
- communicate results (e.g., using graphs, tables, diagrams, lab reports)
- create models (e.g., of a cell, or an organelle)
- demonstrate ethical, responsible, co-operative behaviour

CELL BIOLOGY (CELL STRUCTURE)

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
B1 analyse the functional inter-relationships of cell structures	❑ describe the following cell structures and their functions: – cell membrane – cell wall – chloroplast – cytoskeleton – cytoplasm – Golgi bodies – lysosomes – mitochondria – including cristae and matrix – nucleus – including nuclear pore, nucleolus, chromatin, nuclear envelope, and chromosomes – ribosomes (polysomes) – smooth and rough endoplasmic reticulum – vacuoles – vesicles ❑ state the balanced chemical equation for cellular respiration ❑ describe how the following organelles function to compartmentalize the cell and move materials through it: – rough and smooth endoplasmic reticulum – vesicles – Golgi bodies – cell membrane ❑ identify cell structures depicted in diagrams and electron micrographs

Key Elements: Cell Biology (Cell Compounds and Biological Molecules)

Estimated Time: 7–9 hours

By the end of this course, students will have an understanding of the structures and function of cell compounds and biological molecules.

Vocabulary

acid, acid (carboxyl) group, adenine, adenosine triphosphate (ATP), alpha helix, amine group, amino acid, base, beta pleated sheet, bonding, buffer, carbohydrate, cellulose, complementary base pairing, cytosine, dehydration synthesis, deoxyribonucleic acid (DNA), deoxyribose, dipeptide, disaccharide, double helix, glucose, glycerol, guanine, glycogen, hemoglobin, hydrogen bonding, hydrolysis, lipid, lubricant, maltose, monomer, monosaccharide, neutral fat, nitrogenous base, nucleic acids, nucleotide, organic, peptide bond, pH, phosphate, phospholipid, polarity, polymer, polypeptide, polysaccharide, primary structure, protein, quaternary structure, R-group, ribonucleic acid (RNA), ribose, saturated fatty acid, secondary structure, solvent, starch, steroid, sugar-phosphate backbone, temperature regulator, tertiary structure, thymine, unsaturated fatty acid, uracil

Knowledge

- characteristics of water and its role in biological systems
- importance of pH and the role of acids, bases, and buffers in biological systems
- structure and function of biological molecules in living systems: carbohydrates, lipids, proteins, and nucleic acids
- dehydration synthesis and hydrolysis
- types of carbohydrates, lipids, proteins, and nucleic acids
- empirical formula of a carbohydrate

Skills and Attitudes

- create molecular models
- conduct experiments (e.g., to observe the effects of acids and bases on indicators; to test foods for the presence of carbohydrates, lipids, and proteins)
- communicate results (e.g., using graphs, tables, diagrams, lab reports)
- demonstrate ethical, responsible, co-operative behaviour

CELL BIOLOGY (CELL COMPOUNDS AND BIOLOGICAL MOLECULES)

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
B2 describe the characteristics of water and its role in biological systems	❑ describe the role of water as a solvent, temperature regulator, and lubricant ❑ describe how the polarity of the water molecule results in hydrogen bonding
B3 describe the role of acids, bases, and buffers in biological systems in the human body *Suborganizer 'Cell Biology (Cell Compounds and Biological Molecules)' continued on page 50*	❑ differentiate among acids, bases, and buffers ❑ describe the importance of pH to biological systems in the human body

Prescribed Learning Outcomes	Suggested Achievement Indicators
Suborganizer 'Cell Biology (Cell Compounds and Biological Molecules)' continued from page 49 B4 analyse the structure and function of biological molecules in living systems, including – carbohydrates – lipids – proteins – nucleic acids *Suborganizer 'Cell Biology (Cell Compounds and Biological Molecules),' PLO B4 continued on page 51*	❑ demonstrate a knowledge of dehydration synthesis and hydrolysis as applied to organic monomers and polymers ❑ differentiate among carbohydrates, lipids, proteins, and nucleic acids with respect to chemical structure ❑ recognize the following molecules in structural diagrams: – adenosine triphosphate (ATP) – deoxyribonucleic acid (DNA) – disaccharide – glucose – glycerol – hemoglobin – monosaccharide – neutral fat – phospholipid – polysaccharide (starch, glycogen, and cellulose) – ribose – RNA – saturated and unsaturated fatty acids – steroids ❑ recognize the empirical formula of a monosaccharide as $C_nH_{2n}O_n$ ❑ list the main functions of carbohydrates ❑ differentiate among monosaccharides (e.g., glucose), disaccharides (e.g., maltose), and polysaccharides ❑ differentiate among starch, cellulose, and glycogen with respect to – function – type of bonding – level of branching ❑ describe the location, structure, and function of the following in the human body: – neutral fats – steroids – phospholipids

Prescribed Learning Outcomes	Suggested Achievement Indicators
Suborganizer 'Cell Biology (Cell Compounds and Biological Molecules),' PLO B4 continued from page 50	❑ compare saturated and unsaturated fatty acids in terms of molecular structure ❑ list the major functions of proteins ❑ draw a generalized amino acid and identify the amine, acid (carboxyl), and R-groups ❑ identify the peptide bonds in dipeptides and polypeptides ❑ differentiate among the following levels of protein organization with respect to structure and types of bonding: – primary – secondary (alpha helix, beta pleated sheet) – tertiary – quaternary (e.g., hemoglobin) ❑ list the major functions of nucleic acids (RNA and DNA) ❑ name the four nitrogenous bases in ribonucleic acid (RNA) and describe the structure of RNA using the following terms: – nucleotide (ribose, phosphate, nitrogenous base, adenine, uracil, cytosine, guanine) – linear, single stranded – sugar-phosphate backbone ❑ name the four nitrogenous bases in DNA and describe the structure of DNA using the following terms: – nucleotide (deoxyribose, phosphate, nitrogenous base, adenine, thymine, cytosine, guanine) – complementary base pairing – double helix – hydrogen bonding – sugar-phosphate backbone ❑ compare the general structural composition of DNA and RNA ❑ relate the general structure of the ATP molecule to its role as the "energy currency" of cells

Key Elements: Cell Biology (DNA Replication)

Estimated Time: 4–5 hours

By the end of this course, students will have an understanding of the process of DNA replication.

Vocabulary

complementary base pairing, DNA helicase, DNA polymerase, nucleotides, recombinant DNA, replication, semi-conservative replication

Knowledge

- purpose of DNA replication
- site of DNA replication in the cell
- semi-conservative DNA replication
- recombinant DNA

Skills and Attitudes

- interpret graphs, tables, and diagrams
- create models (e.g., of DNA replication)
- conduct experiments (e.g., to isolate DNA, to produce recombinant DNA)
- demonstrate ethical, responsible, co-operative behaviour

CELL BIOLOGY (DNA REPLICATION)

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
B5 describe DNA replication	❑ describe the three steps in the semi–conservative replication of DNA: – "unzipping" (DNA helicase) – complementary base pairing (DNA polymerase) – joining of adjacent nucleotides (DNA polymerase) ❑ describe the purpose of DNA replication ❑ identify the site of DNA replication within the cell
B6 describe recombinant DNA	❑ define recombinant DNA ❑ describe a minimum of three uses for recombinant DNA

Key Elements: Cell Biology (Protein Synthesis)

Estimated Time: 4–6 hours

By the end of this course, students will have an understanding of the process of protein synthesis.

Vocabulary

amino acid, anti-codon, codon, DNA sequence (genetic code), elongation, environmental mutagen, genetic disorder, initiation, messenger RNA (mRNA), mutation, polypeptide chain, ribosomes, termination, transcription, transfer RNA (tRNA), translation

Knowledge

- process of protein synthesis
- how mutations in DNA affect protein synthesis
- mutations causing genetic disorders

Skills and Attitudes

- interpret tables and diagrams
- create models (e.g., protein synthesis or mutation)
- demonstrate ethical, responsible, co-operative behaviour

CELL BIOLOGY (PROTEIN SYNTHESIS)

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
B7 demonstrate an understanding of the process of protein synthesis	❑ identify the roles of DNA, messenger RNA (mRNA), transfer RNA (tRNA), and ribosomes in the processes of transcription and translation, including initiation, elongation, and termination ❑ determine the sequence of amino acids coded for by a specific DNA sequence (genetic code), given a table of mRNA codons ❑ identify the complementary nature of the mRNA codon and the tRNA anti-codon
B8 explain how mutations in DNA affect protein synthesis	❑ give examples of two environmental mutagens that can cause mutations in humans ❑ use examples to explain how mutations in DNA change the sequence of amino acids in a polypeptide chain, and as a result may lead to genetic disorders

Key Elements: Cell Biology (Transport Across Cell Membrane)

Estimated Time: 6–7 hours

By the end of this course, students will have an understanding of the structure and function of cell membranes.

Vocabulary

active transport, carbohydrates, carrier protein, cell membrane, channel protein, cholesterol, concentration gradient, diffusion, endocytosis, exocytosis, facilitated transport, fluid-mosaic membrane model, glycolipid, glycoprotein, hydrophilic, hydrophobic, hypertonic, hypotonic, isotonic, osmosis, passive transport processes, phagocytosis, phospholipid, phospholipid bilayer, pinocytosis, pressure gradient, protein, selectively permeable, surface area-to-volume ratio, tonicity

Knowledge

- structure and function of the cell membrane
- factors affecting rate of diffusion
- transport processes
- why cells divide when they reach a particular surface area-to-volume ratio

Skills and Attitudes

- interpret diagrams, tables, and graphs (e.g., of surface area to volume ratio)
- create models (e.g., of cell membrane, compare surface area-to-volume ratio of objects of different sizes)
- conduct experiments (e.g., to determine the tonicity of cells, diffusion)
- demonstrate ethical, responsible, co-operative behaviour

CELL BIOLOGY (TRANSPORT ACROSS CELL MEMBRANE)

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
B9 analyse the structure and function of the cell membrane	❑ apply knowledge of organic molecules – including phospholipids, proteins, glycoproteins, glycolipids, carbohydrates, and cholesterol – to explain the structure and function of the fluid-mosaic membrane model ❑ identify the hydrophobic and hydrophilic regions of the phospholipid bilayer ❑ explain why the cell membrane is described as "selectively permeable" ❑ describe passive transport processes including diffusion, osmosis, and facilitated transport ❑ explain factors that affect the rate of diffusion across a cell membrane (e.g., temperature, size of molecule, charge of molecule, concentration gradient, pressure gradient) ❑ predict the effects of hypertonic, isotonic, and hypotonic environments on osmosis in animal cells ❑ describe active transport processes including active transport, endocytosis (phagocytosis and pinocytosis), and exocytosis ❑ compare specific transport processes – including diffusion, osmosis, facilitated transport, active transport, endocytosis, and exocytosis – in terms of – concentration gradient – use of channel or carrier protein – use of energy – types/sizes of molecules transported ❑ devise an experiment using the scientific method (e.g., to investigate the tonicity of cells)
B10 explain why cells divide when they reach a particular surface area-to-volume ratio	❑ differentiate between cells that have a high or low surface area-to-volume ratio ❑ demonstrate an understanding of the significance of surface area-to-volume ratio in cell size

Key Elements: Cell Biology (Enzymes)

Estimated Time: 6–7 hours

By the end of this course, students will have an understanding of the role of enzymes in biochemical reactions.

Vocabulary

activation energy, biochemical reaction, coenzyme, competitive inhibitor, enzyme, enzyme activity, enzyme concentration, heavy metal, induced fit model, metabolism, non-competitive inhibitor, pH, proteins, substrate, substrate concentration, thyroid, thyroxin, vitamins

Knowledge

- roles of enzymes and coenzymes in biochemical reactions
- balanced chemical equation for cellular respiration
- effects on enzyme activity
- thyroxin and its source gland

Skills and Attitudes

- interpret graphs, tables, and diagrams
- create models (e.g., enzyme action – induced fit)
- conduct experiments (e.g., observing enzyme activity at varying pH and temperatures)
- demonstrate ethical, responsible, co-operative behaviour

CELL BIOLOGY (ENZYMES)

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
B11 analyse the roles of enzymes in biochemical reactions	❑ explain the following terms: metabolism, enzyme, substrate, coenzyme, activation energy ❑ use graphs to identify the role of enzymes in lowering the activation energy of a biochemical reaction ❑ explain models of enzymatic action (e.g., induced fit) ❑ differentiate between the roles of enzymes and coenzymes in biochemical reactions ❑ identify the role of vitamins as coenzymes ❑ apply knowledge of proteins to explain the effects on enzyme activity of pH, temperature, substrate concentration, enzyme concentration, competitive inhibitors, and non-competitive inhibitors including heavy metals ❑ devise an experiment using the scientific method (e.g., to investigate the activity of enzymes) ❑ identify the thyroid as the source gland for thyroxin, and relate the function of thyroxin to metabolism

Key Elements: Human Biology (Digestive System)

Estimated Time: 8–10 hours

By the end of this course, students will have an understanding of the structures and function of the digestive system.

Vocabulary

absorption, anaerobic bacteria, anus, appendix, bile, capillary, cardiac sphincter, chemical digestion, digestive enzyme, digestive tract, duodenum, emulsification, epiglottis, esophagus, gall bladder, gastric juice, hydrochloric acid (HCl), insulin, intestinal juice, lacteals, large intestine (colon), lipase, liver, maltase, microvillus, nuclease, pancreas, pancreatic amylase, pancreatic juice, pepsin, pepsinogen, peptidase, peristalsis, pH, pharynx, physical digestion, protease, pyloric sphincter, rectum, salivary amylase, salivary gland, salivary juice/saliva, small intestine, sodium bicarbonate, stomach, swallowing, trypsin, villus

Knowledge

- structures of the digestive system and their inter-relationships
- components, pH, and digestive actions of salivary, gastric, pancreatic, and intestinal juices

Skills and Attitudes

- interpret graphs, tables, and diagrams
- demonstrate safe and correct dissection technique
- demonstrate correct use of a dissection microscope (e.g., interior surface of stomach and small intestine)
- demonstrate proper technique for handling and disposing of laboratory materials
- create models (e.g., of specific aspects of the digestive system such as peristalsis)
- conduct experiments (e.g., to test the effect of digestive enzymes such as amylase or pepsin)
- communicate results (e.g., using tables, graphs, diagrams, lab reports)
- demonstrate ethical, responsible, co-operative behaviour
- show respect for living things

HUMAN BIOLOGY (DIGESTIVE SYSTEM)

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
C1 analyse the functional inter-relationships of the structures of the digestive system	❑ identify and give a function for each of the following: – mouth – tongue – teeth – salivary glands – pharynx – epiglottis – esophagus – cardiac sphincter – stomach – pyloric sphincter – duodenum – liver – gall bladder – pancreas – small intestine – appendix – large intestine (colon) – rectum – anus ❑ describe swallowing and peristalsis ❑ identify the pancreas as the source gland for insulin, and describe the function of insulin in maintaining blood sugar levels ❑ list at least six major functions of the liver ❑ explain the role of bile in the emulsification of fats ❑ describe how the small intestine is specialized for chemical and physical digestion and absorption ❑ describe the structure of the villus, including mircovilli, and explain the functions of the capillaries and lacteals within it ❑ describe the functions of anaerobic bacteria in the colon ❑ demonstrate the correct use of the dissection microscope to examine the various structures of the digestive system
Suborganizer 'Human Biology (Digestive System)' continued on page 62	

Prescribed Learning Outcomes	Suggested Achievement Indicators
Suborganizer 'Human Biology (Digestive System)' continued from page 61	
C2 describe the components, pH, and digestive actions of salivary, gastric, pancreatic, and intestinal juices	❑ relate the following digestive enzymes to their glandular sources and describe the digestive reactions they promote: – salivary amylase – pancreatic amylase – proteases (pepsinogen, pepsin, trypsin) – lipase – peptidase – maltase – nuclease ❑ describe the role of water as a component of digestive juices ❑ describe the role of sodium bicarbonate in pancreatic juice ❑ describe the role of hydrochloric acid (HCl) in gastric juice ❑ describe the role of mucus in gastric juice ❑ describe the importance of the pH level in various regions of the digestive tract

Key Elements: Human Biology (Circulatory System)

Estimated Time: 14–16 hours

By the end of this course, students will have an understanding of the structures and function of the circulatory system, including the heart, blood vessels, blood, and the role of lymphatic system.

Vocabulary

anterior vena cava, antibody, antigen, aorta, arterial duct atrioventricular valve, autonomic nervous system, atrioventricular (AV) node, blood, blood pressure, blood velocity, blood vessel, capillary-tissue fluid exchange, carotid artery, chordae tendineae, coronary artery, coronary vein, diastolic pressure, fetal circulation, heart rate, hepatic portal vein, hepatic vein, hypertension, hypotension, iliac artery, iliac vein, jugular vein, left atrium, left ventricle, lymph capillaries, lymph node, lymphatic system, lymphatic veins, mesenteric artery, oval opening, plasma, platelets, posterior vena cava, pulmonary arteries, pulmonary circulation, pulmonary trunk, pulmonary veins, Purkinje fibres, red blood cell, renal artery, renal vein, right atrium, right ventricle, sinoatrial (SA) node, semi-lunar valve, septum, subclavian artery, subclavian vein, systemic circulation, systolic pressure, total cross-sectional area, umbilical artery, umbilical vein, valve, veins, venous duct, vessel wall, white blood cell

Knowledge

- structures of the circulatory system and their inter-relationships
- structure of the heart
- relationship between heart rate and blood pressure
- structures and functions of blood vessels
- pulmonary and system circulation
- components of blood
- fetal circulation
- roles of antigens and antibodies
- structures and functions of the lymphatic system

Skills and Attitudes

- interpret graphs, tables, and diagrams
- demonstrate safe and correct dissection technique
- demonstrate correct use of a compound microscope (e.g., blood slides)
- demonstrate correct use of a dissection microscope (e.g., heart dissection)
- demonstrate proper technique for handling and disposing of laboratory materials
- create models (e.g., antigens and antibodies, specific aspects of the circulatory system such as the heart)
- conduct experiments (e.g., to test the effect of physical activity on heart rate and blood pressure)
- communicate results (e.g., using tables, graphs, diagrams, lab reports)
- demonstrate ethical, responsible, co-operative behaviour
- show respect for living things

HUMAN BIOLOGY (CIRCULATORY SYSTEM)

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
C3 describe the inter-relationships of the structures the heart	❑ identify and give functions (including where blood is coming from and going to, as applicable) for each of the following: – left and right atria – left and right ventricles – coronary arteries and veins – anterior and posterior vena cava – aorta – pulmonary arteries and veins – pulmonary trunk – atrioventricular valves – chordae tendineae – semi-lunar valves – septum ❑ recognize heart structures using both internal and external diagram views
C4 analyse the relationship between heart rate and blood pressure	❑ describe the location and functions of the sinoatrial (SA) node, atrioventricular (AV) node, and Purkinje fibres ❑ describe how the autonomic nervous system increases and decreases heart rate and blood pressure ❑ differentiate between systolic and diastolic pressures ❑ describe hypertension and hypotension and their causes ❑ demonstrate the measurement of blood pressure
C5 analyse the functional inter-relationships of the vessels of the circulatory system *Suborganizer 'Human Biology (Circulatory System)' PLO C5* *continued on page 65*	❑ identify and give the function (including where the vessel is carrying blood from and where it is carrying blood to) of each of the following: – subclavian arteries and veins – jugular veins – carotid arteries – mesenteric arteries – anterior and posterior vena cava – pulmonary veins and arteries – hepatic vein – hepatic portal vein – renal arteries and veins – iliac arteries and veins – coronary arteries and veins – aorta ❑ describe and differentiate among the five types of blood vessels with reference to characteristics such as – structure and thickness of vessel walls – presence of valves – direction of blood flow (toward or away from the heart)

Prescribed Learning Outcomes	Suggested Achievement Indicators
Suborganizer 'Human Biology (Circulatory System)' PLO C5 continued from page 64	❑ differentiate between pulmonary and systemic circulation with respect to oxygenation or deoxygenation of blood in the vessels involved ❑ demonstrate a knowledge of the path of a blood cell from the aorta through the body and back to the left ventricle ❑ relate blood pressure and blood velocity to the total cross-sectional area of the five types of blood vessels ❑ describe capillary-tissue fluid exchange ❑ identify and describe differences in structure and circulation between fetal and adult systems, with reference to umbilical vein and arteries, oval opening, venous duct, arterial duct
C6 describe the components of blood	❑ describe the shape, function, and origin of red blood cells, white blood cells, and platelets ❑ list the major components of plasma ❑ explain the roles of antigens and antibodies
C7 describe the inter-relationships of the structures of the lymphatic system	❑ describe the functions of the lymphatic system ❑ identify and give functions of lymph capillaries, veins, and nodes

Key Elements: Human Biology (Respiratory System)

Estimated Time: 6–8 hours

By the end of this course, students will have an understanding of the structures and function of the respiratory system.

Vocabulary

alveoli, aortic bodies, bicarbonate ions, bronchi, bronchioles, carbaminohemoglobin, carbon dioxide, carbonic anhydrase, carotid bodies, cilia, diaphragm, exhalation, external respiration, hydrogen ions, inhalation, intercostal (rib) muscles, internal respiration, larynx, lungs, mucus, nasal cavity, oxygen, oxyhemoglobin, pH, pharynx, pleural membrane, reduced hemoglobin, respiratory centre in the medulla oblongata, respiratory tract, ribs, stretch receptors, thoracic cavity, trachea

Knowledge

- structures of the respiratory system and their inter-relationships
- processes of breathing
- internal and external respiration
- role of various substances in stimulating breathing

Skills and Attitudes

- interpret graphs, tables, and diagrams
- demonstrate safe and correct dissection technique
- demonstrate correct use of a compound microscope (e.g., slides showing cilia)
- demonstrate correct use of a dissection microscope (e.g., lung tissue)
- demonstrate proper technique for handling and disposing of laboratory materials
- create models (e.g., inhalation and exhalation, respiratory tract)
- conduct experiments (e.g., to measure vital capacity)
- communicate results (e.g., using tables, graphs, diagrams, lab reports)
- demonstrate ethical, responsible, co-operative behaviour
- show respect for living things

HUMAN BIOLOGY (RESPIRATORY SYSTEM)

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
C8 analyse the functional inter-relationships of the structures of the respiratory system	❑ identify and give functions for each of the following: – nasal cavity – pharynx – larynx – trachea – bronchi – bronchioles – alveoli – diaphragm and ribs – pleural membranes – thoracic cavity ❑ explain the roles of cilia and mucus in the respiratory tract ❑ explain the relationship between the structure and function of alveoli
C9 analyse the processes of breathing	❑ describe the interactions of the following structures in the breathing process: – respiratory centre in the medulla oblongata – lungs – pleural membranes – diaphragm – intercostal (rib) muscles – stretch receptors ❑ compare the processes of inhalation and exhalation ❑ explain the roles of carbon dioxide and hydrogen ions in stimulating the respiratory centre in the medulla oblongata ❑ explain the roles of oxygen, carbon dioxide, and hydrogen ions in stimulating carotid and aortic bodies
C10 analyse internal and external respiration	❑ describe the exchange of carbon dioxide and oxygen during internal and external respiration, including – location of exchange – conditions that favour exchange (e.g., pH, temperature) ❑ explain the roles of oxyhemoglobin, carbaminohemoglobin, reduced hemoglobin, bicarbonate ions, and carbonic anhydrase in the transport of carbon dioxide and oxygen in the blood ❑ write the chemical equations for internal and external respiration

Key Elements: Human Biology (Nervous System)

Estimated Time: 12–14 hours

By the end of this course, students will have an understanding of the structures and function of the nervous system.

Vocabulary

acetylcholine (ACh), acetylcholinesterase (AChE), action potential, adrenal medulla, adrenalin, "all-or-none" response, autonomic nervous system, axomembrane, axon, axoplasm, calcium ion, cell body, central nervous system, cerebellum, cerebrum, contractile protein, corpus callosum, dendrite, depolarization, effector, excitatory neurotransmitter, hypothalamus, impulse, inhibitory neurotransmitter, interneuron, medulla oblongata, meninges, motor neuron, myelin sheath, myelinated nerve fibre, neuroendocrine control centre, neuron, neurotransmitters, node of Ranvier, norepinephrine, parasympathetic division, peripheral nervous system, pituitary gland, polarity, postsynaptic membrane, potassium gate, presynaptic membrane, receptor, reflex arc, refractory period, repolarization, resting potential, saltatory transmission, Schwann cell, sensory neuron, sodium gate, sodium-potassium pump, somatic nervous system, sympathetic division, synapse, synaptic cleft, synaptic ending, synaptic vesicle, thalamus, threshold value

Knowledge

- transmission of nerve impulses
- components of a synapse
- impulse transmission across synapses
- structure and function of a reflex arc
- divisions of the nervous system and their inter-relationships
- functions of parts of the brain
- autonomic and somatic nervous systems; sympathetic and parasympathetic divisions

Skills and Attitudes

- interpret graphs, tables, and diagrams
- demonstrate safe and correct dissection technique
- demonstrate correct use of a compound microscope (e.g., nerve cells)
- demonstrate correct use of a dissection microscope (e.g., brain, spinal cord)
- demonstrate proper technique for handling and disposing of laboratory materials
- create models (e.g., reflex arc, nerve impulse transmission)
- communicate results (e.g., using tables, diagrams, lab reports)
- demonstrate ethical, responsible, co-operative behaviour
- show respect for living things

HUMAN BIOLOGY (NERVOUS SYSTEM)

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
C11 analyse the transmission of nerve impulses *Suborganizer 'Human Biology (Nervous System)' continued on page 70*	❑ identify and give functions for each of the following: dendrite, cell body, axon, axoplasm, and axomembrane ❑ differentiate among sensory, motor, and interneurons with respect to structure and function ❑ explain the transmission of a nerve impulse through a neuron, using the following terms: – resting and action potential – depolarization and repolarization – refractory period – sodium and potassium gates – sodium-potassium pump – threshold value – "all-or-none" response – polarity ❑ relate the structure of a myelinated nerve fibre to the speed of impulse conduction, with reference to myelin sheath, Schwann cell, node of Ranvier, and saltatory transmission ❑ identify the major components of a synapse, including – synaptic ending – presynaptic and postsynaptic membranes – synaptic cleft – synaptic vesicle – calcium ions and contractile proteins – excitatory and inhibitory neurotransmitters (e.g., norepinephrine, acetylcholine – ACh) – receptor – acetylcholinesterase (AChE) ❑ explain the process by which impulses travel across a synapse ❑ describe how neurotransmitters are broken down in the synaptic cleft ❑ describe the structure of a reflex arc (receptor, sensory neuron, interneuron, motor neuron, and effector) and relate its structure to how it functions

Prescribed Learning Outcomes	Suggested Achievement Indicators
Suborganizer 'Human Biology (Nervous System)' continued *from page 69* C12 analyse the functional inter-relationships of the divisions of the nervous system	❑ compare the locations and functions of the central and peripheral nervous systems ❑ identify and give functions for each of the following parts of the brain: – medulla oblongata – cerebrum – thalamus – cerebellum – hypothalamus – pituitary gland – corpus callosum – meninges ❑ explain how the hypothalamus and pituitary gland interact as the neuroendocrine control centre ❑ differentiate between the functions of the autonomic and somatic nervous systems ❑ describe the inter-related functions of the sympathetic and parasympathetic divisions of the autonomic nervous system, with reference to – effect on body functions including heart rate, breathing rate, pupil size, digestion – neurotransmitters involved – overall response ("fight or flight" or relaxed state) ❑ identify the source gland for adrenalin (adrenal medulla) and explain its role in the "fight or flight" response

Key Elements: Human Biology (Urinary System)

Estimated Time: 9–11 hours

By the end of this course, students will have an understanding of the structures and function of the urinary system.

Vocabulary

antidiuretic hormone (ADH), adrenal cortex, afferent and efferent arterioles, aldosterone, ammonia, Bowman's capsule, collecting duct, glomerulus, glucose, homeostasis, hypothalamus, kidney, loop of Henle, metabolic waste, nephron, nitrogenous waste, osmotic gradient, peritubular capillary network, pH, posterior pituitary, pressure filtration, proximal and distal convoluted tubules, reabsorption of water, renal artery, renal cortex, renal medulla, renal pelvis, renal vein, selective reabsorption, tubular excretion, urea, ureter, urethra, urinary bladder, urine

Knowledge

- structures of the urinary system and their inter-relationships
- components of the nephron
- urine production
- kidneys and blood pH
- homeostasis of water and sodium levels in the blood

Skills and Attitudes

- interpret graphs, tables, and diagrams
- demonstrate safe and correct dissection technique
- demonstrate correct use of a compound microscope (e.g., nephrons)
- demonstrate correct use of a dissection microscope (e.g., internal structure of the kidney)
- demonstrate proper technique for handling and disposing of laboratory materials
- create models (e.g., nephron)
- communicate results (e.g., using tables, diagrams, lab reports)
- demonstrate ethical, responsible, co-operative behaviour
- show respect for living things

HUMAN BIOLOGY (URINARY SYSTEM)

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
C13 analyse the functional inter-relationships of the structures of the urinary system	❑ identify and explain the functions of each of the following: – kidney – ureter – urethra – urinary bladder – renal cortex – renal medulla – renal pelvis – nephron ❑ identify and explain the functions of the following components of the nephron: – glomerulus – Bowman's capsule – afferent and efferent arterioles – peritubular capillary network – proximal and distal convoluted tubules – collecting duct – loop of Henle ❑ describe the production of urine with reference to the following terms: – pressure filtration – selective reabsorption – reabsorption of water following an osmotic gradient – tubular excretion – metabolic waste (e.g., nitrogenous waste, urea, ammonia) ❑ describe how the kidneys maintain blood pH ❑ compare urea and glucose content of blood in the renal artery with that of the renal vein ❑ identify the source glands for antidiuretic hormone (ADH) and aldosterone ❑ describe how the hypothalamus, posterior pituitary, ADH, and the nephron achieve homeostasis of water levels in the blood ❑ describe how the adrenal cortex, aldosterone, and the nephron achieve homeostasis of water and sodium levels in the blood

Key Elements: Human Biology (Reproductive System)

Estimated Time: 9–11 hours

By the end of this course, students will have an understanding of the structures and function of the male and female reproductive systems.

Vocabulary

acrosome, anterior pituitary, cervix, clitoris, corpus luteum, Cowper's glands, ductus (vas) deferens, endometrium, epididymis, estrogen, follicles, follicle-stimulating hormone (FSH), follicular phase, gonadotropin-releasing hormone (GnRH), head, homeostatic regulation, human chorionic gonadotropin (HCG), hypothalamus, implantation, interstitial cells, luteal phase, luteinizing hormone (LH), menstruation, midpiece, ovarian cycle, ovaries, oviducts (fallopian tubes), ovulation, oxytocin, penis, positive feedback mechanism, progesterone, proliferative phase, prostate gland, scrotum, secretory phase, seminal fluid, seminal vesicles, seminiferous tubules, sperm, tail (flagellum), testes, testosterone, urethra, urethral opening, uterine cycle, uterus, vagina

Knowledge

- functional structures of the male and female reproductive systems
- components of seminal fluid
- ovarian and uterine cycles
- production, regulation, and functions of male and female hormones

Skills and Attitudes

- interpret graphs, tables, and diagrams
- demonstrate safe and correct dissection technique
- demonstrate correct use of a compound microscope (e.g., to examine sperm)
- demonstrate proper technique for handling and disposing of laboratory materials
- communicate results (e.g., using tables, diagrams, lab reports)
- demonstrate ethical, responsible, co-operative behaviour
- show respect for living things

HUMAN BIOLOGY (REPRODUCTIVE SYSTEM)

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
C14 analyse the functional interrelationships of the structures of the male reproductive system	❑ identify and give functions for each of the following: – testes (seminiferous tubules and interstitial cells) – scrotum – epididymis – ductus (vas) deferens – prostate gland – Cowper's glands – seminal vesicles – penis – urethra ❑ describe the path of sperm from the seminiferous tubules to the urethral opening ❑ list the components seminal fluid (as contributed by the Cowper's glands, prostate gland, and seminal vesicles), and describe the functions of each component ❑ identify the tail (flagellum), midpiece, head, and acrosome of a mature sperm and state their functions ❑ describe the functions of testosterone ❑ describe the homeostatic regulation of testosterone levels by the hypothalamus, anterior pituitary, and testes
C15 analyse the functional interrelationships of the structures of the female reproductive system	❑ identify and give functions for each of the following: – ovaries (follicles and corpus luteum) – oviducts (fallopian tubes) – uterus – endometrium – cervix – vagina – clitoris ❑ describe the functions of estrogen ❑ describe the sequence of events in the ovarian cycle, with reference the follicular phase, ovulation, and the luteal phase ❑ describe the sequence of events in the uterine cycle, with reference to menstruation, the proliferative phase, and the secretory phase ❑ describe the control of the ovarian and uterine cycles by hormones including gonadotropin-releasing hormone (GnRH), follicle-stimulating hormone (FSH), luteinizing hormone (LH), estrogen, and progesterone ❑ describe the hormonal changes that occur as a result of implantation, including – production of human chorionic gonadotropin (HCG) to maintain the corpus luteum – increased production of progesterone by the corpus luteum ❑ describe a positive feedback mechanism involving oxytocin

Learning Resources

Biology 11 and 12

This section contains general information on learning resources, and provides a link to the titles, descriptions, and ordering information for the recommended learning resources in the Biology 11 and 12 Grade Collections.

What Are Recommended Learning Resources?
Recommended learning resources are resources that have undergone a provincial evaluation process using teacher evaluators and have Minister's Order granting them provincial recommended status. These resources may include print, video, software and CD-ROMs, games and manipulatives, and other multimedia formats. They are generally materials suitable for student use, but may also include information aimed primarily at teachers.

Information about the recommended resources is organized in the format of a Grade Collection. A Grade Collection can be regarded as a "starter set" of basic resources to deliver the curriculum. In many cases, the Grade Collection provides a choice of more than one resource to support curriculum organizers, enabling teachers to select resources that best suit different teaching and learning styles. Teachers may also wish to supplement Grade Collection resources with locally approved materials.

How Can Teachers Choose Learning Resources to Meet Their Classroom Needs?
Teachers must use either:

- provincially recommended resources OR
- resources that have been evaluated through a local, board-approved process

Prior to selecting and purchasing new learning resources, an inventory of resources that are already available should be established through consultation with the school and district resource centres. The ministry also works with school districts to negotiate cost-effective access to various learning resources.

What Are the Criteria Used to Evaluate Learning Resources?
The Ministry of Education facilitates the evaluation of learning resources that support BC curricula, and that will be used by teachers and/or students for instructional and assessment purposes. Evaluation criteria focus on content, instructional design, technical considerations, and social considerations.

Additional information concerning the review and selection of learning resources is available from the ministry publication, *Evaluating, Selecting and Managing Learning Resources: A Guide* (Revised 2002)
www.bced.gov.bc.ca/irp/resdocs/esm_guide.pdf

What Funding is Available for Purchasing Learning Resources?
As part of the selection process, teachers should be aware of school and district funding policies and procedures to determine how much money is available for their needs. Funding for various purposes, including the purchase of learning resources, is provided to school districts. Learning resource selection should be viewed as an ongoing process that requires a determination of needs, as well as long-term planning to co-ordinate individual goals and local priorities.

What Kinds of Resources Are Found in a Grade Collection?
The Grade Collection charts list the recommended learning resources by media format, showing links to the curriculum organizers and suborganizers. Each chart is followed by an annotated bibliography. Teachers should check with suppliers for complete and up-to-date ordering information. Most suppliers maintain web sites that are easy to access.

BIOLOGY 11 AND 12 GRADE COLLECTIONS

The Grade Collections for Biology 11 and 12 list the recommended learning resources for these courses. Resources previously recommended for the 1996 version of the curriculum, where still valid, continue to support this updated IRP. The ministry updates the Grade Collections on a regular basis as new resources are developed and evaluated.

Please check the following ministry web site for the most current list of recommended learning resources in the Biology 11 and 12 Grade Collections: www.bced.gov.bc.ca/irp_resources/lr/resource/gradcoll.htm

This document represents an updating of the 1995 IRP. This updating has been undertaken for the purpose of

- clarifying the Prescribed Learning Outcomes
- introducing Suggested Achievement Indicators
- addressing content overload

Resources previously recommended for the 1995 version of the curriculum, where still valid, continue to support this updated IRP. (See the Learning Resources section in this IRP for additional information.)

CHEMISTRY 11 AND 12

Integrated Resource Package 2006

BRITISH COLUMBIA
The Best Place on Earth

Ministry of Education

IRP 141

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Acknowledgments

This document has been updated from the 1995 IRP to include suggested achievement indicators, a more clear and succinct set of prescribed learning outcomes, a snapshot of the course's key elements, and other minor refinements, while maintaining the original intent and essence of the 1995 curricular content.

Many people contributed their expertise to the Chemistry 11-12 IRP. The Project Manager (2005-2006) was Mr. Waël Afifi of the Ministry of Education, working with other ministry personnel and our partners in education. We would like to thank all who participated in this process, including the teams of educators who developed the 1995 Chemistry 11-12 IRP, and the following individuals who contributed to the 2005-2006 updating of this document:

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Preface

This Integrated Resource Package (IRP) provides basic information teachers will require in order to implement Chemistry 11 and 12. This document supersedes the *Chemistry 11 and 12 Integrated Resource Package* (1995).

The information contained in this document is also available on the Internet at www.bced.gov.bc.ca/irp/irp.htm

The following paragraphs provide brief descriptions of the components of the IRP.

Introduction

The Introduction provides general information about Chemistry 11 and 12, including special features and requirements.

Included in this section are

- a rationale for teaching Chemistry 11 and 12 in BC schools
- information about graduation program requirements and provincial examinations
- listings of the curriculum organizers – groupings for prescribed learning outcomes that share a common focus
- suggested time allotments for each course

Considerations for Program Delivery

This section of the IRP contains additional information to help educators develop their school practices and plan their program delivery to meet the needs of all learners.

Prescribed Learning Outcomes

This section contains the *prescribed learning outcomes*, the legally required content standards for the provincial education system. The learning outcomes define the required knowledge, skills, and attitudes for each subject. They are statements of what students are expected to know and be able to do by the end of the course.

Student Achievement

This section of the IRP contains information about classroom assessment and measuring student achievement, including sets of specific achievement indicators for each prescribed learning outcome. Achievement indicators are statements that describe what students should be able to do in order to demonstrate that they fully meet the expectations set out by the prescribed learning outcomes. Achievement indicators are not mandatory; they are provided to assist in the assessment of how well students achieve the prescribed learning outcomes.

Also included in this section are key elements – descriptions of content that help determine the intended depth and breadth of the prescribed learning outcomes.

Learning Resources

This section contains general information on learning resources, and provides a link to titles, descriptions, and ordering information for the recommended learning resources in the Chemistry 11 and 12 Grade Collections.

INTRODUCTION

Chemistry 11 and 12

This Integrated Resource Package (IRP) sets out the provincially prescribed curriculum for Chemistry 11 and 12. The development of this IRP has been guided by the principles of learning:

- Learning requires the active participation of the student.
- People learn in a variety of ways and at different rates.
- Learning is both an individual and a group process.

In addition to these three principles, this document recognizes that British Columbia's schools include students of varied backgrounds, interests, abilities, and needs. Wherever appropriate for this curriculum, ways to meet these needs and to ensure equity and access for all learners have been integrated as much as possible into the learning outcomes and achievement indicators.

This document represents an updating of the 1995 IRP. This updating has been undertaken for the purpose of

- clarifying the prescribed learning outcomes
- introducing suggested achievement indicators
- addressing content overload

Resources previously recommended for the 1995 version of the curriculum continue to support this updated IRP. (See the Learning Resources section later in this IRP for additional information.)

Chemistry 11 and 12, in draft form, was available for public review and response from November to December, 2005. Feedback from educators, students, parents, and other educational partners informed the development of this updated IRP.

RATIONALE

The science curriculum of British Columbia provides a foundation for the scientific literacy of citizens, for the development of a highly skilled and adaptable work force, and for the development of new technologies. It is a foundation on which teachers can develop a science program that provides a comprehensive set of knowledge, skills, and experiences related to science.

School science programs that are planned to develop scientifically literate students provide experiences that

- help students become flexible and adaptable rather than focussing on acquiring specialized knowledge
- develop the capacity to think critically
- call for a wide range of knowledge, methods, and approaches that enable students to analyse personal and societal issues critically
- encourage students to examine the impact of scientific knowledge on their lives, society, and the environment
- develop a positive attitude toward science
- cultivate students' appreciation of the scientific endeavour and their potential to contribute to it

The science curriculum of British Columbia provides a framework of opportunities for students to become scientifically literate by

- examining basic concepts, principles, laws, and theories through scientific inquiry
- actively gaining knowledge, skills, and attitudes that provide the basis for sound and ethical problem solving and decision making
- developing an understanding of the place of science in society and history and its relationship to other disciplines
- making informed and responsible decisions about themselves, their homes, workplaces, and the global community

Chemistry is the science that deals with the properties and reactions of materials. It is concerned with the identification, characterization, and transformations of matter, and with the energy changes accompanying these transformations. As such, it makes an important contribution to our ability to

- comprehend the natural environment
- understand various other pure and applied sciences, as well as the nature of scientific inquiry

Through participation in co-operative labs, independent research, and other classroom experiences, students acquire knowledge, skills, and attitudes that enable them to pursue further study and experience success in the workplace as informed decision makers and full participants.

Introduction to Chemistry 11 and 12

Requirements and Graduation Credits

Chemistry 11 and 12 are two of the courses available for students to satisfy the Grade 11-12 Graduation Program science requirement.

Chemistry 11 and 12 are each designated as four-credit courses, and must be reported as such to the Ministry of Education for transcript purposes. Letter grades and percentages must be reported for these courses. It is not possible to obtain partial credit for these courses.

The course codes for Chemistry 11 and 12 are CH 11 and CH 12. These courses are also available in French (Chimie 11, Chimie 12; course codes CHF 11, CHF 12).

Graduation Program Examination

Chemistry 12 has an optional Graduation Program examination, worth 40% of the final course mark for students who choose to write it. Although students are not required to take this exam to receive credit for the course, they should be advised that some post-secondary institutions require Grade 12 exams to meet entrance requirements, and that writing Grade 12 exams also provides opportunities for provincial scholarships.

For more information, refer to the Ministry of Education examinations web site: www.bced.gov.bc.ca/exams/

Curriculum Organizers

A curriculum organizer consists of a set of prescribed learning outcomes that share a common focus. The prescribed learning outcomes for Chemistry 11 and 12 are grouped under the following curriculum organizers.

Note that the ordering of these organizers is not intended to imply an order of instruction.

Chemistry 11	Chemistry 12
• Skills and Processes of Chemistry • The Nature of Matter • Mole Concept • Chemical Reactions • Atomic Theory • Solution Chemistry • Organic Chemistry	• Reaction Kinetics • Dynamic Equilibrium • Solubility Equilibria • Nature of Acids and Bases • Acids and Bases: Quantitative Problem Solving • Applications of Acid-Base Reactions • Oxidation-Reduction • Applications of Redox Reactions

Suggested Timeframe

Provincial curricula are developed in accordance with the amount of instructional time recommended by the Ministry of Education for each subject area. Teachers may choose to combine various curricula to enable students to integrate ideas and make meaningful connections.

Chemistry 11 and 12 each require approximately 90–110 hours of instructional time. Although a four-credit course is typically equivalent to 120 hours, this timeframe allows for flexibility to address local needs. The Student Achievement section of this IRP provides a suggested breakdown of this suggested time allotment by curriculum organizer.

Considerations for Program Delivery

Chemistry 11 and 12

This section of the IRP contains additional information to help educators develop their school practices and plan their program delivery to meet the needs of all learners. Included in this section is information about

- Alternative Delivery policy
- addressing local contexts
- involving parents and guardians
- course requirements respecting beliefs
- safety considerations
- confidentiality
- inclusion, equity, and accessibility for all learners
- working with the school and community
- working with the Aboriginal community
- information and communications technology
- copyright and responsibility

Alternative Delivery Policy

The Alternative Delivery policy does not apply to Chemistry 11 and 12.

The Alternative Delivery policy outlines how students, and their parents or guardians, in consultation with their local school authority, may choose means other than instruction by a teacher within the regular classroom setting for addressing prescribed learning outcomes contained in the Health curriculum organizer of the following curriculum documents:

- Health and Career Education K to 7, and Personal Planning K to 7 Personal Development curriculum organizer (until September 2008)
- Health and Career Education 8 and 9
- Planning 10

The policy recognizes the family as the primary educator in the development of children's attitudes, standards, and values, but the policy still requires that all prescribed learning outcomes be addressed and assessed in the agreed-upon alternative manner of delivery.

It is important to note the significance of the term "alternative delivery" as it relates to the Alternative Delivery policy. The policy does not permit schools to omit addressing or assessing any of the prescribed learning outcomes within the health and career education curriculum. Neither does it allow students to be excused from meeting any learning outcomes related to health. It is expected that students who arrange for alternative delivery will address the health-related learning outcomes and will be able to demonstrate their understanding of these learning outcomes.

For more information about policy relating to alternative delivery, refer to www.bced.gov.bc.ca/policy/

Addressing Local Contexts

There is some flexibility in the Chemistry 11 and 12 curriculum, providing opportunities for individual teacher and student choice in the selection of topics to meet learning outcomes. This flexibility enables educators to plan their programs by using topics and examples that are relevant to their local context and to the particular interests of their students. When selecting topics it may be appropriate to incorporate student input.

Involving Parents and Guardians

The family is the primary educator in the development of students' attitudes and values. The school plays a supportive role by focussing on the prescribed learning outcomes in the Chemistry 11 and 12 curriculum. Parents and guardians can support, enrich, and extend the curriculum at home.

It is highly recommended that schools inform parents and guardians about the Chemistry 11 and 12 curriculum, and teachers (along with school and district administrators) may choose to do so by

- informing parents/guardians and students of the prescribed learning outcomes for the subject by sending home class letters, providing an overview during parent-teacher interviews, etc.
- responding to parent and guardian requests to discuss course unit plans, learning resources, etc.

Considerations for Program Delivery

Course Requirements Respecting Beliefs

For many students and teachers, the study of some science concepts may lead to issues and questions that go beyond the immediate scope of curriculum (e.g., science is used to meet many industrial requirements, but industrial decision makers must consider factors other than scientific feasibility before adopting a particular process). The technological application of science in areas such as genetic engineering, human reproduction, and medical technology raises questions of ethics and values. Because these social questions arise, in part, from capabilities that science makes possible, they should be addressed. It must be made clear to students, however, that science only provides the background for what is hoped will be informed personal and social decisions. Teachers must handle these questions objectively and with sensitivity.

Reconciling scientific discoveries (for example, in age dating) and religious faith poses a particular challenge for some students. While respecting the personal beliefs of students, teachers should be careful to distinguish between knowledge based on the application of scientific methods, and religious teachings and associated beliefs such as creationism, theory of divine creation, or intelligent design theory.

Safety Considerations

Science education is an activity-based process that provides an exciting method of teaching and learning. However, experiments and demonstrations may involve inherent risks for both the teacher and the student.

Safety guidelines must be discussed with students. These safety guidelines must support and encourage the investigative approach generally and laboratory instruction specifically, while at the same time promoting safety in the classroom and laboratory. Encouraging a positive safety attitude is a responsibility shared among the board, school administrators, teachers, and students in every school district. The co-operation of all these groups helps develop a strong safety consciousness both inside and outside our schools.

Field work and field trips require special vigilance with respect to traffic and road safety, safe practices in study areas and when obtaining samples, and an awareness of changes in weather.

Another important aspect of in-school safety is the Workplace Hazardous Materials Information Systems (WHMIS). Through labelling, material safety data sheets, and education and training, WHMIS is designed to ensure that those using hazardous materials have sufficient information to handle them safely. Each school district should have an individual trained in WHMIS who can work with teachers to establish safe, well-ventilated classroom and laboratory working conditions.

To assist teachers in providing a safe science-learning environment, the Ministry of Education publishes the *Science Safety Resource Manual*, which has been distributed to every school.

The *Science Safety Resource Manual* is available online at www.bced.gov.bc.ca/irp/resdocs/scisafety.htm

Confidentiality

The *Freedom of Information and Protection of Privacy Act* (FOIPPA) applies to students, to school districts, and to all curricula. Teachers, administrators, and district staff should consider the following:

- Be aware of district and school guidelines regarding the provisions of FOIPPA and how it applies to all subjects, including Chemistry 11 and 12.
- Do not use students' Personal Education Numbers (PEN) on any assignments that students wish to keep confidential.
- Ensure students are aware that if they disclose personal information that indicates they are at risk for harm, then that information cannot be kept confidential.
- Inform students of their rights under FOIPPA, especially the right to have access to their own personal information in their school records. Inform parents of their rights to access their children's school records.

- Minimize the type and amount of personal information collected, and ensure that it is used only for purposes that relate directly to the reason for which it is collected.
- Inform students that they will be the only ones recording personal information about themselves unless they, or their parents, have consented to teachers collecting that information from other people (including parents).
- Provide students and their parents with the reason(s) they are being asked to provide personal information in the context of the Chemistry 11 and 12 curriculum.
- Inform students and their parents that they can ask the school to correct or annotate any of the personal information held by the school, in accordance with Section 29 of FOIPPA.
- Ensure students are aware that their parents may have access to the schoolwork they create only insofar as it pertains to students' progress.
- Ensure that any information used in assessing students' progress is up-to-date, accurate, and complete.

For more information about confidentiality, refer to www.mser.gov.bc.ca/FOI_POP/index.htm

Inclusion, Equity, and Accessibility for All Learners

British Columbia's schools include students of varied backgrounds, interests, and abilities. The Kindergarten to Grade 12 school system focusses on meeting the needs of all students. When selecting specific topics, activities, and resources to support the implementation of Chemistry 11 and 12, teachers are encouraged to ensure that these choices support inclusion, equity, and accessibility for all students. In particular, teachers should ensure that classroom instruction, assessment, and resources reflect sensitivity to diversity and incorporate positive role portrayals, relevant issues, and themes such as inclusion, respect, and acceptance.

Government policy supports the principles of integration and inclusion of students for whom English is a second language and of students with special needs. Most of the prescribed learning outcomes and suggested achievement indicators in this IRP can be met by all students, including those with special needs and/or ESL needs. Some strategies may require adaptations to ensure that those with special and/or ESL needs can successfully achieve the learning outcomes. Where necessary, modifications can be made to the prescribed learning outcomes for students with Individual Education Plans.

For more information about resources and support for students with special needs, refer to www.bced.gov.bc.ca/specialed/

For more information about resources and support for ESL students, refer to www.bced.gov.bc.ca/esl/

Working with the School and Community

This curriculum addresses a wide range of skills and understandings that students are developing in other areas of their lives. It is important to recognize that learning related to this curriculum extends beyond the science classroom.

School and district-wide programs support and extend learning in Biology 11 and 12. Community organizations may also support the curriculum with locally developed learning resources, guest speakers, workshops, and field studies. Teachers may wish to draw on the expertise of these community organizations and members.

Working with the Aboriginal Community

The Ministry of Education is dedicated to ensuring that the cultures and contributions of Aboriginal peoples in BC are reflected in all provincial curricula. To address these topics in the classroom in a way that is accurate and that respectfully reflects Aboriginal concepts of teaching and learning, teachers are strongly encouraged to seek the advice and support of local Aboriginal communities. Aboriginal communities are diverse in terms of language, culture, and available resources, and each community will have its own unique protocol to gain support for integration of local knowledge and expertise. To begin discussion

of possible instructional and assessment activities, teachers should first contact Aboriginal education co-ordinators, teachers, support workers, and counsellors in their district who will be able to facilitate the identification of local resources and contacts such as elders, chiefs, tribal or band councils, Aboriginal cultural centres, Aboriginal Friendship Centres, and Métis or Inuit organizations.

In addition, teachers may wish to consult the various Ministry of Education publications available, including the "Planning Your Program" section of the resource, *Shared Learnings*. This resource was developed to help all teachers provide students with knowledge of, and opportunities to share experiences with, Aboriginal peoples in BC.

For more information about these documents, consult the Aboriginal Education web site: www.bced.gov.bc.ca/abed/welcome.htm

Information and Communications Technology

The study of information and communications technology is increasingly important in our society. Students need to be able to acquire and analyse information, to reason and communicate, to make informed decisions, and to understand and use information and communications technology for a variety of purposes. Development of these skills is important for students in their education, their future careers, and their everyday lives.

Literacy in the area of information and communications technology can be defined as the ability to obtain and share knowledge through investigation, study, instruction, or transmission of information by means of media technology. Becoming literate in this area involves finding, gathering, assessing, and communicating information using electronic means, as well as developing the knowledge and skills to use and solve problems effectively with the technology. Literacy also involves a critical examination and understanding of the ethical and social issues related to the use of information and communications technology. When planning for instruction and assessment in Chemistry 11 and 12, teachers should provide opportunities for students to develop literacy in relation to information and communications technology sources, and to reflect critically on the role of these technologies in society.

Copyright and Responsibility

Copyright is the legal protection of literary, dramatic, artistic, and musical works; sound recordings; performances; and communications signals. Copyright provides creators with the legal right to be paid for their work and the right to say how their work is to be used. The law permits certain exceptions for schools (i.e., specific things permitted) but these are very limited, such as copying for private study or research. The copyright law determines how resources can be used in the classroom and by students at home.

In order to respect copyright it is necessary to understand the law. It is unlawful to do the following, unless permission has been given by a copyright owner:

- photocopy copyrighted material to avoid purchasing the original resource for any reason
- photocopy or perform copyrighted material beyond a very small part – in some cases the copyright law considers it "fair" to copy whole works, such as an article in a journal or a photograph, for purposes of research and private study, criticism, and review
- show recorded television or radio programs to students in the classroom unless these are cleared for copyright for educational use (there are exceptions such as for news and news commentary taped within one year of broadcast that by law have record-keeping requirements – see the web site at the end of this section for more details)
- photocopy print music, workbooks, instructional materials, instruction manuals, teacher guides, and commercially available tests and examinations
- show videorecordings at schools that are not cleared for public performance
- perform music or do performances of copyrighted material for entertainment (i.e., for purposes other than a specific educational objective)

- copy work from the Internet without an express message that the work can be copied

Permission from or on behalf of the copyright owner must be given in writing. Permission may also be given to copy or use all or some portion of copyrighted work through a licence or agreement. Many creators, publishers, and producers have formed groups or "collectives" to negotiate royalty payments and copying conditions for educational institutions. It is important to know what licences are in place and how these affect the activities schools are involved in. Some licences may also require royalty payments that are determined by the quantity of photocopying or the length of performances. In these cases, it is important to assess the educational value and merits of copying or performing certain works to protect the school's financial exposure (i.e., only copy or use that portion that is absolutely necessary to meet an educational objective).

It is important for education professionals, parents, and students to respect the value of original thinking and the importance of not plagiarizing the work of others. The works of others should not be used without their permission.

For more information about copyright, refer to www.cmec.ca/copyright/indexe.stm

Prescribed Learning Outcomes

Chemistry 11 and 12

Prescribed learning outcomes are content standards for the provincial education system; they are the prescribed curriculum. Clearly stated and expressed in measurable and observable terms, learning outcomes set out the required knowledge, skills, and attitudes – what students are expected to know and be able to do – by the end of the specified course.

Schools have the responsibility to ensure that all prescribed learning outcomes in this curriculum are met; however, schools have flexibility in determining how delivery of the curriculum can best take place.

It is expected that student achievement will vary in relation to the learning outcomes. Evaluation, reporting, and student placement with respect to these outcomes are dependent on the professional judgment and experience of teachers, guided by provincial policy.

Prescribed learning outcomes for Chemistry 11 and 12 are presented by grade and by curriculum organizer, and are coded alphanumerically for ease of reference; however, this arrangement is not intended to imply a required instructional sequence.

WORDING OF PRESCRIBED LEARNING OUTCOMES

All learning outcomes complete the stem, "It is expected that students will…."

When used in a prescribed learning outcome, the word "**including**" indicates that any ensuing item **must be addressed**. Lists of items introduced by the word "including" represent a set of minimum requirements associated with the general requirement set out by the outcome. The lists are not necessarily exhaustive, however, and teachers may choose to address additional items that also fall under the general requirement set out by the outcome.

DOMAINS OF LEARNING

Prescribed learning outcomes in BC curricula identify required learning in relation to one or more of the three domains of learning: cognitive, psychomotor, and affective. The following definitions of the three domains are based on Bloom's taxonomy.

The **cognitive domain** deals with the recall or recognition of knowledge and the development of intellectual abilities. The cognitive domain can be further specified as including three cognitive levels: knowledge, understanding and application, and higher mental processes. These levels are determined by the verb used in the learning outcome, and illustrate how student learning develops over time.

- *Knowledge* includes those behaviours that emphasize the recognition or recall of ideas, material, or phenomena.
- *Understanding and application* represents a comprehension of the literal message contained in a communication, and the ability to apply an appropriate theory, principle, idea, or method to a new situation.
- *Higher mental processes* include analysis, synthesis, and evaluation. The higher mental processes level subsumes both the knowledge and the understanding and application levels.

The **affective domain** concerns attitudes, beliefs, and the spectrum of values and value systems.

The **psychomotor domain** includes those aspects of learning associated with movement and skill demonstration, and integrates the cognitive and affective consequences with physical performances.

Domains of learning and, particularly, cognitive levels, inform the design and development of the Graduation Program examination for Chemistry 12.

Prescribed Learning Outcomes

Prescribed Learning Outcomes: Chemistry 11

It is expected that students will:

Skills and Processes of Chemistry

A1 demonstrate appropriate safety techniques and proper use of protective equipment
A2 demonstrate skills in measuring and in recording data
A3 communicate results and data in clear and understandable forms

The Nature of Matter

B1 relate the observable properties and characteristics of elements, compounds, and mixtures to the concept of atoms and molecules
B2 write the names and formulae for ionic and covalent compounds, given appropriate charts or data tables
B3 describe the characteristics of matter
B4 differentiate between physical and chemical changes
B5 select an appropriate way of separating the components of a mixture

Mole Concept

C1 explain the significance and use of the mole
C2 perform calculations involving the mole
C3 determine relationships between molar quantities of gases at STP
C4 perform calculations involving molecular and empirical formulae to identify a substance
C5 describe concentration in terms of molarity
C6 perform calculations involving molarity

Chemical Reactions

D1 explain chemical reactions in terms of the rearrangement of the atoms as bonds are broken and new bonds are formed
D2 apply the law of conservation of mass to balance formula equations
D3 devise balanced equations for various chemical reactions
D4 describe reactions in terms of energy changes
D5 perform stoichiometric calculations involving chemical reactions

Prescribed Learning Outcomes: Chemistry 11

ATOMIC THEORY

- E1 describe the development of the model of the atom
- E2 describe the sub-atomic structures of atoms, ions, and isotopes, using calculation where appropriate
- E3 describe the development of the modern periodic table
- E4 draw conclusions about the similarities and trends in the properties of elements, with reference to the periodic table
- E5 justify chemical and physical properties in terms of electron population
- E6 demonstrate knowledge of various types of chemical bonding
- E7 apply understanding of bonding to create formulae and Lewis structures

SOLUTION CHEMISTRY

- F1 distinguish between a solution and a pure substance
- F2 predict the relative solubility of a solute in a solvent, based on its polarity
- F3 relate ion formation to electrical conductivity in aqueous solutions
- F4 calculate the concentration of ions in solution

ORGANIC CHEMISTRY

- G1 describe characteristic features and common applications of organic chemistry
- G2 demonstrate knowledge of the various ways that carbon and hydrogen can combine to form a wide range of compounds
- G3 generate names and structures for simple organic compounds
- G4 differentiate the various types of bonding between carbon atoms
- G5 identify common functional groups
- G6 perform a simple organic preparation

Prescribed Learning Outcomes

Prescribed Learning Outcomes: Chemistry 12

It is expected that students will:

Reaction Kinetics

A1 demonstrate awareness that reactions occur at differing rates
A2 experimentally determine rate of a reaction
A3 demonstrate knowledge of collision theory
A4 describe the energies associated with reactants becoming products
A5 apply collision theory to explain how reaction rates can be changed
A6 analyse the reaction mechanism for a reacting system
A7 represent graphically the energy changes associated with catalyzed and uncatalyzed reactions
A8 describe the uses of specific catalysts in a variety of situations

Dynamic Equilibrium

B1 explain the concept of chemical equilibrium with reference to reacting systems
B2 predict, with reference to entropy and enthalpy, whether reacting systems will reach equilibrium
B3 apply Le Châtelier's principle to the shifting of equilibrium
B4 apply the concept of equilibrium to a commercial or industrial process
B5 draw conclusions from the equilibrium constant expression
B6 perform calculations to evaluate the changes in the value of K_{eq} and in concentrations of substances within an equilibrium system

Solubility Equilibria

C1 determine the solubility of a compound in aqueous solution
C2 describe a saturated solution as an equilibrium system
C3 determine the concentration of ions in a solution
C4 determine the relative solubility of a substance, given solubility tables
C5 apply solubility rules to analyse the composition of solutions
C6 formulate equilibrium constant expressions for various saturated solutions
C7 perform calculations involving solubility equilibrium concepts
C8 devise a method for determining the concentration of a specific ion

Nature of Acid and Bases

D1 identify acids and bases through experimentation
D2 identify various models for representing acids and bases
D3 analyse balanced equations representing the reaction of acids or bases with water
D4 classify an acid or base in solution as either weak or strong, with reference to its electrical conductivity
D5 analyse the equilibria that exist in weak acid or weak base systems
D6 identify chemical species that are amphiprotic

Prescribed Learning Outcomes: Chemistry 12

ACIDS AND BASES: QUANTITATIVE PROBLEM SOLVING

E1 analyse the equilibrium that exists in water
E2 perform calculations relating pH, pOH, $[H_3O^+]$, and $[OH^-]$
E3 explain the significance of the K_a and K_b equilibrium expressions
E4 perform calculations involving K_a and K_b

APPLICATIONS OF ACID-BASE REACTIONS

F1 demonstrate an ability to design, perform, and analyse a titration experiment involving the following:
- primary standards
- standardized solutions
- titration curves
- appropriate indicators

F2 describe an indicator as an equilibrium system
F3 perform and interpret calculations involving the pH in a solution and K_a for an indicator
F4 describe the hydrolysis of ions in salt solutions
F5 analyse the extent of hydrolysis in salt solutions
F6 describe buffers as equilibrium systems
F7 describe the preparation of buffer systems
F8 predict what will happen when oxides dissolve in rain water

OXIDATION-REDUCTION

G1 describe oxidation and reduction processes
G2 analyse the relative strengths of reducing and oxidizing agents
G3 balance equations for redox reactions
G4 determine the concentration of a species by performing a redox titration

APPLICATIONS OF REDOX REACTIONS

H1 analyse an electrochemical cell in terms of its components and their functions
H2 describe how electrochemical concepts can be used in various practical applications
H3 analyse the process of metal corrosion in electrochemical terms
H4 analyse an electrolytic cell in terms of its components and their functions
H5 describe how electrolytic concepts can be used in various practical applications

Student Achievement

Chemistry 11 and 12

This section of the IRP contains information about classroom assessment and student achievement, including specific achievement indicators to assist in the assessment of student achievement in relation to each prescribed learning outcome. Also included in this section are key elements – descriptions of content that help determine the intended depth and breadth of prescribed learning outcomes.

CLASSROOM ASSESSMENT AND EVALUATION

Assessment is the systematic gathering of information about what students know, are able to do, and are working toward. Assessment evidence can be collected using a wide variety of methods, such as

- observation
- student self-assessments and peer assessments
- quizzes and tests (written, oral, practical)
- samples of student work
- projects and presentations
- oral and written reports
- journals and learning logs
- performance reviews
- portfolio assessments

Assessment of student performance is based on the information collected through assessment activities. Teachers use their insight, knowledge about learning, and experience with students, along with the specific criteria they establish, to make judgments about student performance in relation to prescribed learning outcomes.

Three major types of assessment can be used in conjunction to support student achievement.

- Assessment **for** learning is assessment for purposes of greater learning achievement.
- Assessment **as** learning is assessment as a process of developing and supporting students' active participation in their own learning.
- Assessment **of** learning is assessment for purposes of providing evidence of achievement for reporting.

Assessment for Learning

Classroom assessment for learning provides ways to engage and encourage students to become involved in their own day-to-day assessment – to acquire the skills of thoughtful self-assessment and to promote their own achievement.

This type of assessment serves to answer the following questions:

- What do students need to learn to be successful?
- What does the evidence of this learning look like?

Assessment for learning is criterion-referenced, in which a student's achievement is compared to established criteria rather than to the performance of other students. Criteria are based on prescribed learning outcomes, as well as on suggested achievement indicators or other learning expectations.

Students benefit most when assessment feedback is provided on a regular, ongoing basis. When assessment is seen as an opportunity to promote learning rather than as a final judgment, it shows students their strengths and suggests how they can develop further. Students can use this information to redirect their efforts, make plans, communicate with others (e.g., peers, teachers, parents) about their growth, and set future learning goals.

Assessment for learning also provides an opportunity for teachers to review what their students are learning and what areas need further attention. This information can be used to inform teaching and create a direct link between assessment and instruction. Using assessment as a way of obtaining feedback on instruction supports student achievement by informing teacher planning and classroom practice.

Student Achievement

Assessment as Learning

Assessment as learning actively involves students in their own learning processes. With support and guidance from their teacher, students take responsibility for their own learning, constructing meaning for themselves. Through a process of continuous self-assessment, students develop the ability to take stock of what they have already learned, determine what they have not yet learned, and decide how they can best improve their own achievement.

Although assessment as learning is student-driven, teachers can play a key role in facilitating how this assessment takes place. By providing regular opportunities for reflection and self-assessment, teachers can help students develop, practise, and become comfortable with critical analysis of their own learning.

Assessment of Learning

Assessment of learning can be addressed through summative assessment, including large-scale assessments and teacher assessments. These summative assessments can occur at the end of the year or at periodic stages in the instructional process.

Large-scale assessments, such as Foundation Skills Assessment (FSA) and Graduation Program exams, gather information on student performance throughout the province and provide information for the development and revision of curriculum. These assessments are used to make judgments about students' achievement in relation to provincial and national standards. There is no large-scale provincial assessment for Chemistry 11. The large-scale provincial assessment for Chemistry 12 is the optional graduation program examination, worth 40% of the final course mark for students who choose to write it.

Assessment of learning is also used to inform formal reporting of student achievement.

For Ministry of Education reporting policy, refer to www.bced.gov.bc.ca/policy/policies/student_reporting.htm

Assessment *for* Learning	Assessment *as* Learning	Assessment *of* Learning
Formative assessment is ***ongoing in the classroom***	**Formative assessment is** ***ongoing in the classroom***	**Summative assessment occurs** ***at end of year or at key stages***
• teacher assessment, student self-assessment, and/or student peer assessment • criterion-referenced – criteria based on prescribed learning outcomes identified in the provincial curriculum, reflecting performance in relation to a specific learning task • involves both teacher and student in a process of continual reflection and review about progress • teachers adjust their plans and engage in corrective teaching in response to formative assessment	• self-assessment • provides students with information on their own achievement and prompts them to consider how they can continue to improve their learning • student-determined criteria based on previous learning and personal learning goals • students use assessment information to make adaptations to their learning process and to develop new understandings	• teacher assessment • may be either criterion-referenced (based on prescribed learning outcomes) or norm-referenced (comparing student achievement to that of others) • information on student performance can be shared with parents/guardians, school and district staff, and other education professionals (e.g., for the purposes of curriculum development) • used to make judgments about students' performance in relation to provincial standards

For more information about assessment for, as, and of learning, refer to the following resource developed by the Western and Northern Canadian Protocol (WNCP): *Rethinking Assessment with Purpose in Mind.*

This resource is available online at www.wncp.ca/

Criterion-Referenced Assessment and Evaluation

In criterion-referenced evaluation, a student's performance is compared to established criteria rather than to the performance of other students. Evaluation in relation to prescribed curriculum requires that criteria be established based on the learning outcomes.

Criteria are the basis for evaluating student progress. They identify, in specific terms, the critical aspects of a performance or a product that indicate how well the student is meeting the prescribed learning outcomes. For example, weighted criteria, rating scales, or scoring guides (reference sets) are ways that student performance can be evaluated using criteria.

Wherever possible, students should be involved in setting the assessment criteria. This helps students develop an understanding of what high-quality work or performance looks like.

Criterion-referenced assessment and evaluation may involve these steps:

Step 1	Identify the prescribed learning outcomes and suggested achievement indicators (as articulated in this IRP) that will be used as the basis for assessment.
Step 2	Establish criteria. When appropriate, involve students in establishing criteria.
Step 3	Plan learning activities that will help students gain the knowledge, skills, and attitudes outlined in the criteria.
Step 4	Prior to the learning activity, inform students of the criteria against which their work will be evaluated.
Step 5	Provide examples of the desired levels of performance.
Step 6	Conduct the learning activities.
Step 7	Use appropriate assessment instruments (e.g., rating scale, checklist, scoring guide) and methods (e.g., observation, collection, self-assessment) based on the particular assignment and student.
Step 8	Review the assessment data and evaluate each student's level of performance or quality of work in relation to criteria.
Step 9	Where appropriate, provide feedback and/or a letter grade to indicate how well the criteria are met.
Step 10	Communicate the results of the assessment and evaluation to students and parents/guardians.

Student Achievement

Key Elements

Key elements provide an overview of content in each curriculum organizer. They can be used to determine the expected depth and breadth of the prescribed learning outcomes.

Achievement Indicators

To support the assessment of provincially prescribed curricula, this IRP includes sets of achievement indicators in relation to each learning outcome.

Achievement indicators, taken together as a set, define the specific level of knowledge acquired, skills applied, or attitudes demonstrated by the student in relation to a corresponding prescribed learning outcome. They describe what evidence to look for to determine whether or not the student has fully met the intent of the learning outcome. Since each achievement indicator defines only one aspect of the corresponding learning outcome, the entire set of achievement indicators should be considered when determining whether students have fully met the learning outcome.

In some cases, achievement indicators may also include suggestions as to the type of task that would provide evidence of having met the learning outcome (e.g., a constructed response such as a list, comparison, analysis, or chart; a product created and presented such as a report, drama presentation, poster, letter, or model; a particular skill demonstrated such as interpreting graphs).

Achievement indicators support the principles of assessment *for* learning, assessment *as* learning, and assessment *of* learning. They provide teachers and parents with tools that can be used to reflect on what students are learning, as well as provide students with a means of self-assessment and ways of defining how they can improve their own achievement.

Achievement indicators are not mandatory; they are suggestions only, provided to assist in the assessment of how well students achieve the prescribed learning outcomes.

Achievement indicators may be useful to provincial examination development teams and inform the development of exam items. However, examination questions, item formats, exemplars, rubrics, or scoring guides will not necessarily be limited to the achievement indicators as outlined in the Integrated Resource Packages.

Specifications for provincial examinations are available online at www.bced.gov.bc.ca/exams/specs/

The following pages contain the suggested achievement indicators corresponding to each prescribed learning outcome for the Chemistry 11 and 12 curriculum. The achievement indicators are arranged by curriculum organizer and suborganizer for each grade; however, this order is not intended to imply a required sequence of instruction and assessment.

STUDENT ACHIEVEMENT

Chemistry 11

Key Elements: Skills and Processes of Chemistry

Estimated Time: 5–6 hours

By the end of this course, students will be able to make observations in a safe and systematic manner and will collect and record data according to standard scientific technique, with special attention to significant figures and uncertainty.

Vocabulary

accuracy, analysis, interpretation, observation, precision, SI unit, significant figures, unit

Knowledge

- safety and protective equipment available in the laboratory
- common chemistry laboratory hazards
- SI units and their accepted alternatives in chemistry
- significant figures

Skills and Attitudes

- following safety procedures
- data manipulation when performing analyses and calculations
- distinguishing between observation and interpretation
- connecting objectives and conclusions
- interpreting tables
- observing, recording data from, and analysing chemical reactions

SKILLS AND PROCESSES OF CHEMISTRY

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
A1 demonstrate appropriate safety techniques and proper use of protective equipment	❑ identify the safety and protective equipment available in the laboratory and describe how and when to use each piece of equipment ❑ indicate on a school map the location of the nearest fire alarm and appropriate fire exits ❑ list sources of first-aid assistance other than the classroom teacher ❑ describe common chemistry laboratory hazards and the appropriate procedure or technique for dealing with each ❑ produce a list of general rules of safe laboratory conduct ❑ perform laboratory experiments in a safe manner
A2 demonstrate skills in measuring and in recording data	❑ use SI units and their accepted alternatives in chemistry ❑ recognize the imprecise nature of all measurements ❑ determine the number of significant figures in a measured quantity and relate to its uncertainty ❑ round off calculated results to the appropriate number of significant figures ❑ correctly determine the unit of a derived quantity (unit analysis)
A3 communicate results and data in clear and understandable forms	❑ produce lab reports in required formats ❑ draw appropriate connections between objectives and conclusions ❑ manipulate data correctly when performing analyses and calculations ❑ distinguish between observation and interpretation in the presentation of results

Key Elements: The Nature of Matter

Estimated Time: 9–13 hours

By the end of this course, students will be able to perform simple mixture separations and analyse data to distinguish and identify elements, compounds, and mixtures based on their chemical and physical properties.

Vocabulary

acid, atom, base, boiling point, chemical change, chemical property, chemical reactivity, chromatography, compound, distillation, element, evaporation, filtration, freezing point, gas, ion charge, ion/ionic, kinetic molecular theory, liquid, mass, matter, melting point, metal, mixture, molecular formula, molecule, monatomic ions, non-metal, physical change, physical property, pure substance, salt, solid

Knowledge

- characteristics of matter
- the naming system and correlation of chemical names and formulae
- physical and chemical changes of matter

Skills and Attitudes

- following safety procedures
- data manipulation when performing analyses and calculations
- distinguishing between observation and interpretation
- connecting objectives and conclusions
- interpreting tables (periodic table and table of common ions)
- classifying matter (elements into families; elements and compounds; pure substances and mixtures)
- naming compounds and writing formulae for compounds (organic and inorganic)
- separating components of a mixture (e.g., physical methods: chromatographic separation, distillation; chemical methods: reactivity with acids)
- observing, recording data from, and analysing chemical reactions

THE NATURE OF MATTER

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
B1 relate the observable properties and characteristics of elements, compounds, and mixtures to the concept of atoms and molecules	❑ classify a given material as an element, compound, or mixture, using the properties of the material ❑ describe a pure substance as having a set of unique and identifiable properties ❑ differentiate between atoms, molecules, and ions
B2 write the names and formulae for ionic and covalent compounds, given appropriate charts or data tables	❑ derive a chemical name, given a formula, periodic table, and table of common ions ❑ derive a formula (or symbol), given a chemical name, periodic table, and table of common ions ❑ name and write formulae for some common acids and bases ❑ use the prefix naming system for covalent compounds
B3 describe the characteristics of matter	❑ describe chemistry as the science concerned with the properties, composition, and behaviour of matter ❑ classify a substance as solid, liquid, or gas, and describe its different properties ❑ define the terms, matter, boiling point, freezing point, and melting point ❑ state the kinetic molecular theory ❑ describe the simple molecular motions and arrangements of particles in solids, liquids, and gases
B4 differentiate between physical and chemical changes	❑ describe the types of changes that may be observed when matter is heated, cooled, combined, or separated ❑ relate the heat changes that occur during phase changes to changes in molecular motions and arrangements
B5 select an appropriate way of separating the components of a mixture	❑ use various mechanical means to separate components of a mixture, including filtration, evaporation, chromatography, and distillation ❑ relate the method of separation to the properties of the mixture's components

Key Elements: Mole Concept

Estimated Time: 14–17 hours

By the end of this course, students will be able to relate the concept of the mole to the quantitative properties of matter.

Vocabulary

empirical formula, molarity, molar mass, molar solution, molar volume, mole, molecular formula, molecular mass, percentage composition, relative atomic mass, standard solution, stoichiometry, STP

Knowledge

- significance and use of the mole
- law of conservation of mass
- Avogadro's hypothesis

Skills and Attitudes

- following safety procedures
- data manipulation when performing analyses and calculations
- connecting objectives and conclusions
- interpreting tables (periodic table and table of common ions)
- naming compounds and writing formulae for compounds (organic and inorganic)
- performing calculations
  - involving moles, molarity, empirical and molecular formulae
  - involving stoichiometry
  - involving percent composition
- observing, recording data from, and analysing chemical reactions (e.g., formula of a hydrate, iron nail in copper (II) sulphate)

MOLE CONCEPT

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
C1 explain the significance and use of the mole	❑ recognize the significance of relative atomic mass, with reference to the periodic table ❑ identify the mole as the unit for counting atoms, molecules, or ions
C2 perform calculations involving the mole	❑ convert among the numbers of particles, moles, and mass ❑ determine the molar mass of an element or compound
C3 determine relationships between molar quantities of gases at STP	❑ define STP and state the molar volume of a gas at STP (i.e., 22.4 L/mol) ❑ determine experimentally the molar volume of a gas at room temperature and pressure ❑ calculate the moles or mass of a gas from a given volume at STP or vice versa
C4 perform calculations involving molecular and empirical formulae to identify a substance	❑ distinguish between empirical and molecular formulae ❑ determine the percent composition by mass from the formula of a compound ❑ determine the empirical formula for the compound from the percent composition by mass ❑ determine a molecular formula from the molecular mass and empirical formula
C5 describe concentration in terms of molarity	❑ express molarity using mol/L or M ❑ prepare a solution of known molarity (standard solution)
C6 perform calculations involving molarity	❑ perform calculations relating mass (or moles) of solute, volume of solution, and molarity ❑ calculate the resulting concentration when a given volume of a standard solution is diluted with water

Key Elements: Chemical Reactions

Estimated Time: 20–22 hours

By the end of this course, students will be able to explain changes to matter that occur in chemical reacting systems, use the mole ratio from balanced equations to calculate quantities of materials produced and consumed, and describe energy changes that occur during a physical or chemical change.

Vocabulary

acid-base neutralization, chemical reactivity, coefficients, combustion, decomposition, double replacement, endothermic, exothermic, formula equation, limiting reagent, precipitate, products, reactants, single replacement, stoichiometry, synthesis, thermochemical equation

Knowledge

- types of chemical reactions
- energy changes in reacting systems
- stoichiometry (percent composition, limiting and excess reactants)

Skills and Attitudes

- following safety procedures
- data manipulation when performing analyses and calculations
- connecting objectives and conclusions
- interpreting tables (periodic table and table of common ions)
- classifying types of compounds (e.g., carbonates, sulphates, acids, bases)
- naming compounds and writing formulae for compounds (organic and inorganic)
- performing calculations
  - involving moles, molarity, mass, and gas volumes at STP
  - involving stoichiometry (limiting and excess reactants)
- observing, recording data from, and analysing chemical reactions (synthesis, decomposition, single and double replacement, neutralization, combustion)
- balancing equations

CHEMICAL REACTIONS

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
D1 explain chemical reactions in terms of the rearrangement of the atoms as bonds are broken and new bonds are formed	❑ define reactants and products ❑ observe and record changes that occur during a chemical reaction
D2 apply the law of conservation of mass to balance formula equations	❑ gather experimental data that lead to the law of conservation of mass ❑ balance formula equations for chemical reactions ❑ use abbreviations (s, l, g, aq) to represent solids, liquids, gases, and aqueous solutions
D3 devise balanced equations for various chemical reactions	❑ classify, predict products, and write balanced equations for the following types of chemical reactions: – synthesis – decomposition – single replacement – double replacement – combustion – acid-base neutralization
D4 describe reactions in terms of energy changes	❑ define exothermic and endothermic reactions ❑ classify reactions as exothermic or endothermic based on experimental observations ❑ relate energy changes to bond breaking and forming ❑ write equations for chemical reactions including the energy term (thermochemical equations)
D5 perform stoichiometric calculations involving chemical reactions	❑ state Avogadro's hypothesis ❑ relate the coefficients in a balanced equation to the relative number of molecules or moles (the mole ratio) of reactants and products in the chemical reaction ❑ perform calculations involving reactions using any of the following: – number of molecules – moles – mass – gas volume at STP – solution concentration and volume (e.g., titration) ❑ perform calculations involving a limiting reagent

Key Elements: Atomic Theory

Estimated Time: 14–17 hours

By the end of this course, students will be able to relate the structure of the atom and the use of the periodic table to observed behaviours and trends in properties of various elements and will explain the significance of covalent and ionic bond types for simple compounds.

Vocabulary

alkali metals, alkaline earth metals, atom, atomic mass, atomic number, atomic radius, Bohr model, covalent bonding, electrical conductivity, electron, electron dot diagram, halogens, ionic bonding, ionization energy, isotope, Lewis structure, melting point, metal, metalloid, mole, neutron, noble gases, non-metal, particle charge, polarity, proton, relative atomic mass, transition metals, valence electrons

Knowledge

- atomic theory, structure, and periodicity
- electron arrangement for the first 20 elements (significance of spectral data)
- similarities and trends in the properties of elements
- types of chemical bonding
- the relationship between bonding, formulae, and Lewis structures

Skills and Attitudes

- interpreting tables (periodic table and table of common ions)
- classifying matter (isotopes, chemical families)
- observing (spectra of various elements)

ATOMIC THEORY

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
E1 describe the development of the model of the atom	❑ describe changes in the model of the atom as a result of the work of Dalton, Thomson, Rutherford, and Bohr
E2 describe the sub-atomic structures of atoms, ions, and isotopes, using calculation where appropriate	❑ describe the relative position, mass, and charge for a proton, neutron, and electron ❑ identify the atomic number of an element, using a table ❑ describe a simple electron arrangement for the first 20 elements ❑ define *isotope* ❑ calculate the number of neutrons, protons, and electrons for an atom or ion, given the mass number of the isotope and the charge of the ion ❑ calculate the average atomic mass from isotopic data
E3 describe the development of the modern periodic table	❑ explain the significance of the work of Mendeleev ❑ distinguish the ordering of elements in early periodic tables (based on atomic mass) from the ordering of elements in the modern periodic table (based on atomic number)
E4 draw conclusions about the similarities and trends in the properties of elements, with reference to the periodic table *Organizer 'Atomic Theory' continued on page 38*	❑ classify elements as metal, non-metal, or metalloid and locate them on the periodic table ❑ describe trends in properties such as melting point, ionization energy, atomic radius, chemical reactivity, ion charge, and conductivity ❑ identify the following families of elements: alkali metals, alkaline earth metals, halogens, noble gases, transition metals ❑ describe some properties of the alkali metals, alkaline earth metals, halogens, noble gases, and transition metals ❑ predict the characteristics of elements knowing the characteristics of another element in that family ❑ predict the formulae of compounds given the formula of another compound containing elements in the same families

Prescribed Learning Outcomes	Suggested Achievement Indicators
Organizer 'Atomic Theory' *continued from page 37*	
E5 justify chemical and physical properties in terms of electron population	❑ relate noble gas stability to electron arrangement within the atom ❑ predict the probable electron gain or loss for elements in columns 1, 2, 13, 15, 16, and 17 ❑ relate the observed charge of monatomic ions of metals and non-metals to numbers of electrons lost or gained
E6 demonstrate knowledge of various types of chemical bonding	❑ define *covalent* and *ionic bonding* ❑ define *valence electrons* ❑ recognize the connection between bonding and valence electrons
E7 apply understanding of bonding to create formulae and Lewis structures	❑ identify from a chemical formula the probable type of bond (ionic or covalent) ❑ draw an electron dot diagram (Lewis structures) for an atom, ion, or molecule ❑ draw structural formulae for simple molecules and ions, and deduce molecular formulae

Key Elements: Solution Chemistry

Estimated Time: 14–17 hours

By the end of this course, students will be able to demonstrate and explain solution formation, solubility, and the interactions between solute and solvent.

Vocabulary

acid-base neutralization, dissociation equation, electrical conductivity, ion charge, ionization equation, molarity, molar solution, mole, non-polar, polar, solute, solvent, solution

Knowledge

- the difference between pure substances and solutions
- electrical conductivity in aqueous solutions
- nature of solutes and solvents (polar and non-polar)

Skills and Attitudes

- following safety procedures
- interpreting tables (periodic table and table of common ions)
- classifying solutes and solvents (polar and non-polar)
- performing calculations
  - involving moles and molarity
  - involving stoichiometry
  - determining the concentration of ions in solution
- observing, recording data from, and analysing solute-solvent interactions (e.g., sugar, salt, or iodine in water vs. paint thinner)
- balancing ionic equations

SOLUTION CHEMISTRY

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
F1 distinguish between a solution and a pure substance	❑ define *solution* as a homogeneous mixture comprised of a solute and solvent ❑ give examples of solid, liquid, or gaseous solutions
F2 predict the relative solubility of a solute in a solvent, based on its polarity	❑ categorize various common solvents as polar and non-polar ❑ on the basis of lab observations, make deductions concerning the solubility of ionic, polar, and non-polar solutes in polar and non-polar solvents
F3 relate ion formation to electrical conductivity in aqueous solutions	❑ use lab observations to describe the relative conductivity of several solutes in aqueous solution ❑ summarize the results of a conductivity experiment as to the types of solute that conduct electricity when dissolved in water ❑ write dissociation or ionization equations for several substances that dissolve in water to give conducting solutions
F4 calculate the concentration of ions in solution	❑ calculate the molarity of each ion in a salt solution given the molarity of the solution ❑ calculate the concentration of ions resulting when two solutions of known concentration and volume are mixed (assuming no reaction)

Key Elements: Organic Chemistry

Estimated Time: 14–18 hours

By the end of this course, students will be able to demonstrate an awareness of the variety and complexity of organic chemical systems, with specific reference to various functional groups.

Vocabulary

alcohol, aldehyde, alkane, alkene, alkyne, amide, amine, aromatic, benzene ring, bromo-, chloro-, cyclic, ester, ether, ethyl-, fluoro-, hydrocarbon, ketone, methyl-, organic acid, organic chemistry, substituent groups

Knowledge

- nature, features, and uses of organic chemistry
- the various ways that carbon and hydrogen can combine (including carbon-carbon bonding)
- names and structures of alkanes, alkenes, and alkynes up to C_{10} and of substituent groups (methyl, ethyl, fluoro, chloro, bromo, and iodo)
- common functional groups

Skills and Attitudes

- following safety procedures
- connecting objectives and conclusions
- classifying compounds (functional groups)
- naming compounds and writing formulae for organic compounds
- balancing equations
- performing simple organic preparations (e.g., ester preparation lab)

ORGANIC CHEMISTRY

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
G1 describe characteristic features and common applications of organic chemistry	❑ identify carbon as the "backbone" of organic chemistry ❑ identify the multiple bonding character of carbon atoms ❑ relate organic chemistry to products such as plastics, fuels, pharmaceutical drugs, pesticides, insecticides, solvents, and synthetics ❑ identify major sources of organic compounds
G2 demonstrate knowledge of the various ways that carbon and hydrogen can combine to form a wide range of compounds	❑ define *hydrocarbon, alkane, alkene, alkyne, cyclic,* and *aromatic* as they relate to organic compounds ❑ classify a hydrocarbon as either saturated or unsaturated ❑ compare the geometry of single, double, and triple bonds between two carbon atoms ❑ draw the structure of a benzene ring
G3 generate names and structures for simple organic compounds	❑ name and draw structures of alkanes, alkenes, and alkynes up to C_{10} ❑ recognize and name the substituent groups methyl, ethyl, fluoro, chloro, bromo, and iodo ❑ name and draw structures of simple substituted alkanes to C_{10}
G4 differentiate the various types of bonding between carbon atoms	❑ compare the rotational ability in single, double, and triple bonds ❑ consistently identify cis- or trans- isomers of alkenes ❑ name and draw structures for simple alcohols
G5 identify common functional groups	❑ define the term *functional group* ❑ identify a compound as an alcohol, aldehyde, ketone, ether, organic acid, ester, amine, or amide when given a structural diagram
G6 perform a simple organic preparation	❑ demonstrate how an ester can be prepared through the reaction of an alcohol and an organic acid and how it can be detected (by its aroma)

Student Achievement

Chemistry 12

Key Elements: Reaction Kinetics

Estimated Time: 14–16 hours

By the end of this course, students will be able to explain the significance of reaction rates, demonstrate how rates can be measured and explain, with reference to Collision Theory and reaction mechanisms, how rates are altered.

Vocabulary

activated complex, activation energy, catalyst, collision theory, ΔH notation, endothermic, enthalpy, exothermic, KE distribution curve, kinetic energy (KE), potential energy (PE), product, rate-determining step, reactant, reaction intermediate, reaction mechanism, reaction rate, successful collision, thermochemical equation

Knowledge

- reaction rates
- collision theory (significance with respect to reaction rates)
- factors affecting reaction rates
- reaction mechanisms (including role and applications of catalysts)

Skills and Attitudes

- calculating reaction rates from experimental data (e.g., bleach decomposition, zinc in hydrochloric acid, iodine clock reaction)
- analysing reaction mechanisms
- graphically representing energy changes in reactions

REACTION KINETICS

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
A1 demonstrate awareness that reactions occur at differing rates	❑ give examples of reactions proceeding at different rates ❑ recognize that rate is described in terms of some quantity (produced or consumed) per unit of time
A2 experimentally determine rate of a reaction	❑ identify properties that could be monitored in order to determine a reaction rate ❑ recognize some of the factors that control reaction rates ❑ compare and contrast factors affecting the rates of both homogeneous and heterogeneous reactions ❑ describe situations in which the rate of reaction must be controlled ❑ calculate the rate of a reaction using experimental data
A3 demonstrate knowledge of collision theory	❑ identify the following principles as aspects of collision theory: – reactions are the result of collisions between reactant particles – not all collisions are successful – sufficient kinetic energy (KE) and favourable geometry are required – to increase the rate of a reaction, one must increase the frequency of successful collisions – energy changes are involved in reactions as bonds are broken and formed – a KE distribution curve can explain how changing temperature or adding a catalyst changes the rate
A4 describe the energies associated with reactants becoming products *Organizer 'Reaction Kinetics' continued on page 46*	❑ describe the activated complex in terms of its potential energy (PE), stability, and structure ❑ define *activation energy* ❑ correctly describe the relationship between activation energy and rate of reaction ❑ describe the changes in KE and PE as reactant molecules approach each other ❑ draw and label PE diagrams for both exothermic and endothermic reactions, including ΔH, activation energy, and the energy of the activated complex ❑ relate the sign of ΔH to whether the reaction is exothermic or endothermic ❑ write chemical equations that describe energy effects in two ways: – a chemical equation that includes the energy term (thermochemical equation) – a chemical equation using ΔH notation

Prescribed Learning Outcomes	Suggested Achievement Indicators
Organizer 'Reaction Kinetics' continued from page 45	
A5 apply collision theory to explain how reaction rates can be changed	❑ use collision theory to explain the effect of the following factors on reaction rate: – nature of reactants – concentration – temperature – surface area
A6 analyse the reaction mechanism for a reacting system	❑ explain why most reactions involve more than one step ❑ describe a reaction mechanism as the series of steps (collisions) that result in the overall reaction and describe the role of the rate-determining step ❑ explain the significance and role of a catalyst ❑ identify reactant, product, reaction intermediate, activated complex, and catalyst from a given reaction mechanism
A7 represent graphically the energy changes associated with catalyzed and uncatalyzed reactions	❑ compare the PE diagrams for a catalyzed and uncatalyzed reaction in terms of – reactants – products – activated complex – reaction intermediates – reaction mechanism – ΔH – activation energy
A8 describe the uses of specific catalysts in a variety of situations	❑ identify platinum in automobile catalytic converters as a catalyst ❑ describe the effect of a catalyst on a number of reactions, such as – decomposition of hydrogen peroxide (catalysts: manganese (IV) oxide, raw liver, raw potato) – the reaction of the oxalate ion with acidified potassium permanganate solution (catalyst: Mn^{2+}) – the decomposition of bleach (catalyst: cobalt (II) chloride)

Key Elements: Dynamic Equilibrium

Estimated Time: 14–16 hours

By the end of this course, students will be able to analyse reversible reacting systems, with reference to equilibrium systems, Le Châtelier's Principle, and the concept of a reaction constant, K_{eq}.

Vocabulary

chemical equilibrium, closed system, dynamic equilibrium, enthalpy, entropy, equilibrium concentration, equilibrium constant expression, equilibrium shift, Haber process, heterogeneous reaction, homogeneous reaction, K_{eq}, Le Châtelier's principle, macroscopic properties, open system, PE diagram

Knowledge

- characteristics of chemical equilibrium
- requirements for chemical equilibrium
- Le Châtelier's principle (dynamic equilibrium and equilibrium shifts – significance and application)

Skills and Attitudes

- predicting effect on equilibrium when changes are made (e.g., chromate-dichromate, iron (III) thiocyanide equilibria)
- performing calculations involving K_{eq}, initial concentrations, and equilibrium concentration

DYNAMIC EQUILIBRIUM

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
B1 explain the concept of chemical equilibrium with reference to reacting systems	❑ describe the reversible nature of most chemical reactions and how it can be represented on a PE diagram ❑ describe the dynamic nature of chemical equilibrium ❑ relate the changes in rates of the forward and reverse reactions to the changing concentrations of the reactants and products as equilibrium is established ❑ describe chemical equilibrium as a closed system at constant temperature: – whose macroscopic properties are constant – where the forward and reverse reaction rates are equal – that can be achieved from either direction – where the concentrations of reactants and products are constant ❑ infer that a system not at equilibrium will tend to move toward a position of equilibrium
B2 predict, with reference to entropy and enthalpy, whether reacting systems will reach equilibrium	❑ explain the significance of enthalpy and entropy ❑ determine entropy and enthalpy changes from a chemical equation (qualitatively) ❑ predict the result when enthalpy and entropy factors – both favour the products – both favour the reactants – oppose one another
B3 apply Le Châtelier's principle to the shifting of equilibrium	❑ explain the term shift as it applies to equilibria ❑ describe shifts resulting from the following: – temperature change – concentration change – volume change of gaseous systems ❑ explain equilibrium shifts using the concepts of reaction kinetics ❑ identify the effect of a catalyst on dynamic equilibrium
B4 apply the concept of equilibrium to a commercial or industrial process *Organizer 'Dynamc Equilibrium' continued on page 49*	❑ describe the Haber process for the production of ammonia (NH_3)

Prescribed Learning Outcomes	Suggested Achievement Indicators
Organizer 'Dynamic Equilibrium' continued from page 48	
B5 draw conclusions from the equilibrium constant expression	❑ gather and interpret data on the concentration of reactants and products of a system at equilibrium ❑ write the expression for the equilibrium constant when given the equation for either a homogeneous or heterogeneous equilibrium system ❑ explain why certain terms (i.e., pure solids and liquids) are not included in the equilibrium constant expression ❑ relate the equilibrium position to the value of K_{eq} and vice versa ❑ predict the effect (or lack of effect) on the value of K_{eq} of changes in the following factors: temperature, pressure, concentration, surface area, and catalyst
B6 perform calculations to evaluate the changes in the value of K_{eq} and in concentrations of substances within an equilibrium system	❑ perform calculations involving the value of K_{eq} and the equilibrium concentration of all species ❑ perform calculations involving the value of K_{eq}, the initial concentrations of all species, and one equilibrium concentration ❑ perform calculations involving the equilibrium concentrations of all species, the value of K_{eq}, and the initial concentrations ❑ determine whether a system is at equilibrium, and if not, in which direction it will shift to reach equilibrium when given a set of concentrations for reactants and products

Key Elements: Solubility Equilibria

Estimated Time: 14–16 hours

By the end of this course, students will be able to demonstrate and explain solute-solvent interactions in solubility equilibria and describe the significance of K_{sp} with respect to saturated systems.

Vocabulary

aqueous solution, common ion, complete ionic equation, dissociation equation, electrical conductivity, formula equation, hard water, ionic solution, K_{sp}, molecular solution, net ionic equation, precipitate, relative solubility, saturated solution, solubility equilibrium

Knowledge

- ionic vs. molecular solutions
- relative solubility of solutes
- solubility rules
- equilibrium in saturated solutions

Skills and Attitudes

- distinguishing between ionic and molecular solutions (e.g., electrical conductivity)
- determining the composition of solutions and the concentration of an ion in a given solution
- performing calculations involving solubility equilibrium concepts

SOLUBILITY EQUILIBRIA

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
C1 determine the solubility of a compound in aqueous solution	❑ classify a solution as ionic or molecular, given its conductivity or the formula of the solute ❑ describe the conditions necessary to form a saturated solution ❑ describe solubility as the concentration of a substance in a saturated solution ❑ use appropriate units to represent the solubility of substances in aqueous solutions
C2 describe a saturated solution as an equilibrium system	❑ describe the equilibrium that exists in a saturated aqueous solution ❑ describe a saturated solution using a net ionic equation
C3 determine the concentration of ions in a solution	❑ write dissociation equations ❑ calculate the concentration of the positive and negative ions given the concentration of a solute in an aqueous solution
C4 determine the relative solubility of a substance, given solubility tables *Organizer 'Solubility Equilibria'* *continued on page 52*	❑ describe a compound as having high or low solubility relative to 0.1 M by using a solubility chart ❑ use a solubility chart to predict if a precipitate will form when two solutions are mixed, and identify the precipitate ❑ write a formula equation, complete ionic equation, and net ionic equation that represent a precipitation reaction

Prescribed Learning Outcomes	Suggested Achievement Indicators
Organizer 'Solubility Equilibria' continued from page 51	
C5 apply solubility rules to analyse the composition of solutions	❑ use a solubility chart to predict if ions can be separated from solution through precipitation, and outline an experimental procedure that includes – compound added – precipitate formed – method of separation ❑ predict qualitative changes in the solubility equilibrium upon the addition of a common ion or the removal of an ion ❑ identify an unknown ion through experimentation involving a qualitative analysis scheme ❑ devise a procedure by which the calcium and/or magnesium ions can be removed from hard water
C6 formulate equilibrium constant expressions for various saturated solutions	❑ describe the K_{sp} expression as a specialized K_{eq} expression ❑ write a K_{sp} expression for a solubility equilibrium
C7 perform calculations involving solubility equilibrium concepts	❑ calculate the K_{sp} for a compound when given its solubility (e.g., AgCl, Ag_2S, $PbCl_2$) ❑ calculate the solubility of a compound from its K_{sp} ❑ predict the formation of a precipitate by comparing the trial ion product to the K_{sp} value using specific data ❑ calculate the maximum allowable concentration of one ion given the K_{sp} and the concentration of the other ion just before precipitation occurs
C8 devise a method for determining the concentration of a specific ion	❑ determine the concentration of chloride ion (by titration or gravimetric methods) using a precipitation reaction with silver ion

Key Elements: Nature of Acids and Bases

Estimated Time: 7–10 hours

By the end of this course, students will be able to describe the specific characteristics of acids and bases and distinguish the varying strengths of acids or bases for equilibria using a Brönsted-Lowry model.

Vocabulary

acid, amphiprotic, Arrhenius, base, Brönsted-Lowry, conjugate acid-base pair, electrical conductivity, strong acid, strong base, weak acid, weak base

Knowledge

- names, properties, and formulae of acids and bases
- models for representing acids and bases
- weak and strong acids and bases

Skills and Attitudes

- identifying acids or bases experimentally (e.g., common household acids and bases with litmus paper)
- writing balanced equations involving acids or bases
- analysing weak-acid and weak-base equilibria

NATURE OF ACIDS AND BASES

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
D1 identify acids and bases through experimentation	❑ list general properties of acids and bases ❑ write names and formulae of some common household acids and bases ❑ write balanced equations representing the neutralization of acids by bases in solution ❑ outline some of the uses and commercial names of common household acids and bases
D2 identify various models for representing acids and bases	❑ define *Arrhenius acids* and *bases* ❑ define *Brönsted-Lowry acids* and *bases*
D3 analyse balanced equations representing the reaction of acids or bases with water	❑ identify Brönsted-Lowry acids and bases in an equation ❑ define *conjugate acid-base pair* ❑ identify the conjugate of a given acid or base ❑ show that in any Brönsted-Lowry acid-base equation there are two conjugate pairs present ❑ identify an H_3O^+ ion as a protonated H_2O molecule that can be represented in shortened form as H^+
D4 classify an acid or base in solution as either weak or strong, with reference to its electrical conductivity	❑ relate electrical conductivity in a solution to the total concentration of ions in the solution ❑ define and give several examples for the following terms: – strong acid – strong base – weak acid – weak base ❑ write equations to show what happens when strong and weak acids and bases are dissolved in water
D5 analyse the equilibria that exist in weak acid or weak base systems	❑ compare the relative strengths of acids or bases by using a table of relative acid strengths ❑ predict whether products or reactants are favoured in an acid-base equilibrium by comparing the strength of the two acids (or two bases) ❑ compare the relative concentrations of H_3O^+ (or OH^-) between two acids (or between two bases) using their relative positions on an acid strength table
D6 identify chemical species that are amphiprotic	❑ define *amphiprotic* ❑ describe situations in which H_2O would act as an acid or base

Key Elements: Acids and Bases: Quantitative Problem Solving

Estimated Time: 8–12 hours

By the end of this course, students will be able to describe the special role played by water in aqueous systems and use the acid-base equilibrium constants (K_a and K_b) and the ionization constant of water (K_w) to calculate pH and pOH values for different acid-base equilibria.

Vocabulary

acid ionization constant (K_a), base ionization constant (K_b), ion product constant, pH, pK_w, pOH, water ionization constant (K_w)

Knowledge

- the pH/pOH scale
- acid and base ionization constants
- water ionization constant
- the K_a table

Skills and Attitudes

- analysing weak-acid and weak-base equilibria using the K_a table
- performing calculations
  - involving K_a and K_b
  - relating pH, pOH, $[H_3O^+]$, and $[OH^-]$

ACIDS AND BASES: QUANTITATIVE PROBLEM SOLVING

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
E1 analyse the equilibrium that exists in water	❑ write equations representing the ionization of water using either H_3O^+ and OH^- or H^+ and OH^- ❑ predict the effect of the addition of an acid or base to the equilibrium system: $2H_2O \leftrightarrows H_3O^+ + OH^-$ ❑ state the relative concentrations of H_3O^+ and OH^- in acid, base, and neutral solutions ❑ write the equilibrium expression for the ion product constant of water (water ionization constant: K_w) ❑ state the value of K_w at 25°C ❑ describe and explain the variation in the value of K_w with temperature ❑ calculate the concentration of H_3O^+ (or OH^-) given the other, using K_w
E2 perform calculations relating pH, pOH, $[H_3O^+]$, and $[OH^-]$	❑ define pH and pOH ❑ define pK_w, give its value at 25°C, and its relation to pH and pOH ❑ calculate $[H_3O^+]$ or $[OH^-]$ from pH and pOH ❑ describe the pH scale with reference to everyday solutions
E3 explain the significance of the K_a and K_b equilibrium expressions	❑ write K_a and K_b equilibrium expressions for weak acids or weak bases ❑ relate the magnitude of K_a (the acid ionization constant) or K_b (the base ionization constant) to the strength of the acid or base
E4 perform calculations involving K_a and K_b	❑ given the K_a, K_b, and initial concentration, calculate any of the following: – $[H_3O^+]$ – $[OH^-]$ – pH – pOH ❑ calculate the value of K_b for a base given the value of K_a for its conjugate acid (or vice versa) ❑ calculate the value of K_a or K_b given the pH and initial concentration ❑ calculate the initial concentration of an acid or base, given the appropriate K_a, K_b, pH, or pOH values

Key Elements: Applications of Acid-Base Reactions

Estimated Time: 11–14 hours

By the end of this course, students will be able to identify practical applications of acid-base systems, demonstrate the use of titrations to determine quantities of materials, explain the significance of hydrolysis, and relate buffer systems and acid rain to the concept of acid-base equilibrium.

Vocabulary

acid rain, buffers, dissociation equation, equivalence point (stoichiometric point), hydrolysis, hydrolysis reaction, indicator, primary standards, salt, titration, titration curve, transition point

Knowledge

- significance and use of indicators
- hydrolysis of ions in salt solutions
- buffer systems (characteristics, significance, applications)
- acid rain (nature, causes, significance)

Skills and Attitudes

- performing calculations
  - involving K_a and K_b
  - relating pH, pOH, $[H_3O^+]$, and $[OH^-]$
  - involving the pH in a solution and K_a for an indicator
- designing, performing, and analysing a titration experiment (e.g., acid-base titration)

APPLICATIONS OF ACID-BASE REACTIONS

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
F1 demonstrate an ability to design, perform, and analyse a titration experiment involving the following: – primary standards – standardized solutions – titration curves – appropriate indicators	❑ write formulae, complete ionic equations, and net ionic equations for – a strong acid reacting with a strong base (neutralization) – a weak acid reacting with a strong base – a strong acid reacting with a weak base ❑ demonstrate proper titration technique when performing a titration experiment ❑ explain the difference between the equivalence point (stoichiometric point) of a strong acid-strong base titration and the equivalence point of a titration involving a weak acid-strong base or strong acid-weak base ❑ interpret titration curves plotted from experimental data ❑ select indicators whose transition point coincides with the equivalence point of the titration reaction ❑ calculate the concentration of an acid or base using titration data or similar data (e.g., grams or moles) ❑ calculate the volume of an acid or base of known molarity needed to completely react with a given amount of base or acid ❑ calculate the pH of a solution formed when a strong acid is mixed with a strong base
F2 describe an indicator as an equilibrium system	❑ describe an indicator as a mixture of a weak acid and its conjugate base, each with distinguishing colours ❑ describe the term transition point of an indicator, including the conditions that exist in the equilibrium system ❑ describe the shift in equilibrium and resulting colour changes as an acid or a base is added to an indicator
F3 perform and interpret calculations involving the pH in a solution and K_a for an indicator *Organizer 'Applications of Acid-Base Reactions' continued on page 59*	❑ predict the approximate pH at the transition point using the K_a value of an indicator ❑ predict the approximate K_a value for an indicator given the approximate pH range of the colour change ❑ match an indicator's colour in a solution with an approximate pH, using a table of indicators

Prescribed Learning Outcomes	Suggested Achievement Indicators
Organizer 'Applications of Acid-Base Reactions' continued from page 58	
F4 describe the hydrolysis of ions in salt solutions	❑ write a dissociation equation for a salt in water ❑ write net ionic equations representing the hydrolysis of ions in solution
F5 analyse the extent of hydrolysis in salt solutions	❑ predict whether a salt solution would be acidic, basic, or neutral (compare K_a and K_b values, where necessary) ❑ determine whether an amphiprotic ion will act as a base or an acid in solution (compare K_a and K_b values, where necessary) ❑ calculate the pH of a salt solution from relevant data, assuming that the predominant hydrolysis reaction is the only reaction determining the pH
F6 describe buffers as equilibrium systems	❑ describe the tendency of buffer solutions to resist changes in pH (i.e., able to buffer the addition of small amounts of strong acid or the addition of small amounts of strong base) ❑ describe the composition of an acidic buffer and a basic buffer ❑ describe qualitatively how the buffer equilibrium shifts as small quantities of acid or base are added to the buffer; the stress being the change in the concentration of the stronger acid (H_3O^+) or base (OH^-) ❑ describe in detail a common buffer system (e.g., the blood buffer system)
F7 describe the preparation of buffer systems	❑ outline a procedure to prepare a buffer solution ❑ identify the limitations in buffering action
F8 predict what will happen when oxides dissolve in rain water	❑ write equations representing the formation of acidic solutions or basic solutions from non-metal and metal oxides ❑ describe the pH conditions required for rain to be called acid rain (pH 5.0 and lower) ❑ relate the pH of normal rain water to the presence of dissolved CO_2 (approximately pH 5.6) ❑ describe sources of NO_x (automobile engines) and SO_x (fuels containing sulfur and smelters of sulfide ores) ❑ discuss general environmental problems associated with acid rain

Key Elements: Oxidation-Reduction

Estimated Time: 12–13 hours

By the end of this course, students will be able to describe the essential components of reacting systems that involve electron transfer, determine the stoichiometry of redox reactions by balancing redox reactions, and apply their findings to perform redox titrations.

Vocabulary

half-reaction, oxidation, oxidation number, oxidizing agent, redox reaction, redox titration, reducing agent, reduction

Knowledge

- vocabulary of redox reactions
- characteristics of redox reactions
- "Standard Reduction Potentials of Half-Cells" table

Skills and Attitudes

- recognizing redox reactions
- assigning oxidation numbers
- creating a simple table of reduction half-reactions
- predicting the spontaneity of reactions
- analysing the relative strengths of reducing and oxidizing agents
- balancing redox equations
- perform a redox titration (e.g., the iron (II) ion with the permanganate ion)

OXIDATION-REDUCTION

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
G1 describe oxidation and reduction processes	❑ define and identify – oxidation – reduction – oxidizing agent – reducing agent – half-reaction – redox reaction ❑ determine the following: – the oxidation number of an atom in a chemical species – the change in oxidation number an atom undergoes when it is oxidized or reduced – whether an atom has been oxidized or reduced by its change in oxidation number ❑ relate change in oxidation number to gain or loss of electrons
G2 analyse the relative strengths of reducing and oxidizing agents	❑ from data for a series of simple redox reactions, create a simple table of reduction half-reactions ❑ identify the relative strengths of oxidizing and reducing agents from their positions on a half-reaction table ❑ use the "Standard Reduction Potentials of Half-Cells" table to predict whether a spontaneous redox reaction will occur between any two species
G3 balance equations for redox reactions	❑ balance the equation for – a half-reaction in solutions that are acidic, basic, or neutral – a net ionic redox reaction in acidic or basic solution ❑ write the equations for reduction and oxidation half-reactions, given a redox reaction ❑ identify reactants and products for various redox reactions performed in a laboratory, and write balanced equations
G4 determine the concentration of a species by performing a redox titration	❑ demonstrate familiarity with at least two common reagents used in redox titrations (e.g., permanganate, dichromate, hydrogen peroxide) ❑ select a suitable reagent to be used in a redox titration, in order to determine the concentration of a species ❑ calculate the concentration of a species in a redox titration from data (e.g., grams, moles, molarity)

Key Elements: Applications of Redox Reactions

Estimated Time: 10–13 hours

By the end of this course, students will be able to use the concept of spontaneous and non-spontaneous reactions to explain practical applications of redox such as batteries, electroplating, electrorefining, and corrosion.

Vocabulary

cathodic protection, corrosion, electrochemical cell, electrode, electrolysis, electrolytic cell, electroplating, electrorefining, half-cell

Knowledge

- electrochemical cells: parts, voltages (E^0), half-reactions involved, practical applications
- common electrochemical cells (e.g., lead-acid battery, fuel cell, alkaline cell)
- electrolytic cells: parts, voltages required, half-reactions involved, practical applications
- metal corrosion as a chemical process (causes, prevention)

Skills and Attitudes

- designing and building electrochemical and electrolytic cells
- predicting ion flow and calculating voltages in electrochemical and electrolytic cells

APPLICATIONS OF REDOX REACTIONS

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
H1 analyse an electrochemical cell in terms of its components and their functions	❑ construct an electrochemical cell ❑ define and label the parts of an electrochemical cell ❑ determine the half-reactions that take place at each electrode of an electrochemical cell, and use these to make predictions about the overall reaction and about – the direction of movement of each type of ion in the cell – the direction of flow of electrons in an external circuit – what will happen to the mass of each electrode as the cell operates ❑ predict the cell potential when equilibrium is reached ❑ determine voltages of half-reactions by analysing the voltages of several cells, with reference to the standard hydrogen half-cell ❑ identify the standard conditions for E^0 values ❑ predict the voltage (E^0) of an electrochemical cell using the "Standard Reduction Potentials of Half-Cells" table ❑ predict the spontaneity of the forward or reverse reaction from the E^0 of a redox reaction
H2 describe how electrochemical concepts can be used in various practical applications	❑ give examples of applications of electrochemical cells, including lead-acid storage batteries, alkali cells, and hydrogen-oxygen fuel cells, and explain how each functions
H3 analyse the process of metal corrosion in electrochemical terms	❑ describe the conditions necessary for corrosion of metals to occur ❑ suggest several methods of preventing or inhibiting corrosion of a metal, including cathodic protection, and account for the efficacy of each method
H4 analyse an electrolytic cell in terms of its components and their functions	❑ define *electrolysis* and *electrolytic cell* ❑ design and label the parts of an electrolytic cell used for the electrolysis of a molten binary salt such as NaCl liquid ❑ design and label the parts of an electrolytic cell capable of electrolyzing an aqueous salt such as KI aqueous (use of overpotential effect not required) ❑ predict the direction of flow of all ions in the cell and electrons in the external circuit ❑ write the half-reaction occurring at each electrode and predict observations based on this information ❑ write the overall cell reaction and predict the minimum voltage required for it to operate under standard conditions
H5 describe how electrolytic concepts can be used in various practical applications	❑ explain the principles involved in simple electroplating ❑ design and label an electrolytic cell capable of electroplating an object ❑ demonstrate familiarity with electrolytic cells in metal refining processes, including refining of zinc and aluminum

Learning Resources

Chemistry 11 and 12

This section contains general information on learning resources, and provides a link to the titles, descriptions, and ordering information for the recommended learning resources in the Chemistry 11 and 12 Grade Collections.

What Are Recommended Learning Resources?
Recommended learning resources are resources that have undergone a provincial evaluation process using teacher evaluators and have Minister's Order granting them provincial recommended status. These resources may include print, video, software and CD-ROMs, games and manipulatives, and other multimedia formats. They are generally materials suitable for student use, but may also include information aimed primarily at teachers.

Information about the recommended resources is organized in the format of a Grade Collection. A Grade Collection can be regarded as a "starter set" of basic resources to deliver the curriculum. In many cases, the Grade Collection provides a choice of more than one resource to support curriculum organizers, enabling teachers to select resources that best suit different teaching and learning styles. Teachers may also wish to supplement Grade Collection resources with locally approved materials.

How Can Teachers Choose Learning Resources to Meet Their Classroom Needs?
Teachers must use either:

- provincially recommended resources OR
- resources that have been evaluated through a local, board-approved process

Prior to selecting and purchasing new learning resources, an inventory of resources that are already available should be established through consultation with the school and district resource centres. The ministry also works with school districts to negotiate cost-effective access to various learning resources.

What Are the Criteria Used to Evaluate Learning Resources?
The Ministry of Education facilitates the evaluation of learning resources that support BC curricula, and that will be used by teachers and/or students for instructional and assessment purposes. Evaluation criteria focus on content, instructional design, technical considerations, and social considerations.

Additional information concerning the review and selection of learning resources is available from the ministry publication, *Evaluating, Selecting and Managing Learning Resources: A Guide* (Revised 2002)
www.bced.gov.bc.ca/irp/resdocs/esm_guide.pdf

What Funding is Available for Purchasing Learning Resources?
As part of the selection process, teachers should be aware of school and district funding policies and procedures to determine how much money is available for their needs. Funding for various purposes, including the purchase of learning resources, is provided to school districts. Learning resource selection should be viewed as an ongoing process that requires a determination of needs, as well as long-term planning to co-ordinate individual goals and local priorities.

What Kinds of Resources Are Found in a Grade Collection?
The Grade Collection charts list the recommended learning resources by media format, showing links to the curriculum organizers and suborganizers. Each chart is followed by an annotated bibliography. Teachers should check with suppliers for complete and up-to-date ordering information. Most suppliers maintain web sites that are easy to access.

CHEMISTRY 11 AND 12 GRADE COLLECTIONS

The Grade Collections for Chemistry 11 and 12 list the recommended learning resources for these courses. Resources previously recommended for the 1995 version of the curriculum, where still valid, continue to support this updated IRP. The ministry updates the Grade Collections on a regular basis as new resources are developed and evaluated.

Please check the following ministry web site for the most current list of recommended learning resources in the Chemistry 11 and 12 Grade Collections: www.bced.gov.bc.ca/irp_resources/lr/resource/gradcoll.htm

This document represents an updating of the 1996 IRP. This updating has been undertaken for the purpose of

- clarifying the Prescribed Learning Outcomes
- introducing Suggested Achievement Indicators
- addressing content overload

Resources previously recommended for the 1996 version of the curriculum, where still valid, continue to support this updated IRP. (See the Learning Resources section in this IRP for additional information.)

PHYSICS 11 AND 12

Integrated Resource Package 2006

BRITISH COLUMBIA
The Best Place on Earth

Ministry of Education

IRP 142

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Acknowledgments

This document has been updated from the 1996 IRP to include suggested achievement indicators, a more clear and succinct set of prescribed learning outcomes, a snapshot of the course's key elements, and other minor refinements, while maintaining the original intent and essence of the 1996 curricular content.

Many people contributed their expertise to the Physics 11 and 12 IRP. The Project Manager (2005-2006) was Mr. Waël Afifi of the Ministry of Education, working with other ministry personnel and our partners in education. We would like to thank all who participated in this process, including the teams of educators who developed the 1996 Physics 11 and 12 IRP, and the following individuals who contributed to the 2005-2006 updating of this document:

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Preface

This Integrated Resource Package (IRP) provides basic information teachers will require in order to implement Physics 11 and 12. This document supersedes the *Physics 11 and 12 Integrated Resource Package* (1996).

The information contained in this document is also available on the Internet at www.bced.gov.bc.ca/irp/irp.htm

The following paragraphs provide brief descriptions of the components of the IRP.

Introduction

The Introduction provides general information about Physics 11 and 12, including special features and requirements.

Included in this section are

- a rationale for teaching Physics 11 and 12 in BC schools
- information about graduation program requirements and provincial examinations
- listings of each course's curriculum organizers and suborganizers – groupings for prescribed learning outcomes that share a common focus
- suggested time allotments for each course

Considerations for Program Delivery

This section of the IRP contains additional information to help educators develop their school practices and plan their program delivery to meet the needs of all learners.

Prescribed Learning Outcomes

This section contains the *prescribed learning outcomes*, the legally required content standards for the provincial education system. The learning outcomes define the required knowledge, skills, and attitudes for each subject. They are statements of what students are expected to know and be able to do by the end of the course.

Student Achievement

This section of the IRP contains information about classroom assessment and measuring student achievement, including sets of specific achievement indicators for each prescribed learning outcome. Achievement indicators are statements that describe what students should be able to do in order to demonstrate that they fully meet the expectations set out by the prescribed learning outcomes. Achievement indicators are not mandatory; they are provided to assist in the assessment of how well students achieve the prescribed learning outcomes.

Also included in this section are key elements – descriptions of content that help determine the intended depth and breadth of the prescribed learning outcomes.

Learning Resources

This section contains general information on learning resources, and provides a link to titles, descriptions, and ordering information for the recommended learning resources in the Physics 11 and 12 Grade Collections.

INTRODUCTION

Physics 11 and 12

This Integrated Resource Package (IRP) sets out the provincially prescribed curriculum for Physics 11 and 12. The development of this IRP has been guided by the principles of learning:

- Learning requires the active participation of the student.
- People learn in a variety of ways and at different rates.
- Learning is both an individual and a group process.

In addition to these three principles, this document recognizes that British Columbia's schools include young people of varied backgrounds, interests, abilities, and needs. Wherever appropriate for this curriculum, ways to meet these needs and to ensure equity and access for all learners have been integrated as much as possible into the learning outcomes and achievement indicators.

This document represents an updating of the 1996 IRP. This updating has been undertaken for the purpose of

- clarifying the prescribed learning outcomes
- introducing suggested achievement indicators
- addressing content overload

Resources previously recommended for the 1996 version of the curriculum, where still valid, continue to support this updated IRP. (See the Learning Resources section later in this IRP for additional information.)

Physics 11 and 12, in draft form, was available for public review and response from December, 2005 to January, 2006. Feedback from educators, students, parents, and other educational partners informed the development of this updated IRP.

RATIONALE

The science curriculum of British Columbia provides a foundation for the scientific literacy of citizens, for the development of a highly skilled and adaptable work force, and for the development of new technologies. It is a foundation on which teachers can develop a science program that provides a comprehensive set of knowledge, skills, and experiences related to science.

School science programs that are planned to develop scientifically literate students provide experiences that

- help students become flexible and adaptable rather than focussing on acquiring specialized knowledge
- develop the capacity to think critically
- call for a wide range of knowledge, methods, and approaches that enable students to analyse personal and societal issues critically
- encourage students to examine the impact of scientific knowledge on their lives, society, and the environment
- develop a positive attitude toward science
- cultivate students' appreciation of the scientific endeavour and their potential to contribute to it

The science curricula of British Columbia provide a framework of opportunities for students to become scientifically literate by

- examining basic concepts, principles, laws, and theories through scientific inquiry
- actively gaining knowledge, skills, and attitudes that provide the basis for sound and ethical problem solving and decision making
- developing an understanding of the place of science in society and history and its relationship to other disciplines
- making informed and responsible decisions about themselves, their homes, workplaces, and the global community

Introduction to Physics 11 and 12

Requirements and Graduation Credits

Physics 11 and 12 are two of the courses available for students to satisfy the Grade 11-12 Graduation Program science requirement.

Physics 11 and 12 are each designated as four-credit courses, and must be reported as such to the Ministry of Education for transcript purposes. Letter grades and percentages must be reported for these courses. It is not possible to obtain partial credit for these courses.

The course codes for Physics 11 and 12 are PH 11 and PH 12. These courses are also available in French (Physique 11, Physique 12; course codes PHYSF 11, PHYSF 12).

Graduation Program Examination

Physics 12 has an optional Graduation Program examination, worth 40% of the final course mark for students who choose to write it. Although students are not required to take this exam to receive credit for the course, they should be advised that some post-secondary institutions require Grade 12 exams to meet entrance requirements, and that writing Grade 12 exams also provides opportunities for provincial scholarships.

For more information, refer to the Ministry of Education examinations web site: www.bced.gov.bc.ca/exams/

Curriculum Organizers

A curriculum organizer consists of a set of prescribed learning outcomes that share a common focus. The prescribed learning outcomes for Physics 11 and 12 are grouped under the following curriculum organizers.

Note that the ordering of these organizers is not intended to imply an order of instruction.

Physics 11	Physics 12
• Skills, Methods, and Nature of Physics • Wave Motion and Geometrical Optics • Kinematics • Forces • Newton's Laws • Momentum • Energy • Special Relativity • Nuclear Fission and Fusion	• Experiments and Graphical Methods • Vectors • Kinematics • Dynamics • Work, Energy, and Power • Momentum • Equilibrium • Circular Motion • Gravitation • Electrostatics • Electric Circuits • Electromagnetism

Suggested Timeframe

Provincial curricula are developed in accordance with the amount of instructional time recommended by the Ministry of Education for each subject area. Teachers may choose to combine various curricula to enable students to integrate ideas and make meaningful connections.

Physics 11 and 12 each require approximately 90–110 hours of instructional time. Although a four-credit course is typically equivalent to 120 hours, this timeframe allows for flexibility to address local needs. The Student Achievement section of this IRP provides a suggested breakdown of this suggested time allotment by curriculum organizer.

Considerations for Program Delivery

Physics 11 and 12

This section of the IRP contains additional information to help educators develop their school practices and plan their program delivery to meet the needs of all learners. Included in this section is information about

- Alternative Delivery policy
- addressing local contexts
- involving parents and guardians
- course requirements respecting beliefs
- safety considerations
- confidentiality
- inclusion, equity, and accessibility for all learners
- working with the school and community
- working with the Aboriginal community
- information and communications technology
- copyright and responsibility

Alternative Delivery Policy

The Alternative Delivery policy does not apply to Physics 11 and 12.

The Alternative Delivery policy outlines how students, and their parents or guardians, in consultation with their local school authority, may choose means other than instruction by a teacher within the regular classroom setting for addressing prescribed learning outcomes contained in the Health curriculum organizer of the following curriculum documents:

- Health and Career Education K to 7, and Personal Planning K to 7 Personal Development curriculum organizer (until September 2008)
- Health and Career Education 8 and 9
- Planning 10

The policy recognizes the family as the primary educator in the development of children's attitudes, standards, and values, but the policy still requires that all prescribed learning outcomes be addressed and assessed in the agreed-upon alternative manner of delivery.

It is important to note the significance of the term "alternative delivery" as it relates to the Alternative Delivery policy. The policy does not permit schools to omit addressing or assessing any of the prescribed learning outcomes within the health and career education curriculum. Neither does it allow students to be excused from meeting any learning outcomes related to health. It is expected that students who arrange for alternative delivery will address the health-related learning outcomes and will be able to demonstrate their understanding of these learning outcomes.

For more information about policy relating to alternative delivery, refer to www.bced.gov.bc.ca/policy/

Addressing Local Contexts

There is some flexibility in the Physics 11 and 12 curriculum, providing opportunities for individual teacher and student choice in the selection of topics to meet learning outcomes. This flexibility enables educators to plan their programs by using topics and examples that are relevant to their local context and to the particular interests of their students. When selecting topics it may be appropriate to incorporate student input.

Involving Parents and Guardians

The family is the primary educator in the development of students' attitudes and values. The school plays a supportive role by focussing on the prescribed learning outcomes in the Physics 11 and 12 curriculum. Parents and guardians can support, enrich, and extend the curriculum at home.

It is highly recommended that schools inform parents and guardians about the Physics 11 and 12 curriculum, and teachers (along with school and district administrators) may choose to do so by

- informing parents/guardians and students of the prescribed learning outcomes for the subject by sending home class letters, providing an overview during parent-teacher interviews, etc.
- responding to parent and guardian requests to discuss course unit plans, learning resources, etc.

Course Requirements Respecting Beliefs

For many students and teachers, the study of some science concepts may lead to issues and questions that go beyond the immediate scope of curriculum (e.g., science is used to meet many industrial

requirements, but industrial decision makers must consider factors other than scientific feasibility before adopting a particular process). The technological application of science in areas such as genetic engineering, human reproduction, and medical technology raises questions of ethics and values. Because these social questions arise, in part, from capabilities that science makes possible, they should be addressed. It must be made clear to students, however, that science only provides the background for what is hoped will be informed personal and social decisions. Teachers must handle these questions objectively and with sensitivity.

Reconciling scientific discoveries (for example, in age dating) and religious faith poses a particular challenge for some students. While respecting the personal beliefs of students, teachers should be careful to distinguish between knowledge based on the application of scientific methods, and religious teachings and associated beliefs such as creationism, theory of divine creation, or intelligent design theory.

Safety Considerations

Science education is an activity-based process that provides an exciting method of teaching and learning. However, experiments and demonstrations may involve inherent risks for both the teacher and the student.

Safety guidelines must be discussed with students. These safety guidelines must support and encourage the investigative approach generally and laboratory instruction specifically, while at the same time promoting safety in the classroom and laboratory. Encouraging a positive safety attitude is a responsibility shared among the board, school administrators, teachers, and students in every school district. The co-operation of all these groups helps develop a strong safety consciousness both inside and outside our schools.

Field work and field trips require special vigilance with respect to traffic and road safety, safe practices in study areas and when obtaining samples, and an awareness of changes in weather.

Another important aspect of in-school safety is the Workplace Hazardous Materials Information Systems (WHMIS). Through labelling, material safety data sheets, and education and training, WHMIS is designed to ensure that those using hazardous materials have sufficient information to handle them safely. Each school district should have an individual trained in WHMIS who can work with teachers to establish safe, well-ventilated classroom and laboratory working conditions.

To assist teachers in providing a safe science-learning environment, the Ministry of Education publishes the *Science Safety Resource Manual*, which has been distributed to every school.

The *Science Safety Resource Manual* is available online at www.bced.gov.bc.ca/irp/resdocs/scisafety.htm

Confidentiality

The *Freedom of Information and Protection of Privacy Act* (FOIPPA) applies to students, to school district employees, and to all curricula. Teachers, administrators, and district staff should consider the following:

- Be aware of district and school guidelines regarding the provisions of FOIPPA and how it applies to all subjects, including Physics 11 and 12.
- Do not use students' Personal Education Numbers (PEN) on any assignments that students wish to keep confidential.
- Ensure students are aware that if they disclose personal information that indicates they are at risk for harm, then that information cannot be kept confidential.
- Inform students of their rights under FOIPPA, especially the right to have access to their own personal information in their school records. Inform parents of their rights to access their children's school records.
- Minimize the type and amount of personal information collected, and ensure that it is used only for purposes that relate directly to the reason for which it is collected.

- Inform students that they will be the only ones recording personal information about themselves unless they, or their parents, have consented to teachers collecting that information from other people (including parents).
- Provide students and their parents with the reason(s) they are being asked to provide personal information in the context of the Physics 11 and 12 curriculum.
- Inform students and their parents that they can ask the school to correct or annotate any of the personal information held by the school, in accordance with Section 29 of FOIPPA.
- Ensure students are aware that their parents may have access to the schoolwork they create only insofar as it pertains to students' progress.
- Ensure that any information used in assessing students' progress is up-to-date, accurate, and complete.

For more information about confidentiality, refer to www.mser.gov.bc.ca/FOI_POP/index.htm

Inclusion, Equity, and Accessibility for All Learners

British Columbia's schools include students of varied backgrounds, interests, and abilities. The Kindergarten to Grade 12 school system focuses on meeting the needs of all students. When selecting specific topics, activities, and resources to support the implementation of Physics 11 and 12, teachers are encouraged to ensure that these choices support inclusion, equity, and accessibility for all students. In particular, teachers should ensure that classroom instruction, assessment, and resources reflect sensitivity to diversity and incorporate positive role portrayals, relevant issues, and themes such as inclusion, respect, and acceptance.

Government policy supports the principles of integration and inclusion of students for whom English is a second language and of students with special needs. Most of the prescribed learning outcomes and suggested achievement indicators in this IRP can be met by all students, including those with special needs and/or ESL needs. Some strategies may require adaptations to ensure that those with special and/or ESL needs can successfully achieve the learning outcomes. Where necessary, modifications can be made to the prescribed learning outcomes for students with Individual Education Plans.

For more information about resources and support for students with special needs, refer to www.bced.gov.bc.ca/specialed/

For more information about resources and support for ESL students, refer to www.bced.gov.bc.ca/esl/

Working with the School and Community

This curriculum addresses a wide range of skills and understandings that students are developing in other areas of their lives. It is important to recognize that learning related to this curriculum extends beyond the science classroom.

School and district-wide programs support and extend learning in Physics 11 and 12. Community organizations may also support the curriculum with locally developed learning resources, guest speakers, workshops, and field studies. Teachers may wish to draw on the expertise of these community organizations and members.

Working with the Aboriginal Community

The Ministry of Education is dedicated to ensuring that the cultures and contributions of Aboriginal peoples in BC are reflected in all provincial curricula. To address these topics in the classroom in a way that is accurate and that respectfully reflects Aboriginal concepts of teaching and learning, teachers are strongly encouraged to seek the advice and support of local Aboriginal communities. Aboriginal communities are diverse in terms of language, culture, and available resources, and each community will have its own unique protocol to gain support for integration of local knowledge and expertise. To begin discussion of possible instructional and assessment activities, teachers should first contact Aboriginal education co-ordinators, teachers, support workers, and counsellors in their district who will be able to facilitate the identification of local resources and

contacts such as elders, chiefs, tribal or band councils, Aboriginal cultural centres, Aboriginal Friendship Centres, and Métis or Inuit organizations.

In addition, teachers may wish to consult the various Ministry of Education publications available, including the "Planning Your Program" section of the resource, *Shared Learnings*. This resource was developed to help all teachers provide students with knowledge of, and opportunities to share experiences with, Aboriginal peoples in BC.

For more information about these documents, consult the Aboriginal Education web site: www.bced.gov.bc.ca/abed/welcome.htm

Information and Communications Technology

The study of information and communications technology is increasingly important in our society. Students need to be able to acquire and analyse information, to reason and communicate, to make informed decisions, and to understand and use information and communications technology for a variety of purposes. Development of these skills is important for students in their education, their future careers, and their everyday lives.

Literacy in the area of information and communications technology can be defined as the ability to obtain and share knowledge through investigation, study, instruction, or transmission of information by means of media technology. Becoming literate in this area involves finding, gathering, assessing, and communicating information using electronic means, as well as developing the knowledge and skills to use and solve problems effectively with the technology. Literacy also involves a critical examination and understanding of the ethical and social issues related to the use of information and communications technology. When planning for instruction and assessment in Physics 11 and 12, teachers should provides opportunities for students to develop literacy in relation to information and communications technology sources, and to reflect critically on the role of these technologies in society.

Copyright and Responsibility

Copyright is the legal protection of literary, dramatic, artistic, and musical works; sound recordings; performances; and communications signals. Copyright provides creators with the legal right to be paid for their work and the right to say how their work is to be used. The law permits certain exceptions for schools (i.e., specific things permitted) but these are very limited, such as copying for private study or research. The copyright law determines how resources can be used in the classroom and by students at home.

In order to respect copyright it is necessary to understand the law. It is unlawful to do the following, unless permission has been given by a copyright owner:

- photocopy copyrighted material to avoid purchasing the original resource for any reason
- photocopy or perform copyrighted material beyond a very small part – in some cases the copyright law considers it "fair" to copy whole works, such as an article in a journal or a photograph, for purposes of research and private study, criticism, and review
- show recorded television or radio programs to students in the classroom unless these are cleared for copyright for educational use (there are exceptions such as for news and news commentary taped within one year of broadcast that by law have record-keeping requirements – see the web site at the end of this section for more details)
- photocopy print music, workbooks, instructional materials, instruction manuals, teacher guides, and commercially available tests and examinations
- show videorecordings at schools that are not cleared for public performance
- perform music or do performances of copyrighted material for entertainment (i.e., for purposes other than a specific educational objective)
- copy work from the Internet without an express message that the work can be copied

Permission from or on behalf of the copyright owner must be given in writing. Permission may also be given to copy or use all or some portion of copyrighted work through a licence or agreement. Many creators, publishers, and producers have formed groups or "collectives" to negotiate royalty payments and copying conditions for educational institutions. It is important to know what licences are in place and how these affect the activities schools are involved in. Some licences may also require royalty payments that are determined by the quantity of photocopying or the length of performances. In these cases, it is important to assess the educational value and merits of copying or performing certain works to protect the school's financial exposure (i.e., only copy or use that portion that is absolutely necessary to meet an educational objective).

It is important for education professionals, parents, and students to respect the value of original thinking and the importance of not plagiarizing the work of others. The works of others should not be used without their permission.

For more information about copyright, refer to www.cmec.ca/copyright/indexe.stm

Prescribed Learning Outcomes

Physics 11 and 12

Prescribed learning outcomes are content standards for the provincial education system; they are the prescribed curriculum. Clearly stated and expressed in measurable and observable terms, learning outcomes set out the required knowledge, skills, and attitudes – what students are expected to know and be able to do – by the end of the specified course.

Schools have the responsibility to ensure that all prescribed learning outcomes in this curriculum are met; however, schools have flexibility in determining how delivery of the curriculum can best take place.

It is expected that student achievement will vary in relation to the learning outcomes. Evaluation, reporting, and student placement with respect to these outcomes are dependent on the professional judgment and experience of teachers, guided by provincial policy.

Prescribed learning outcomes for Physics 11 and 12 are presented by grade and by curriculum organizer, and are coded alphanumerically for ease of reference; however, this arrangement is not intended to imply a required instructional sequence.

WORDING OF PRESCRIBED LEARNING OUTCOMES

All learning outcomes complete the stem, "It is expected that students will…."

When used in a prescribed learning outcome, the word "including" indicates that any ensuing item **must be addressed**. Lists of items introduced by the word "including" represent a set of minimum requirements associated with the general requirement set out by the outcome. The lists are not necessarily exhaustive, however, and teachers may choose to address additional items that also fall under the general requirement set out by the outcome.

DOMAINS OF LEARNING

Prescribed learning outcomes in BC curricula identify required learning in relation to one or more of the three domains of learning: cognitive, psychomotor, and affective. The following definitions of the three domains are based on Bloom's taxonomy.

The **cognitive domain** deals with the recall or recognition of knowledge and the development of intellectual abilities. The cognitive domain can be further specified as including three cognitive levels: knowledge, understanding and application, and higher mental processes. These levels are determined by the verb used in the learning outcome, and illustrate how student learning develops over time.

- *Knowledge* includes those behaviours that emphasize the recognition or recall of ideas, material, or phenomena.
- *Understanding and application* represents a comprehension of the literal message contained in a communication, and the ability to apply an appropriate theory, principle, idea, or method to a new situation.
- *Higher mental processes* include analysis, synthesis, and evaluation. The higher mental processes level subsumes both the knowledge and the understanding and application levels.

The **affective domain** concerns attitudes, beliefs, and the spectrum of values and value systems.

The **psychomotor domain** includes those aspects of learning associated with movement and skill demonstration, and integrates the cognitive and affective consequences with physical performances.

Domains of learning and, particularly, cognitive levels, inform the design and development of the Graduation Program examination for Physics 12.

Prescribed Learning Outcomes

Prescribed Learning Outcomes: Physics 11
It is expected that students will:
Skills, Methods, and Nature of Physics
A1 describe the nature of physics A2 apply the skills and methods of physics
Wave Motion and Geometrical Optics
B1 analyse the behaviour of light and other waves under various conditions, with reference to the properties of waves and using the universal wave equation B2 use ray diagrams to analyse situations in which light reflects from plane and curved mirrors B3 analyse situations in which light is refracted
Kinematics
C1 apply knowledge of the relationships between time, displacement, distance, velocity, and speed to situations involving objects in one dimension C2 apply knowledge of the relationships between time, velocity, displacement, and acceleration to situations involving objects in one dimension
Forces
D1 solve problems involving the force of gravity D2 analyse situations involving the force due to friction D3 apply Hooke's law to the deformation of materials
Newton's Laws
E1 solve problems that involve application of Newton's laws of motion in one dimension
Momentum
F1 apply the concept of momentum in one dimension
Energy
G1 perform calculations involving work, force, and displacement G2 solve problems involving different forms of energy G3 analyse the relationship between work and energy, with reference to the law of conservation of energy G4 solve problems involving power and efficiency
Special Relativity
H1 explain the fundamental principles of special relativity
Nuclear Fission and Fusion
I1 analyse nuclear processes

Prescribed Learning Outcomes: Physics 12
It is expected that students will:
EXPERIMENTS AND GRAPHICAL METHODS
A1 conduct appropriate experiments
A2 use graphical methods to analyse results of experiments
VECTORS
B1 perform vector analysis in one or two dimensions
KINEMATICS
C1 apply vector analysis to solve practical navigation problems
C2 apply the concepts of motion to various situations where acceleration is constant
DYNAMICS
D1 apply Newton's laws of motion to solve problems involving acceleration, gravitational field strength, and friction
D2 apply the concepts of dynamics to analyse one-dimensional or two-dimensional situations
WORK, ENERGY, AND POWER
E1 analyse the relationships among work, energy, and power
MOMENTUM
F1 use knowledge of momentum and impulse to analyse situations in one dimension
F2 use knowledge of momentum and impulse to analyse situations in two dimensions
EQUILIBRIUM
G1 use knowledge of force, torque, and equilibrium to analyse various situations
CIRCULAR MOTION
H1 use knowledge of uniform circular motion to analyse various situations
GRAVITATION
I1 analyse the gravitational attraction between masses
ELECTROSTATICS
J1 apply Coulomb's law to analyse electric forces
J2 analyse electric fields and their effects on charged objects
J3 calculate electric potential energy and change in electric potential energy
J4 apply the concept of electric potential to analyse situations involving point charges
J5 apply the principles of electrostatics to a variety of situations
ELECTRIC CIRCUITS
K1 apply Ohm's law and Kirchhoff's laws to direct current circuits
K2 relate efficiency to electric power, electric potential difference, current, and resistance
ELECTROMAGNETISM
L1 analyse electromagnetism, with reference to magnetic fields and their effects on moving charges
L2 analyse the process of electromagnetic induction

Student Achievement

Physics 11 and 12

This section of the IRP contains information about classroom assessment and student achievement, including specific achievement indicators to assist in the assessment of student achievement in relation to each prescribed learning outcome. Also included in this section are key elements – descriptions of content that help determine the intended depth and breadth of prescribed learning outcomes.

CLASSROOM ASSESSMENT AND EVALUATION

Assessment is the systematic gathering of information about what students know, are able to do, and are working toward. Assessment evidence can be collected using a wide variety of methods, such as

- observation
- student self-assessments and peer assessments
- quizzes and tests (written, oral, practical)
- samples of student work
- projects and presentations
- oral and written reports
- journals and learning logs
- performance reviews
- portfolio assessments

Assessment of student performance is based on the information collected through assessment activities. Teachers use their insight, knowledge about learning, and experience with students, along with the specific criteria they establish, to make judgments about student performance in relation to prescribed learning outcomes.

Three major types of assessment can be used in conjunction to support student achievement.

- Assessment **for** learning is assessment for purposes of greater learning achievement.
- Assessment **as** learning is assessment as a process of developing and supporting students' active participation in their own learning.
- Assessment **of** learning is assessment for purposes of providing evidence of achievement for reporting.

Assessment for Learning

Classroom assessment for learning provides ways to engage and encourage students to become involved in their own day-to-day assessment – to acquire the skills of thoughtful self-assessment and to promote their own achievement.

This type of assessment serves to answer the following questions:

- What do students need to learn to be successful?
- What does the evidence of this learning look like?

Assessment for learning is criterion-referenced, in which a student's achievement is compared to established criteria rather than to the performance of other students. Criteria are based on prescribed learning outcomes, as well as on suggested achievement indicators or other learning expectations.

Students benefit most when assessment feedback is provided on a regular, ongoing basis. When assessment is seen as an opportunity to promote learning rather than as a final judgment, it shows students their strengths and suggests how they can develop further. Students can use this information to redirect their efforts, make plans, communicate with others (e.g., peers, teachers, parents) about their growth, and set future learning goals.

Assessment for learning also provides an opportunity for teachers to review what their students are learning and what areas need further attention. This information can be used to inform teaching and create a direct link between assessment and instruction. Using assessment as a way of obtaining feedback on instruction supports student achievement by informing teacher planning and classroom practice.

Student Achievement

Assessment as Learning

Assessment as learning actively involves students in their own learning processes. With support and guidance from their teacher, students take responsibility for their own learning, constructing meaning for themselves. Through a process of continuous self-assessment, students develop the ability to take stock of what they have already learned, determine what they have not yet learned, and decide how they can best improve their own achievement.

Although assessment as learning is student-driven, teachers can play a key role in facilitating how this assessment takes place. By providing regular opportunities for reflection and self-assessment, teachers can help students develop, practise, and become comfortable with critical analysis of their own learning.

Assessment of Learning

Assessment of learning can be addressed through summative assessment, including large-scale assessments and teacher assessments. These summative assessments can occur at the end of the year or at periodic stages in the instructional process.

Large-scale assessments, such as Foundation Skills Assessment (FSA) and Graduation Program exams, gather information on student performance throughout the province and provide information for the development and revision of curriculum. These assessments are used to make judgments about students' achievement in relation to provincial and national standards. There is no large-scale provincial assessment for Physics 11. The large-scale provincial assessment for Physics 12 is the optional graduation program examination, worth 40% of the final course mark for students who choose to write it.

Assessment of learning is also used to inform formal reporting of student achievement.

For Ministry of Education reporting policy, refer to www.bced.gov.bc.ca/policy/policies/student_reporting.htm

Assessment *for* Learning	Assessment *as* Learning	Assessment *of* Learning
Formative assessment is ***ongoing in the classroom***	**Formative assessment is** ***ongoing in the classroom***	**Summative assessment occurs** ***at end of year or at key stages***
• teacher assessment, student self-assessment, and/or student peer assessment • criterion-referenced – criteria based on prescribed learning outcomes identified in the provincial curriculum, reflecting performance in relation to a specific learning task • involves both teacher and student in a process of continual reflection and review about progress • teachers adjust their plans and engage in corrective teaching in response to formative assessment	• self-assessment • provides students with information on their own achievement and prompts them to consider how they can continue to improve their learning • student-determined criteria based on previous learning and personal learning goals • students use assessment information to make adaptations to their learning process and to develop new understandings	• teacher assessment • may be either criterion-referenced (based on prescribed learning outcomes) or norm-referenced (comparing student achievement to that of others) • information on student performance can be shared with parents/guardians, school and district staff, and other education professionals (e.g., for the purposes of curriculum development) • used to make judgments about students' performance in relation to provincial standards

For more information about assessment for, as, and of learning, refer to the following resource developed by the Western and Northern Canadian Protocol (WNCP): *Rethinking Assessment with Purpose in Mind.*

This resource is available online at www.wncp.ca/

Criterion-Referenced Assessment and Evaluation

In criterion-referenced evaluation, a student's performance is compared to established criteria rather than to the performance of other students. Evaluation in relation to prescribed curriculum requires that criteria be established based on the learning outcomes.

Criteria are the basis for evaluating student progress. They identify, in specific terms, the critical aspects of a performance or a product that indicate how well the student is meeting the prescribed learning outcomes. For example, weighted criteria, rating scales, or scoring guides (reference sets) are ways that student performance can be evaluated using criteria.

Wherever possible, students should be involved in setting the assessment criteria. This helps students develop an understanding of what high-quality work or performance looks like.

Criterion-referenced assessment and evaluation may involve these steps:

Step 1	Identify the prescribed learning outcomes and suggested achievement indicators (as articulated in this IRP) that will be used as the basis for assessment.
Step 2	Establish criteria. When appropriate, involve students in establishing criteria.
Step 3	Plan learning activities that will help students gain the knowledge, skills, and attitudes outlined in the criteria.
Step 4	Prior to the learning activity, inform students of the criteria against which their work will be evaluated.
Step 5	Provide examples of the desired levels of performance.
Step 6	Conduct the learning activities.
Step 7	Use appropriate assessment instruments (e.g., rating scale, checklist, scoring guide) and methods (e.g., observation, collection, self-assessment) based on the particular assignment and student.
Step 8	Review the assessment data and evaluate each student's level of performance or quality of work in relation to criteria.
Step 9	Where appropriate, provide feedback and/or a letter grade to indicate how well the criteria are met.
Step 10	Communicate the results of the assessment and evaluation to students and parents/guardians.

Student Achievement

Key Elements

Key elements provide an overview of content in each curriculum organizer. They can be used to determine the expected depth and breadth of the prescribed learning outcomes.

Achievement Indicators

To support the assessment of provincially prescribed curricula, this IRP includes sets of achievement indicators in relation to each learning outcome.

Achievement indicators, taken together as a set, define the specific level of knowledge acquired, skills applied, or attitudes demonstrated by the student in relation to a corresponding prescribed learning outcome. They describe what evidence to look for to determine whether or not the student has fully met the intent of the learning outcome. Since each achievement indicator defines only one aspect of the corresponding learning outcome, the entire set of achievement indicators should be considered when determining whether students have fully met the learning outcome.

In some cases, achievement indicators may also include suggestions as to the type of task that would provide evidence of having met the learning outcome (e.g., a constructed response such as a list, comparison, analysis, or chart; a product created and presented such as a report, drama presentation, poster, letter, or model; a particular skill demonstrated such as interpreting graphs).

Achievement indicators support the principles of assessment *for* learning, assessment *as* learning, and assessment *of* learning. They provide teachers and parents with tools that can be used to reflect on what students are learning. They also provide students with a means of self-assessment and ways of defining how they can improve their own achievement.

Achievement indicators are not mandatory; they are suggestions only, provided to assist in the assessment of how well students achieve the prescribed learning outcomes.

Achievement indicators may be useful to provincial examination development teams and inform the development of exam items. However, examination questions, item formats, exemplars, rubrics, or scoring guides will not necessarily be limited to the achievement indicators as outlined in the Integrated Resource Packages.

Specifications for provincial examinations are available online at www.bced.gov.bc.ca/exams/specs/

The following pages contain the suggested achievement indicators corresponding to each prescribed learning outcome for the Physics 11 and 12 curriculum. The achievement indicators are arranged by curriculum organizer for each grade; however, this order is not intended to imply a required sequence of instruction and assessment.

STUDENT ACHIEVEMENT

Physics 11

PHYSICS 11 FORMULAE

Wave Motion and Geometrical Optics

$$\frac{1}{d_i}+\frac{1}{d_o}=\frac{1}{f} \qquad n=\frac{c}{v}$$

$$n_1\sin(\theta_1)=n_2\sin(\theta_2)$$

$$T=\frac{1}{f} \qquad v=f\lambda$$

Kinematics

$$v=\frac{\Delta d}{\Delta t} \qquad a=\frac{\Delta v}{\Delta t}$$

$$d=\overline{v}t$$

$$v=v_0+at \qquad \overline{v}=\frac{v+v_0}{2}$$

$$d=v_0t+\frac{1}{2}at^2 \qquad v^2=v_0^2+2ad$$

Forces and Dynamics

$$F_g=mg \qquad F_g=\mathrm{G}\frac{m_1m_2}{r^2}$$

$$F_{fr}=\mu F_N \qquad F=k\Delta x$$

$$F_{net}=ma$$

$$p=mv \qquad \Delta p=F_{net}\Delta t$$

Energy

$$W=Fd \qquad W=\Delta E$$

$$E_p=mgh \qquad E_k=\frac{1}{2}mv^2$$

$$P=\frac{W}{\Delta t}=\frac{\Delta E}{\Delta t}$$

$$efficiency=\frac{W_{out}}{W_{in}}=\frac{P_{out}}{P_{in}}$$

Special Relativity

$$t=\frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}} \qquad m=\frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$l=l_0\sqrt{1-\frac{v^2}{c^2}} \qquad v_{total}=\frac{v_1+v_2}{1+\frac{v_1v_2}{c^2}}$$

$$E=mc^2$$

Key Elements: Skills, Methods, and Nature of Physics

Estimated Time: integrated with other curriculum organizers

By the end of this course, students will have developed an understanding of the major areas of study within the field of physics and will be able to appropriately apply the skills and methods of physics.

Vocabulary

coefficient, intercept, inverse, inverse square, linear, slope, square, variable, verify

Knowledge

- characteristics of physics
- major areas of study in physics
- continuing development and refining of physics concepts

Skills and Attitudes

- conduct appropriate experiments
- systematically gather and organize data from experiments
- produce and interpret graphs (e.g., slope and intercept)
- verify relationships (e.g., linear, inverse, square, and inverse square) between variables
- apply mathematical models to solve a variety of problems
- use appropriate units and metric prefixes

SKILLS, METHODS, AND NATURE OF PHYSICS

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
A1 describe the nature of physics	❑ distinguish physics from related disciplines ❑ describe the major areas of study in physics (e.g., optics, kinematics, fluids, nuclear, quantum) ❑ give examples of the continuing development and refining of physics concepts
A2 apply the skills and methods of physics	❑ with teacher support, conduct appropriate experiments ❑ systematically gather and organize data from experiments ❑ produce and interpret graphs (e.g., slope and intercept) ❑ verify relationships (e.g., linear, inverse, square, and inverse square) between variables ❑ use models (e.g., physics formulae, diagrams, graphs) to solve a variety of problems ❑ use appropriate units and metric prefixes

Key Elements: Wave Motion and Geometrical Optics

Estimated Time: 18–22 hours

By the end of this course, students will understand reflection and refraction of light and its wave nature.

Vocabulary

amplitude, angle of incidence, angle of reflection, centre and radius of curvature, critical angle, diffraction, Doppler shift, focal length, focal point, frequency, image and object distance, incident ray, index of refraction, interference (superposition principle), normal, period, phase, polarization, principal axis, reflected ray, reflection, refraction, total internal reflection, wavelength, wave speed

Knowledge

- wave properties
- universal wave equation
- wave phenomena and conditions
- visible light portion of the electromagnetic spectrum
- the law of reflection
- images produced by mirrors (plane, converging, and diverging)
- curved mirrors (concave or convex)
- focal length of a concave mirror
- Snell's law
- lens (convex or concave)
- images produced by converging and diverging lenses
- focal length of a convex lens

Skills and Attitudes

- conduct appropriate experiments
- systematically gather and organize data from experiments
- produce and interpret graphs (e.g., slope and intercept)
- verify relationships (e.g., linear, inverse, square, and inverse square) between variables
- apply models (e.g., physics formulae, diagrams, graphs) to solve a variety of problems
- use appropriate units and metric prefixes

WAVE MOTION AND GEOMETRICAL OPTICS

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
B1 analyse the behaviour of light and other waves under various conditions, with reference to the properties of waves and using the universal wave equation	❑ describe the properties associated with waves, including amplitude, frequency, period, wavelength, phase, speed, and types of waves ❑ use the universal wave equation to solve problems involving speed, frequency (period), and wavelength ❑ describe and give examples of the following wave phenomena and the conditions that produce them: – reflection – refraction – diffraction – interference (superposition principle) – Doppler shift – polarization ❑ identify from an appropriate diagram the visible light portion of the electromagnetic spectrum
B2 use ray diagrams to analyse situations in which light reflects from plane and curved mirrors *Organizer 'Wave Motion and Geometrical Optics' continued on page 31*	❑ state the law of reflection ❑ identify the following on appropriate diagrams: – incident ray – reflected ray – angle of incidence – angle of reflection – normal ❑ show how an image is produced by a plane mirror ❑ describe the characteristics of an image produced by a plane mirror ❑ identify a curved mirror as converging (concave) or diverging (convex) ❑ identify the following on appropriate diagrams: – principal axis – centre and radius of curvature – image and object distance – focal point and focal length ❑ draw accurate scale diagrams for both concave and convex mirrors to show how an image is produced ❑ describe the characteristics of images produced by converging and diverging mirrors ❑ conduct an experiment to determine the focal length of a concave mirror

Prescribed Learning Outcomes	Suggested Achievement Indicators
Organizer 'Wave Motion and Geometrical Optics' continued from page 30	
B3 analyse situations in which light is refracted	❑ identify the following from appropriate diagrams: – incident ray – refracted ray – normal – angle of incidence – angle of reflection ❑ use Snell's law to solve a range of problems involving – index of refraction – angle of incidence – angle of reflection ❑ define *critical angle* and *total internal reflection* ❑ solve problems involving critical angles ❑ identify a lens as converging (convex) or diverging (concave) ❑ for a lens, identify the following from appropriate diagrams: – principal axis – focal point (primary and secondary) – focal length – image and object distance ❑ draw accurate scale diagrams for both convex and concave lenses to show how an image is produced ❑ describe the characteristics of images produced by converging and diverging lenses ❑ conduct an experiment to determine the focal length of a convex lens

Key Elements: Kinematics

Estimated Time: 18–22 hours

By the end of this course, students will be able to describe objects in motion in one dimension, using the principles of kinematics.

Vocabulary

acceleration, average velocity, constant acceleration, displacement, final velocity, instantaneous velocity, initial velocity, kinematics, scalar, speed, vector, velocity

Knowledge

- scalar and vector quantities
- distance and displacement
- speed and velocity
- initial velocity, final velocity, average velocity
- instantaneous velocity
- acceleration
- constant acceleration
- projectile motion

Skills and Attitudes

- conduct appropriate experiments
- systematically gather and organize data from experiments
- produce and interpret graphs (e.g., slope and intercept)
- verify relationships (e.g., linear, inverse, square, and inverse square) between variables
- apply models (e.g., physics formulae, diagrams, graphs) to solve a variety of problems
- use appropriate units and metric prefixes
- construct displacement-versus-time graphs
- construct velocity-versus-time graphs

KINEMATICS

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
C1 apply knowledge of the relationships between time, displacement, distance, velocity, and speed to situations involving objects in one dimension	❑ differentiate between scalar and vector quantities ❑ define *distance, displacement, speed,* and *velocity* ❑ construct displacement-versus-time graphs, based on data from various sources (e.g., from an experiment) ❑ use a displacement-versus-time graph to determine – displacement and distance – average velocity and speed – instantaneous velocity and speed ❑ solve problems involving – displacement – time – average velocity ❑ construct velocity-versus-time graphs, based on data from various sources (e.g., from an experiment) ❑ use velocity-versus-time graphs to determine – velocity – displacement – average velocity
C2 apply knowledge of the relationships between time, velocity, displacement, and acceleration to situations involving objects in one dimension	❑ define *acceleration* ❑ use velocity-versus-time graphs to determine acceleration, given appropriate data ❑ solve a range of problems for objects with constant acceleration involving – displacement – initial velocity – final velocity – acceleration – time ❑ recognize that a projectile experiences a constant downward acceleration due to gravity if friction is ignored ❑ solve projectile motion problems involving – displacement – initial velocity – final velocity – acceleration due to gravity – time

Key Elements: Forces

Estimated Time: 14–16 hours

By the end of this course, students will understand the nature of various forces, notably gravity and friction.

Vocabulary

acceleration, average velocity, change in length, coefficient of friction, constant acceleration, displacement, final velocity, force, friction, gravitational field strength, gravity, initial velocity, instantaneous velocity, kinetic, mass, scalar, static, universal gravitational constant, vector, velocity, weight

Knowledge

- mass
- force
- force due to gravity (weight)
- force due to friction (static and kinetic)
- normal force
- coefficient of friction
- inverse square law
- Newton's law of universal gravitation
- universal gravitational constant
- gravitational field strength
- Hooke's law
- spring constant
- change in length

Skills and Attitudes

- conduct appropriate experiments
- systematically gather and organize data from experiments
- produce and interpret graphs (e.g., slope and intercept)
- verify relationships (e.g., linear, inverse, square, and inverse square) between variables
- apply models (e.g., physics formulae, diagrams, graphs) to solve a variety of problems
- use appropriate units and metric prefixes

FORCES

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
D1 solve problems involving the force of gravity	❑ recognize the relationship between – mass and attractive force due to gravity (e.g., force due to gravity on the Earth's surface is proportional to Earth's mass) – the force of gravity between two objects and their distance of separation (i.e., the inverse square law) ❑ define *gravitational field strength* ❑ solve a variety of problems involving the relationship between – mass – gravitational field strength – force due to gravity (weight) ❑ use Newton's law of universal gravitation to solve problems involving – force – mass – distance of separation – universal gravitational constant
D2 analyse situations involving the force due to friction	❑ define *static friction* and *kinetic friction* ❑ define *normal force* ❑ with teacher support, conduct experiments investigating force due to friction, involving – normal force – various types of material – surface area – speed ❑ define *coefficient of friction* ❑ recognize the relationship between force due to friction and the strengths of normal force and coefficient of friction ❑ solve problems with objects sliding on horizontal surfaces, involving – force of friction – coefficient of friction – normal force
D3 apply Hooke's law to the deformation of materials	❑ state Hooke's law ❑ define *spring constant* ❑ with teacher support, conduct experiments to verify Hooke's law ❑ use Hooke's law to solve problems that involve – force – spring constant – change in length

Key Elements: Newton's Laws

Estimated Time: 9–11 hours

By the end of this course, students will be able to use an understanding of Newton's laws to describe the effects of forces on objects.

Vocabulary

acceleration, action/reaction forces, free-body diagram, inertia, mass, net force

Knowledge

- inertia
- net force
- action/reaction forces
- Newton's three laws of motion

Skills and Attitudes

- conduct appropriate experiments
- systematically gather and organize data from experiments
- produce and interpret graphs (e.g., slope and intercept)
- create free-body diagrams in one dimension
- verify relationships (e.g., linear, inverse, square, and inverse square) between variables
- apply models (e.g., physics formulae, diagrams, graphs) to solve a variety of problems
- use appropriate units and metric prefixes

NEWTON'S LAWS

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
E1 solve problems that involve application of Newton's laws of motion in one dimension	❑ state Newton's three laws of motion ❑ illustrate Newton's first and third laws with examples ❑ create free-body diagrams in one dimension for use in solving problems (e.g., elevator problems) ❑ use Newton's second law to solve problems that involve – net force – mass – acceleration ❑ apply Newton's laws and the concepts of kinematics to solve problems

Key Elements: Momentum

Estimated Time: 9–11 hours

By the end of this course, students will have an understanding of momentum and the role it plays in various collisions and explosions.

Vocabulary

collisions, explosions, impulse (change in momentum), momentum

Knowledge

- momentum (initial and final)
- impulse
- isolated, one-dimensional systems
- law of conservation of momentum
- collisions and explosions

Skills and Attitudes

- conduct appropriate experiments
- systematically gather and organize data from experiments
- produce and interpret graphs (e.g., slope and intercept)
- verify relationships (e.g., linear, inverse, square, and inverse square) between variables
- apply models (e.g., physics formulae, diagrams, graphs) to solve a variety of problems
- use appropriate units and metric prefixes

MOMENTUM

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
F1 apply the concept of momentum in one dimension	❑ define *momentum* ❑ solve a variety of problems involving – momentum – mass – velocity ❑ define *impulse* (i.e., change in momentum) ❑ solve a variety of problems involving – momentum (initial and final) – impulse – net force – time ❑ state the law of conservation of momentum for isolated, one-dimensional systems ❑ solve problems, using the law of conservation of momentum (e.g., collisions and explosions) to determine – momentum (initial and final) – velocity (initial and final) – mass

Key Elements: Energy

Estimated Time: 14–16 hours

By the end of this course, students will recognize three main forms of energy and be able to perform calculations involving the law of conservation of energy.

Vocabulary

efficiency, energy, gravitational potential energy, kinetic energy, power, specific heat capacity, temperature, thermal energy, work

Knowledge

- work
- gravitational potential energy
- height above a reference point
- kinetic energy
- thermal energy
- specific heat capacity
- temperature
- work as change in energy
- total energy
- the law of conservation of energy
- power
- work (input and output)
- efficiency

Skills and Attitudes

- conduct appropriate experiments
- systematically gather and organize data from experiments
- produce and interpret graphs (e.g., slope and intercept)
- verify relationships (e.g., linear, inverse, square, and inverse square) between variables
- apply models (e.g., physics formulae, diagrams, graphs) to solve a variety of problems
- use appropriate units and metric prefixes

ENERGY

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
G1 perform calculations involving work, force, and displacement	❑ define *work* in terms of force and displacement ❑ solve a variety of problems involving – work – force – displacement
G2 solve problems involving different forms of energy	❑ define *energy* ❑ define *gravitational potential energy* ❑ solve a variety of problems involving – gravitational potential energy – mass – acceleration due to gravity – height above a reference point ❑ define *kinetic energy* ❑ solve a variety of problems involving – kinetic energy – mass – velocity ❑ define *temperature*, *thermal energy*, and *specific heat capacity* ❑ solve a variety of problems involving – thermal energy – mass – specific heat capacity – change in temperature
G3 analyse the relationship between work and energy, with reference to the law of conservation of energy	❑ relate energy change to work done ❑ state the law of conservation of energy ❑ solve problems, using the law of conservation of energy to determine – gravitational potential energy – total energy – kinetic energy – thermal energy
G4 solve problems involving power and efficiency	❑ define *power* ❑ perform calculations involving relationships among – power – work – time – define *efficiency* ❑ perform calculations involving relationships among – work (input and output) – power (input and output) – efficiency

Key Elements: Special Relativity

Estimated Time: 4–6 hours

By the end of this course, students will understand the fundamental principles of special relativity.

Vocabulary

inertial reference frame, length contraction, mass increase, null result, relativistic mass, relativistic multiplier, rest mass, speed of light, time dilation

Knowledge

- Michelson-Morley experiment
- special theory of relativity
- relativity principle
- constancy of the speed of light
- relativistic effects of time dilation, length contraction, and mass increase
- equivalence of energy and mass
- objects not exceeding the speed of light in a vacuum
- simultaneous events

Skills and Attitudes

- conduct appropriate experiments
- systematically gather and organize data from experiments
- apply models (e.g., physics formulae, diagrams, graphs) to solve a variety of problems
- use appropriate units and metric prefixes

SPECIAL RELATIVITY

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
H1 explain the fundamental principles of special relativity	❑ define *inertial reference frame* ❑ explain why simultaneous events for one observer may not be simultaneous for another observer ❑ describe the Michelson-Morley experiment, and explain the significance of the "null result" ❑ state the two postulates of the special theory of relativity: – the relativity principle – the constancy of the speed of light ❑ describe and give examples of the relativistic effects of time dilation, length contraction, and mass increase ❑ calculate relativistic time dilation, length contraction, and mass increase ❑ explain, by using relativistic mass increase or relativistic addition of velocities, why objects cannot exceed the speed of light in a vacuum ❑ describe the equivalence of energy and mass, and solve problems involving – energy – mass – speed of light

Key Elements: Nuclear Fission and Fusion

Estimated Time: 4–6 hours

By the end of this course, students will have a basic understanding of nuclear processes.

Vocabulary

chain reaction, critical mass, fission, fusion, moderator

Knowledge

- fusion and fission reactions
- chain reaction, critical mass, and moderator
- different types of nuclear reactors
- advantages and disadvantages of using nuclear energy

Skills and Attitudes

- systematically gather and organize data
- apply models (e.g., physics formulae, diagrams, graphs) to solve a variety of problems
- use appropriate units and metric prefixes

NUCLEAR FISSION AND FUSION

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
I1 analyse nuclear processes	❑ compare fusion and fission reactions and give examples ❑ define *chain reaction*, *critical mass*, and *moderator* ❑ compare different types of nuclear reactors ❑ describe the advantages and disadvantages of using nuclear energy

Student Achievement

Physics 12

PHYSICS 12 FORMULAE

Vector Kinematics in Two Dimensions

$v = v_0 + at$ $\quad \overline{v} = \frac{v + v_0}{2}$

$v^2 = v_0^2 + 2ad$ $\quad d = v_0 t + \frac{1}{2}at^2$

Vector Dynamics

$F_{net} = ma$ $\quad F_g = mg$

$F_{fr} = \mu F_N$

Work, Energy, and Power

$W = Fd$ $\quad E_p = mgh$

$E_k = \frac{1}{2}mv^2$ $\quad P = \frac{W}{\Delta t}$

Momentum

$p = mv$ $\quad \Delta p = F_{net}\,\Delta t$

Equilibrium

$\tau = Fd$

Circular Motion

$T = \frac{1}{f}$ $\quad a_c = \frac{v^2}{r} = \frac{4\partial^2 r}{T^2}$

$F_c = ma_c$

Gravitation

$F_g = \mathrm{G}\frac{m_1 m_2}{r^2}$

Electrostatics

$F = \mathrm{k}\frac{Q_1 Q_2}{r^2}$ $\quad E = \frac{F}{Q}$ $\quad E = \mathrm{k}\frac{Q}{r^2}$

$\Delta V = \frac{\Delta E_p}{Q}$ $\quad E = \frac{\Delta V}{d}$

$E_p = \mathrm{k}\frac{Q_1 Q_2}{r}$ $\quad V = \mathrm{k}\frac{Q}{r}$

Electric Circuits

$I = \frac{Q}{\Delta t}$ $\quad V = IR$

$P = IV$ $\quad V_{terminal} = \varepsilon \pm Ir$

Electromagnetism

$F = BIl$ $\quad F = QvB$

$B = \mu_0 nI = \mu_0 \frac{N}{l} I$ $\quad \varepsilon = Blv$

$\Phi = BA$ $\quad \varepsilon = -N\frac{\Delta\Phi}{\Delta t}$

$V_{back} = \varepsilon - Ir$ $\quad \frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}$

Key Elements: Experiments and Graphical Methods

Estimated Time: integrated with other curriculum organizers

By the end of this course, students will be able to conduct experiments and apply graphical methods to the results.

Vocabulary

coefficient, intercept, inverse, inverse square, linear, proportionality constant, slope, square

Skills and Attitudes

- conduct appropriate experiments
- systematically gather and organize data from experiments
- use graphical methods to analyse results of experiments
- produce and interpret graphs (e.g., slope and intercept)
- verify relationships (e.g., linear, inverse, square, and inverse square) between variables
- use models (e.g., physics formulae, diagrams, graphs) to solve problems
- use appropriate units and metric prefixes

EXPERIMENTS AND GRAPHICAL METHODS

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
A1 conduct appropriate experiments	❑ with teacher support, conduct appropriate experiments (e.g., projectile motion, back emf from a motor, circuits, collisions) ❑ systematically gather and organize data from experiments
A2 use graphical methods to analyse results of experiments	❑ produce and interpret graphs (e.g., slope and intercept) ❑ verify relationships (e.g., linear, inverse, square, and inverse square) between variables ❑ use models (e.g., physics formulae, diagrams, graphs) to solve a variety of problems ❑ use appropriate units and metric prefixes

Key Elements: Vectors

Estimated Time: 2–3 hours

By the end of this course, students will be able to draw vector diagrams and add and subtract vectors.

Vocabulary

orthogonal components, resultant vector, scalar, vector

Knowledge

- scalars and vectors
- resolving a vector into two orthogonal components
- addition of two or more vectors
- subtraction of two vectors

Skills and Attitudes

- write vector equations and create vector diagrams
- use vector diagrams to solve problems
- verify relationships (e.g., linear, inverse, square, and inverse square) between variables
- use models (e.g., physics formulae, diagrams, graphs) to solve problems
- conduct appropriate experiments
- systematically gather and organize data from experiments
- use graphical methods to analyse results of experiments
- use appropriate units and metric prefixes

VECTORS

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
B1 perform vector analysis in one or two dimensions	❑ identify scalars and vectors ❑ resolve a vector into two orthogonal components using a diagram and/or trigonometry ❑ write equations describing the addition of two or more vectors ❑ write equations describing the subtraction of two vectors ❑ add or subtract vectors using vector diagrams and/or trigonometry ❑ identify the resultant vector on a vector diagram

Key Elements: Kinematics

Estimated Time: 6–8 hours

By the end of this course, students will be able to describe objects in motion in one or two dimensions, using the principles of kinematics.

Vocabulary

acceleration, acceleration due to gravity, average velocity, constant acceleration, displacement, final velocity, horizontal motion, horizontal velocity, initial velocity, kinematics, maximum height, projectile motion, projectile velocity, range, relative velocity, time, velocity, vertical motion, vertical velocity

Knowledge

- velocity: initial, average, final, horizontal, vertical
- navigation problems
- displacement
- acceleration due to gravity
- constant acceleration due to gravity
- shape of the path taken by a projectile fired at some angle above the horizon
- independence of horizontal and vertical motion of a projectile
- projectile motion

Skills and Attitudes

- conduct appropriate experiments
- systematically gather and organize data from experiments
- use graphical methods to analyse results of experiments
- produce and interpret graphs (e.g., slope and intercept)
- verify relationships (e.g., linear, inverse, square, and inverse square) between variables
- use models (e.g., physics formulae) to solve problems
- construct vector diagrams
- use appropriate units and metric prefixes

KINEMATICS

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
C1 apply vector analysis to solve practical navigation problems	❑ describe relative velocity ❑ determine velocities, displacement, and time of travel for navigation problems (e.g., airplanes, boats, swimmers)
C2 apply the concepts of motion to various situations where acceleration is constant	❑ solve a variety of kinematic problems involving – displacement – initial velocity – final velocity – average velocity – acceleration – time ❑ describe the shape of the path taken by a projectile fired at some angle above the horizon if friction is negligible ❑ with teacher support, conduct an experiment to establish the independence of a projectile's horizontal and vertical motion ❑ draw conclusions about a projectile's horizontal velocity and downward acceleration due to gravity if friction is discounted ❑ resolve a projectile's velocity into horizontal and vertical components ❑ solve projectile motion problems involving – range – maximum height – time of flight – displacement – velocity – acceleration due to gravity

Key Elements: Dynamics

Estimated Time: 8–10 hours

By the end of this course, students will be able to apply Newton's laws of motion to one- and two-dimensional situations.

Vocabulary

coefficient of friction, direction, dynamics, force as a vector quantity, force of friction, free-body diagrams, gravitational field strength, gravity, magnitude, net force, Newton's three laws of motion, normal force, orthogonal components, unbalanced forces

Knowledge

- Newton's three laws of motion
- net force
- gravitational field strength
- the force of gravity (weight)
- force of friction
- coefficient of friction
- normal force
- force as a vector quantity
- unbalanced forces

Skills and Attitudes

- conduct appropriate experiments
- systematically gather and organize data from experiments
- use graphical methods to analyse results of experiments
- construct vector and free-body diagrams
- verify relationships (e.g., linear, inverse, square, and inverse square) between variables
- use models (e.g., physics formulae, diagrams, graphs) to solve problems
- use appropriate units and metric prefixes

DYNAMICS

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
D1 apply Newton's laws of motion to solve problems involving acceleration, gravitational field strength, and friction	❑ state Newton's three laws of motion ❑ illustrate Newton's first and third laws with examples ❑ solve problems involving Newton's second law, to determine – net force – mass – acceleration ❑ define *gravitational field strength* ❑ solve problems involving – the force of gravity (weight) – gravitational field strength – mass ❑ solve problems involving – force of friction – coefficient of friction – normal force
D2 apply the concepts of dynamics to analyse one-dimensional or two-dimensional situations	❑ describe force as a vector quantity ❑ resolve a force into two orthogonal components ❑ determine the magnitude and direction of a force, given its two orthogonal components ❑ determine the net force from two or more forces ❑ construct free-body diagrams ❑ solve a variety of problems related to unbalanced forces (e.g., sliding objects, Atwood's machine, inclined planes)

Key Elements: Work, Energy, and Power

Estimated Time: 5–7 hours

By the end of this course, students will understand the relationship between work, energy, and power and be able to apply the law of conservation of energy.

Vocabulary

efficiency, energy, gravitational potential energy, kinetic energy, power, work

Knowledge

- work
- energy
- kinetic energy
- gravitational potential energy
- work-energy theorem
- law of conservation of energy
- power
- efficiency

Skills and Attitudes

- conduct appropriate experiments
- systematically gather and organize data from experiments
- use graphical methods to analyse results of experiments
- produce and interpret graphs (e.g., slope and intercept)
- verify relationships (e.g., linear, inverse, square, and inverse square) between variables
- use models (e.g., physics formulae, diagrams, graphs) to solve problems
- use appropriate units and metric prefixes

WORK, ENERGY, AND POWER

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
E1 analyse the relationships among work, energy, and power	❑ define *work* ❑ solve a range of problems involving – work – force – displacement ❑ determine graphically the amount of work done on objects by constant or linearly varying forces ❑ define *energy* ❑ state the work-energy theorem, $W_{net} = \Delta E_k$ ❑ differentiate between *kinetic energy* and *gravitational potential energy*, and give examples of each ❑ solve a range of problems involving – kinetic energy – mass – gravitational potential energy – height – velocity ❑ state the law of conservation of energy, and give examples of its application in a variety of situations (e.g., falling objects, sliding objects, roller coasters) ❑ define *power* ❑ solve a range problems involving – power – work – time – efficiency

Key Elements: Momentum

Estimated Time: 5–7 hours

By the end of this course, students will have an understanding of momentum and impulse and the roles they play in one- or two-dimensional collisions and explosions.

Vocabulary

change in momentum, elastic collision, impulse, inelastic collision, momentum, oblique collision

Knowledge

- momentum and impulse (change in momentum)
- momenta of common objects
- law of conservation of momentum
- oblique collisions
- elastic and inelastic collisions
- objects exploding into no more than three fragments

Skills and Attitudes

- conduct appropriate experiments
- systematically gather and organize data from experiments
- use graphical methods to analyse results of experiments
- produce and interpret graphs (e.g., slope and intercept)
- verify relationships (e.g., linear, inverse, square, and inverse square) between variables
- use models (e.g., physics formulae, diagrams, graphs) to solve problems
- construct vector diagrams
- use appropriate units and metric prefixes

MOMENTUM

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
F1 use knowledge of momentum and impulse to analyse situations in one dimension	❑ define *momentum* and *impulse* ❑ recognize that momentum and impulse are vector quantities ❑ identify and compare momenta of common objects ❑ solve a variety of problems involving – net force – time – impulse – velocity – mass – momentum ❑ state the law of conservation of momentum ❑ determine whether a collision is elastic or inelastic ❑ solve problems related to collisions or explosions, to determine – mass – initial velocity – final velocity – momentum – impulse
F2 use knowledge of momentum and impulse to analyse situations in two dimensions	❑ analyse conservation of momentum in two dimensions ❑ give examples of situations involving momentum and impulse ❑ for situations involving two objects in an oblique collision or an object exploding into no more than three fragments, solve problems to determine – mass – momentum – velocity – impulse

Key Elements: Equilibrium

Estimated Time: 11–13 hours

By the end of this course, students will understand the nature of static equilibrium.

Vocabulary

centre of gravity, lever arm, pivot point, rotational equilibrium, static equilibrium, torque, translational equilibrium

Knowledge

- translational, rotational, and static equilibrium
- pivot point
- lever arm
- torque
- centre of gravity and its location for objects of uniform shape and density

Skills and Attitudes

- conduct appropriate experiments
- systematically gather and organize data from experiments
- use graphical methods to analyse results of experiments
- produce and interpret graphs (e.g., slope and intercept)
- verify relationships (e.g., linear, inverse, square, and inverse square) between variables
- use models (e.g., physics formulae, diagrams, graphs) to solve problems
- construct vector and free-body diagrams
- use appropriate units and metric prefixes

EQUILIBRIUM

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
G1 use knowledge of force, torque, and equilibrium to analyse various situations	❑ define *translational equilibrium* ❑ identify situations involving translational, rotational, and static equilibrium ❑ use free-body diagrams and vector analyses to determine the sum of the forces acting at a single point on an object ❑ solve problems for objects in translational equilibrium ❑ define *torque*, and identify situations involving the application of torque ❑ use free-body diagrams and vector analyses to solve problems involving – torque – force – lever arm ❑ define *centre of gravity*, and determine its location for objects of uniform shape and density ❑ define *rotational equilibrium* ❑ determine the sum of the forces and of the torques on a given object ❑ define *static equilibrium* ❑ recognize that, in static equilibrium, any location can be chosen as the pivot point ❑ solve problems for objects in static equilibrium (e.g., diving boards, shelves, ladders, painters on scaffolds)

Key Elements: Circular Motion

Estimated Time: 7–9 hours

By the end of this course, students will understand the nature of circular motion and the net force associated with it.

Vocabulary

centripetal acceleration, centripetal force, frequency, period, radius of revolution, tangential velocity, uniform circular motion

Knowledge

- uniform circular motion
- radius of revolution
- period and frequency of revolution
- centripetal acceleration
- centripetal force (net force)
- forces acting on objects in circular motion
- tangential velocity

Skills and Attitudes

- conduct appropriate experiments
- systematically gather and organize data from experiments
- use graphical methods to analyse results of experiments
- verify relationships (e.g., linear, inverse, square, and inverse square) between variables
- use models (e.g., physics formulae, diagrams, graphs) to solve problems
- construct free-body diagrams
- use appropriate units and metric prefixes

CIRCULAR MOTION

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
H1 use knowledge of uniform circular motion to analyse various situations	❑ define *uniform circular motion* ❑ describe the velocity of an object moving in uniform circular motion at any point in that motion ❑ explain how the acceleration of an object may result in a change in direction with no change in speed ❑ define *centripetal acceleration* and *centripetal force* ❑ analyse the forces acting on objects in circular motion, using free-body diagrams ❑ solve problems involving – centripetal acceleration – centripetal force – speed – radius of revolution – period and frequency of revolution – mass

Key Elements: Gravitation

Estimated Time: 7–9 hours

By the end of this course, students will understand the implications of a non-constant gravitational field for work and energy.

Vocabulary

distance of separation, gravitational force, gravitational field strength, gravitational potential energy, inverse square relationship

Knowledge

- Newton's law of universal gravitation
- distance of separation
- gravitational field strength
- work required to move an object in a gravitational field
- gravitational potential energy relative to zero at infinity
- satellites in circular orbits
- total energy of a satellite

Skills and Attitudes

- systematically gather and organize data from experiments
- use graphical methods to analyse results of experiments
- produce and interpret graphs (e.g., slope and intercept)
- verify relationships (e.g., linear, inverse, square, and inverse square) between variables
- use models (e.g., physics formulae) to solve problems
- construct free-body diagrams
- use appropriate units and metric prefixes

GRAVITATION

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
I1 analyse the gravitational attraction between masses	❑ state Newton's law of universal gravitation ❑ apply Newton's law of universal gravitation to solve problems involving – force – mass – distance of separation ❑ describe the gravitational field strength of a body in terms of an inverse square relationship ❑ show the area that indicates the work required to move an object in a gravitational field on a graph of gravitational force versus distance of separation ❑ define *gravitational potential energy* ❑ solve problems involving – gravitational potential energy relative to zero at infinity – mass – distance of separation ❑ calculate the work required to change the separation distance between two objects ❑ solve problems for satellites in circular orbits, in terms of gravitational and centripetal forces (e.g., determine the period of a planet around the Sun) ❑ calculate the total energy of a satellite

Key Elements: Electrostatics

Estimated Time: 12–13 hours

By the end of this course, students will have a basic understanding of electrostatic principles and be able to apply them to solve problems.

Vocabulary

cathode ray tube, electric charge, electric field, electric field lines, electric force, electric potential, electric potential difference, electric potential energy, electrostatics, point charge, polarity, voltage

Knowledge

- Coulomb's law
- electric fields
- electric field lines
- electric potential energy
- electric potential
- electric potential difference (voltage)
- cathode ray tube

Skills and Attitudes

- conduct appropriate experiments
- systematically gather and organize data from experiments
- use graphical methods to analyse results of experiments
- produce and interpret graphs (e.g., slope and intercept)
- construct electric field diagrams
- verify relationships (e.g., linear, inverse, square, and inverse square) between variables
- use models (e.g., physics formulae, diagrams, graphs) to solve problems
- construct vector and free-body diagrams
- use appropriate units and metric prefixes

ELECTROSTATICS

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
J1 apply Coulomb's law to analyse electric forces	❑ state Coulomb's law ❑ use Coulomb's law to solve problems that deal with two point charges and that involve – electric force – charge – distance of separation ❑ determine the electric force on a point charge due to two other point charges
J2 analyse electric fields and their effects on charged objects	❑ define *electric field* ❑ describe and illustrate the electric field lines for simple charge distributions, including – one point charge – two point charges – parallel plates ❑ solve problems that deal with positions near one or two point charges and that involve – electric field – charge – distance ❑ recognize the relationship between electric force, electric field, and charge ❑ solve problems that deal with a charge in an electric field and that involve the relationship between the – force – charge – electric field
J3 calculate electric potential energy and change in electric potential energy *Organizer 'Electrostatics'* *continued on page 69*	❑ define *electric potential energy* and *change in electric potential energy* ❑ solve problems that deal with two point charges at rest and that involve – electric potential energy – charge – distance of separation ❑ solve problems that deal with two point charges where one is moved and that involve – change in electric potential energy – distance of separation (initial and final) – charge

Prescribed Learning Outcomes	Suggested Achievement Indicators
Organizer 'Electrostatics' continued from page 68	
J4 apply the concept of electric potential to analyse situations involving point charges	❑ define *electric potential* and *electric potential difference* (voltage) ❑ solve problems that deal with a position near one or two point charges and that involve – electric potential relative to zero at infinity – charge – distance ❑ solve problems that deal with two positions near one or two point charges and that involve – electric potential difference – charge – distance
J5 apply the principles of electrostatics to a variety of situations	❑ recognize that electric potential energy is the product of charge and electric potential ❑ use the law of conservation of energy to solve problems that deal with a charge in an electric field and that involve – speed – mass – charge – distance – work – electric field – electric potential difference ❑ solve problems that deal with a charge in a constant electric field (e.g., between parallel plates) and that involve – electric potential difference – electric potential energy – electric field – distance ❑ qualitatively explain the operation of a cathode ray tube (CRT)

Key Elements: Electric Circuits

Estimated Time: 12–14 hours

By the end of this course, students will be able to apply Kirchhoff's laws to simple DC circuits.

Vocabulary

ammeter, conventional electric current, current, electric power, electromotive force (emf), internal resistance, resistance, terminal voltage, voltmeter

Knowledge

- current
- voltage (electric potential difference)
- Ohm's law
- series and parallel circuits
- schematic diagrams
- placement of ammeters and voltmeters
- equivalent (total) resistance
- Kirchhoff's laws
- electromotive force
- terminal voltage
- efficiency of electric devices

Skills and Attitudes

- conduct appropriate experiments
- systematically gather and organize data from experiments
- use graphical methods to analyse results of experiments
- produce and interpret graphs (e.g., slope and intercept)
- verify relationships (e.g., linear, inverse, square, and inverse square) between variables
- use models (e.g., physics formulae) to solve problems
- draw and interpret circuit diagrams
- construct circuits from schematic diagrams
- use appropriate units and metric prefixes

ELECTRIC CIRCUITS

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
K1 apply Ohm's law and Kirchhoff's laws to direct current circuits	❑ define *conventional electric current*, and relate it to the direction of electron flow in a conductor ❑ solve problems involving – current – time – charge ❑ define *resistance* in terms of Ohm's law ❑ solve problems involving – electric potential difference – current – resistance ❑ calculate the total (equivalent) resistance for resistors connected in parallel, series, or a combination of both ❑ state Kirchhoff's laws, and apply them to circuits containing one source of electric potential difference ❑ draw and interpret circuit diagrams ❑ construct circuits from schematic diagrams ❑ demonstrate the correct placement and use of an ammeter and voltmeter ❑ define *electromotive force (emf)*, *terminal voltage*, and *internal resistance* ❑ solve problems using – terminal voltage – electromotive force (emf) – internal resistance – current – electric potential difference
K2 relate efficiency to electric power, electric potential difference, current, and resistance	❑ define *electric power* ❑ solve a range of problems involving – electric power – electric potential difference – current – resistance ❑ define *efficiency* ❑ solve a range of problems involving the efficiency of electrical devices ❑ explain why electric energy is transmitted through transmission lines at high voltage and low current

Key Elements: Electromagnetism

Estimated Time: 15–17 hours

By the end of this course, students will be able to apply an understanding of the relationship between electricity and magnetism.

Vocabulary

AC current, back emf, DC current, electromagnetic induction, electromagnetism, magnetic field line, magnetic force, magnetic flux, magnetic poles, solenoid, transformer, turns, windings

Knowledge

- magnetic poles
- magnetic field line
- magnetic force
- interaction of magnetic fields and moving charges (currents)
- solenoids
- electromagnetic induction
- magnetic flux
- change in magnetic flux
- Lenz's law
- Faraday's law
- generators
- back emf (motors)
- ideal transformers

Skills and Attitudes

- conduct appropriate experiments
- systematically gather and organize data from experiments
- use graphical methods to analyse results of experiments
- produce and interpret graphs (e.g., slope and intercept)
- verify relationships (e.g., linear, inverse, square, and inverse square) between variables
- use models (e.g., physics formulae, diagrams, graphs) to solve problems
- construct and interpret magnetic field diagrams
- use right-hand rules to determine field and force directions
- use appropriate units and metric prefixes

ELECTROMAGNETISM

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
L1 analyse electromagnetism, with reference to magnetic fields and their effects on moving charges	❑ state the rules explaining how magnetic poles interact with each other ❑ describe and illustrate the direction of the magnetic field lines for a permanent magnet ❑ use the right-hand rule to determine the magnetic field direction for a current-carrying wire or a solenoid ❑ determine the direction of the force exerted on a current-carrying conductor or a moving charge that is within a magnetic field ❑ solve problems that deal with a current-carrying conductor placed in a magnetic field and that involve – magnetic force – current – length of conductor in the field – magnetic field ❑ describe the path of charged particles moving perpendicular to magnetic fields (e.g., circles or arcs of circles) ❑ solve problems that deal with a charge moving through a magnetic field and that involve – magnetic force – charge – speed – magnetic field – centripetal force – mass – radius ❑ solve problems that deal with a solenoid and that involve – current – magnetic field (in the centre of the solenoid) – number of turns per metre of solenoid ❑ apply the principles of electromagnetism to qualitatively explain the operation of a cathode-ray tube
Organizer 'Electromagnetism' *continued on page 74*	

Prescribed Learning Outcomes	Suggested Achievement Indicators
Organizer 'Electromagnetism' continued from page 73	
L2 analyse the process of electromagnetic induction	❑ with respect to a conductor moving perpendicularly through a uniform magnetic field, solve problems involving ❑ electromotive force (emf) induced between the ends of the conductor – speed of the conductor – magnetic field – length of the conductor – define *magnetic flux* ❑ calculate the magnetic flux through a loop or coil placed parallel or perpendicular to a magnetic field ❑ identify, from appropriate diagrams, situations that would produce an induced emf in a coil ❑ use Faraday's law to solve problems involving – time – change in flux – induced emf – number of turns ❑ use Lenz's law to determine the direction of the induced current in a loop or coil placed in a perpendicular magnetic field ❑ qualitatively describe how a generator uses induction to produce an electric current ❑ define *back emf* ❑ with respect to DC motors, solve problems involving – current – back emf – armature resistance – voltage to motor ❑ give examples of current fluctuations due to back emf in motors (e.g., overheating) ❑ solve problems that deal with an ideal transformer and that involve – primary voltage – secondary voltage – number of primary windings – number of secondary windings – primary current – secondary current – identify a transformer as step-up or step-down ❑ give examples of the use of transformers in the home, workplace, and community

Learning Resources

Physics 11 and 12

This section contains general information on learning resources, and provides a link to the titles, descriptions, and ordering information for the recommended learning resources in the Physics 11 and 12 Grade Collections.

What Are Recommended Learning Resources?
Recommended learning resources are resources that have undergone a provincial evaluation process using teacher evaluators and have Minister's Order granting them provincial recommended status. These resources may include print, video, software and CD-ROMs, games and manipulatives, and other multimedia formats. They are generally materials suitable for student use, but may also include information aimed primarily at teachers.

Information about the recommended resources is organized in the format of a Grade Collection. A Grade Collection can be regarded as a "starter set" of basic resources to deliver the curriculum. In many cases, the Grade Collection provides a choice of more than one resource to support curriculum organizers, enabling teachers to select resources that best suit different teaching and learning styles. Teachers may also wish to supplement Grade Collection resources with locally approved materials.

How Can Teachers Choose Learning Resources to Meet Their Classroom Needs?
Teachers must use either:

- provincially recommended resources OR
- resources that have been evaluated through a local, board-approved process

Prior to selecting and purchasing new learning resources, an inventory of resources that are already available should be established through consultation with the school and district resource centres. The ministry also works with school districts to negotiate cost-effective access to various learning resources.

What Are the Criteria Used to Evaluate Learning Resources?
The Ministry of Education facilitates the evaluation of learning resources that support BC curricula, and that will be used by teachers and/or students for instructional and assessment purposes. Evaluation criteria focus on content, instructional design, technical considerations, and social considerations.

Additional information concerning the review and selection of learning resources is available from the ministry publication, *Evaluating, Selecting and Managing Learning Resources: A Guide* (Revised 2002)
www.bced.gov.bc.ca/irp/resdocs/esm_guide.pdf

What Funding is Available for Purchasing Learning Resources?
As part of the selection process, teachers should be aware of school and district funding policies and procedures to determine how much money is available for their needs. Funding for various purposes, including the purchase of learning resources, is provided to school districts. Learning resource selection should be viewed as an ongoing process that requires a determination of needs, as well as long-term planning to co-ordinate individual goals and local priorities.

What Kinds of Resources Are Found in a Grade Collection?
The Grade Collection charts list the recommended learning resources by media format, showing links to the curriculum organizers and suborganizers. Each chart is followed by an annotated bibliography. Teachers should check with suppliers for complete and up-to-date ordering information. Most suppliers maintain web sites that are easy to access.

PHYSICS 11 AND 12 GRADE COLLECTIONS

The Grade Collections for Physics 11 and 12 list the recommended learning resources for these courses. Resources previously recommended for the 1996 version of the curriculum, where still valid, continue to support this updated IRP. The ministry updates the Grade Collections on a regular basis as new resources are developed and evaluated.

Please check the following ministry web site for the most current list of recommended learning resources in the Physics 11 and 12 Grade Collections: www.bced.gov.bc.ca/irp_resources/lr/resource/gradcoll.htm