This document was written primarily for:

<p>| | |</p>
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<thead>
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<tbody>
<tr>
<td>Students</td>
<td></td>
</tr>
<tr>
<td>Teachers</td>
<td>✓ of Science 30</td>
</tr>
<tr>
<td>Administrators</td>
<td>✓</td>
</tr>
<tr>
<td>Parents</td>
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</tr>
<tr>
<td>General Audience</td>
<td></td>
</tr>
<tr>
<td>Others</td>
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</tr>
</tbody>
</table>

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# Contents

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>How to Get Involved</td>
<td>1</td>
</tr>
<tr>
<td>Diploma Examination Weighting</td>
<td>1</td>
</tr>
<tr>
<td>Time Limits on Diploma Examinations</td>
<td>1</td>
</tr>
<tr>
<td>Science 30 Available in French</td>
<td>2</td>
</tr>
<tr>
<td>Course Objectives</td>
<td>2</td>
</tr>
<tr>
<td>Development of Resources to Support the Program of Studies</td>
<td>3</td>
</tr>
<tr>
<td>Performance Expectations</td>
<td>4</td>
</tr>
<tr>
<td>Cognitive Expectations in the Program of Studies</td>
<td>5</td>
</tr>
<tr>
<td>Examination Specifications and Design</td>
<td>7</td>
</tr>
<tr>
<td>Diploma Examinations: Multiple Forms</td>
<td>10</td>
</tr>
<tr>
<td>Maintaining Consistent Standards over Time in Diploma Examinations</td>
<td>11</td>
</tr>
<tr>
<td>Examination Security</td>
<td>11</td>
</tr>
<tr>
<td>Field Testing</td>
<td>12</td>
</tr>
<tr>
<td>Benefits of Field Tests</td>
<td>12</td>
</tr>
<tr>
<td>Special-format Practice Tests</td>
<td>14</td>
</tr>
<tr>
<td>WHMIS 2015</td>
<td>15</td>
</tr>
<tr>
<td>Publications and Supporting Documents</td>
<td>16</td>
</tr>
<tr>
<td>Sample Instructions Pages from the Science 30 Diploma Examination</td>
<td>18</td>
</tr>
<tr>
<td>Assessment of Science, Technology, and Society (STS)</td>
<td>21</td>
</tr>
<tr>
<td>Connections and Communication Skills</td>
<td>21</td>
</tr>
<tr>
<td>Depth of Coverage</td>
<td>24</td>
</tr>
<tr>
<td>Assessment Highlights</td>
<td>78</td>
</tr>
<tr>
<td>Science 30 Sample Examinations</td>
<td>79</td>
</tr>
<tr>
<td>Data Booklet</td>
<td>80</td>
</tr>
<tr>
<td>Ordering Science 30 Print Resources</td>
<td>80</td>
</tr>
<tr>
<td>Using Calculators</td>
<td>80</td>
</tr>
<tr>
<td>Website Links</td>
<td>81</td>
</tr>
<tr>
<td>Contacts 2018–2019</td>
<td>82</td>
</tr>
</tbody>
</table>

Please note that if you cannot access one of the direct links referred to in this document, you can find diploma examination-related materials on the [Alberta Education website](https://www.edu.gov.ab.ca).
How to Get Involved

High-quality diploma examinations are the product of close collaboration between classroom teachers and Alberta Education. Classroom teachers from across Alberta are involved in many aspects of diploma examination development, including the development of raw items; the building, reviewing, administering, and marking of field tests; the reviewing and validating of diploma examinations; and the marking of diploma examinations.

The development of test items from when they are written until when they appear on an examination takes at least one year, if not longer. The writers of all items on Science 30 diploma examinations are Science 30 teachers from across Alberta. After the first year of provincial implementation, items are field tested to ensure their reliability and validity. Diploma examinations are reviewed by editors; a technical advisory working group composed of mathematics experts from post-secondary institutions, teachers, and curriculum staff; translators; and a French validation working group.

Alberta Education values the involvement of the teachers and annually asks school jurisdictions for the names of teachers who are interested in being involved in all of the development processes for diploma examinations. Teachers who are interested in developing raw items, constructing field tests, or reviewing and validating examinations are encouraged to talk to their principals about how they can submit their names for approval to be involved in these processes. Although the call for submission occurs in early fall, teachers are welcome to have their names submitted at any time.

Periodically, we send out information to those Science 30 teachers who are on our contact list. If you are not on that list and would like to become involved in Science 30 events, contact either Stan Bissell, Science 30 Exam Manager, at Stan.Bissell@gov.ab.ca or Mark Haak, Science 30 Examiner, at Mark.Haak@gov.ab.ca.

Diploma Examination Weighting

On September 1, 2015, the diploma examination weighting shifted from a 50/50 weighting to a 70/30 weighting, where the school-awarded grades are worth 70 percent. For further information, please refer to Marks, Results, and Appeals.

Time Limits on Diploma Examinations

All students may now use extra time to write diploma exams. This means that all students now have up to 6 hours to complete the Science 30 Diploma Examination, if they need it. The examination is still designed so that the majority of students can comfortably complete it within 3 hours. The examination instructions state both the original time and the total time now available.

Extra time is available for diploma examinations in all subjects, but the total time allowed is not the same in all subjects. For more information about accommodations and provisions for students, please refer to the General Information Bulletin.
Science 30 Available in French

The Science 20–30 Program of Studies (French) has been available for implementation in Alberta schools since 2015–2016. For this academic year, the Science 30 Diploma Examination will be offered in French in January 2019, June 2019, and August 2019.

Course Objectives

Science 30 is designed for students who want to enhance their understanding of the scientific principles behind the natural events of their world and the technology that they use in their daily lives. Science 30 is an inquiry-based course designed to provide students with the scientific literacy required to function in a technological society and to prepare them for post-secondary studies.

Students of Science 30 will develop their skills for observing, collecting data, forming generalizations, hypothesizing, and making inferences from observations. They will show growth in their understanding of scientific concepts by their ability to apply these concepts to relevant situations. They will develop a global view of the sciences as well as an awareness of the connections between them.

Experience in science courses, particularly Science 10 and Science 20, enables students to develop the knowledge, skills, and attitudes that facilitate success in Science 30. The Guide to Education states that “students who have passed Biology 20, Chemistry 20, Physics 20, or Science 20 may enroll in Science 30.”

The number of students completing Science 30 continues to rise. In the 2017–2018 school year, more than 10,000 diploma examinations were administered, which represents an increase from the previous year. The increase in participation is partially due to a larger number of schools offering the program and greater acceptance of Science 30 by post-secondary institutions. Schools and teachers new to the program are invited to contact the Science 30 Exam Manager, Stan Bissell, at Stan.Bissell@gov.ab.ca for additional information about the Science 30 Diploma Examination or to indicate their interest in participating on examination development committees.

Curriculum Standards

Provincial standards help to communicate the level at which students need to perform to achieve the learning outcomes specified for Science 30. Student learning outcomes refer to specific knowledge, skill, and attitude expectations. The Science Programs of Study detail these expectations. The Science 10, 20, and 30 Programs of Study are available online.

Details regarding these learning outcomes are outlined in the Depth of Coverage section beginning on page 24 of this bulletin. These specific statements of standards are written primarily to inform Science 30 teachers about the extent to which students must master the Science 30 content and demonstrate the required skills in order to meet the standards of the Science 30 Program of Studies and diploma examination.
Development of Resources to Support the Program of Studies

A new Program of Studies for Science 30 was implemented in 2007–2008. Alberta Education has developed a collaborative, innovative resource package to support the revised Science 20 and 30 programs (only in English). The package includes a variety of resources to support teaching and learning.

Resources available:
• Science 30: Student Textbook (includes CD-ROMs), 2007

The student textbook was authored by Science 30 teachers in Alberta and published by Alberta Education. The textbook has been carefully designed to reflect the philosophy of this unique program.

The student textbook contains two CDs with multimedia segments, digital activities supporting related ICT outcomes, detailed answer keys to support textbook activities, digital copies of handouts, and a special folder for students involved in alternative learning environments such as distance learning, blended programs, and virtual school programs.

A comprehensive, digital Science 30 Teacher Resource Guide is also available. The TRG includes extensive support for assessment. Teachers will be able to print handouts from the PDF documents or customize them from the HTML versions provided. This digital resource also includes a distance learning teacher guide folder to support teachers instructing in that environment.

The Science 20 textbook and Science 30 textbook digital files can be accessed on the LearnAlberta website. They can be found under the T4T Courses tab. For further information on these two files, or for assistance, use the Contact Us feature on the LearnAlberta website.
Performance Expectations

Acceptable Standard

Students who achieve the acceptable standard in Science 30 receive a final course mark of 50% to 79%. These students are able to state or solve single-step problems and correctly answer questions involving concepts from specified areas of science. These students are able to follow correct laboratory procedures when given specific directions. When presented with data, they can make connections to the scientific concepts and laboratory activities taught in class. Drawing a graph from experimental data or reading values from a graph does not present a problem for these students. They can use Information and Communication Technology (ICT) skills to gather, manipulate, and communicate information. They use their scientific knowledge to explain the operation and significance of various technologies studied in Science 30. Finally, they are able to present arguments about societal issues such as environmental and ethical concerns related to Science 30 content.

Standard of Excellence

Students who achieve the standard of excellence in Science 30 receive a final course mark of 80% or higher. They have demonstrated their knowledge, ability, and literacy in a broad range of science areas. These students can integrate concepts from many areas of science. They demonstrate creativity and flexibility in solving multistep problems. They are able to design or refine laboratory procedures to demonstrate scientific principles or solve scientific problems. They can use ICT skills to gather, manipulate, and communicate effectively. And they can critically analyze scientific studies, including associated charts, graphs, and conclusions. These students are aware of the variety of viewpoints related to environmental and ethical issues in the fields of science and technology. They are able to clearly express their informed opinions regarding these issues.
Cognitive Expectations in the Program of Studies

Outcomes in the program of studies contain verbs that indicate the cognitive expectations of the outcome. Verbs typically classified under the understanding and remembering levels are coded yellow in the chart below; verbs typically classified under the applying level are coded green; verbs typically classified as higher mental activities (HMA) are coded blue; and those relating to skills are coded pink.

*Verbs can have multiple connotations and can therefore indicate more than one cognitive level. The cognitive expectation is communicated by the context.

The following graphic shows the same information arranged in a hierarchy, which is the arrangement used in the revised Bloom’s taxonomy.

- The verbs arranged in the graphics shown above are only those that have been used in the Science 30 Program of Studies. It is important to remember that the graphics should serve only as a guideline and that the verbs are not permanently fixed in the categories shown. A verb can indicate a variety of cognitive levels depending on the context in which it is used, and the two taken together are what determines the cognitive expectation.

- Note that difficulty is independent of cognitive level. Outcomes at any of the three cognitive levels can be assessed at either the acceptable standard or at the standard of excellence.


**Examination Specifications and Design**

Each Science 30 Diploma Examination is designed to reflect the Science 30 general outcomes (GOs) outlined in the *Science 20–30 Program of Studies, 2007*. The GOs are expressed in more detail by the specific outcomes (SOs), which are organized into the following categories: Outcomes for Knowledge (K); Outcomes for Science, Technology and Society (STS); and Outcomes for Skills (S). Some diploma examination questions will assess achievement of specific outcomes. Some questions will be based on the integration of the specific outcomes.

Examination questions may be organized into sets that relate to broad contexts. Therefore, a set of questions may assess a student’s ability to integrate several GOs.

Each examination is built as closely as possible to these specifications. Small adjustments in emphasis may be necessary because the examination includes machine-scored questions that cover more than one concept area. The concept areas are distributed proportionately over the examination. Questions that require knowledge, STS, and skills in applying scientific processes are distributed throughout the examination but are not associated directly with specific topics.

**General Outcomes**

<table>
<thead>
<tr>
<th>GO</th>
<th>Emphasis (Curricular Fit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1/A2</td>
<td>Circulatory and immune systems</td>
</tr>
<tr>
<td>A3</td>
<td>Genetics</td>
</tr>
<tr>
<td>B1/B2/B3</td>
<td>Environmental chemistry</td>
</tr>
<tr>
<td>C1</td>
<td>Field theory and electrical energy</td>
</tr>
<tr>
<td>C2</td>
<td>Electromagnetic spectrum</td>
</tr>
<tr>
<td>D1/D2</td>
<td>Energy and the environment</td>
</tr>
</tbody>
</table>
The Science 30 Diploma Examinations are constructed to place the following approximate emphases on the Science 30 GOs.

<table>
<thead>
<tr>
<th>Knowledge (K)</th>
<th>Emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>The student can</td>
<td></td>
</tr>
<tr>
<td>• analyze the function of the circulatory and immune systems in maintaining</td>
<td>10–15%</td>
</tr>
<tr>
<td>human health (Unit A, GO A1 and A2)</td>
<td></td>
</tr>
<tr>
<td>• apply the principles of heredity and molecular genetics to human diseases</td>
<td>10–15%</td>
</tr>
<tr>
<td>and technological applications (Unit A, GO A3)</td>
<td></td>
</tr>
<tr>
<td>• analyze the risks and benefits of the production and use of acids, bases,</td>
<td>20–30%</td>
</tr>
<tr>
<td>organic compounds, and chemical technologies (Unit B, GO B1, B2, and B3)</td>
<td></td>
</tr>
<tr>
<td>• explain and analyze the applications of field theory used to produce and</td>
<td>13–18%</td>
</tr>
<tr>
<td>transform electrical energy (Unit C, GO C1)</td>
<td></td>
</tr>
<tr>
<td>• describe the properties and applications of electromagnetic radiation in</td>
<td>7–12%</td>
</tr>
<tr>
<td>medical technologies, communication systems, and the study of the universe</td>
<td></td>
</tr>
<tr>
<td>(Unit C, GO C2)</td>
<td></td>
</tr>
<tr>
<td>• explain the origin and use of conventional and alternative energy technologies and the need to maintain a viable biosphere (Unit D, GO D1 and D2)</td>
<td>20–30%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Science, Technology, and Society Connections (STS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The student can</td>
</tr>
<tr>
<td>• apply cause-and-effect reasoning to formulate relationships in which</td>
</tr>
<tr>
<td>scientific evidence shapes or refutes a theory, and explain the limitations</td>
</tr>
<tr>
<td>of science and technology in answering all questions and solving all</td>
</tr>
<tr>
<td>problems</td>
</tr>
<tr>
<td>• describe and evaluate the design and function of technological solutions to</td>
</tr>
<tr>
<td>practical problems by using scientific principles and theories, and relate</td>
</tr>
<tr>
<td>the ways in which science and technology advance each other</td>
</tr>
<tr>
<td>• evaluate from a variety of perspectives how science and technology are</td>
</tr>
<tr>
<td>influenced and supported by society, and assess the ability of society to</td>
</tr>
<tr>
<td>interact responsibly with the environment</td>
</tr>
<tr>
<td>• apply the skills and knowledge acquired in Science 30 to everyday life and</td>
</tr>
<tr>
<td>to both related and new concepts in post-secondary studies</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scientific Process and Communication Skills (S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The student can</td>
</tr>
<tr>
<td>• design, interpret, explain, analyze, and evaluate investigations</td>
</tr>
<tr>
<td>• organize data into tables, graphs, and diagrams, and predict relationships</td>
</tr>
<tr>
<td>• interpret, explain, analyze, and evaluate data to infer relationships</td>
</tr>
<tr>
<td>• use appropriate scientific terminology and mathematical language to</td>
</tr>
<tr>
<td>communicate and explain scientific concepts</td>
</tr>
</tbody>
</table>
The Science 30 Diploma Examination consists of 55 machine-scored questions worth 100% of the examination mark. The design of the Science 30 Diploma Examinations is as follows:

<table>
<thead>
<tr>
<th>Question Format</th>
<th>Number of Questions</th>
<th>Percentage Emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple Choice</td>
<td>39</td>
<td>71</td>
</tr>
<tr>
<td>Numerical Response</td>
<td>16</td>
<td>29</td>
</tr>
</tbody>
</table>

**Machine-scored Questions**

Each examination contains both multiple-choice and numerical-response questions.

Answers for multiple-choice questions are recorded in the first section of the machine-scored answer sheet. Answers for numerical-response questions are recorded in the second section on the same side of the machine-scored answer sheet.

**Multiple-choice questions** are of two types: discrete and context-dependent. A discrete question stands on its own without any additional directions or information. The item may take the form of a question or an incomplete statement. A context-dependent question provides information separate from the question stem. Most of the multiple-choice questions are context-dependent.

A particular context may be used for more than one multiple-choice question as well as for more than one numerical-response question.

**Numerical-response questions** are of three types: calculation of numerical values; selection and/or matching numbered events, structures, or functions from a diagram or list; and determination of the sequence of listed events.
Diploma Examinations: Multiple Forms

As part of Alberta Education’s commitment to fairness to students and flexibility in the writing of diploma examinations, there are two distinct forms (versions) of diploma examinations in some subjects during major administrations (January and June). The two forms are equated to baseline examinations to ensure that the same standard applies to both forms. Both forms adhere to the established blueprint specifications and are thoroughly reviewed by a technical review committee.

To facilitate the analysis of school-level results, each school receives only one examination form per subject. In subjects offering a translated French-language examination, both forms are administered in English and in French.

For more information, contact

Deanna Shostak  
Director, Diploma Programs  
780-422-5160 or Deanna.Shostak@gov.ab.ca

or

Pascal Couture  
Director, Exam Administration  
780-492-1462 or Pascal.Couture@gov.ab.ca
Maintaining Consistent Standards over Time in Diploma Examinations

A goal of Alberta Education is to make examinations directly comparable from session to session, thereby enhancing fairness to students across administrations.

To achieve this goal, a number of questions, called anchor items, remain the same from one examination to the next. Anchor items are used to find out if the student population writing in one administration differs in achievement from the student population writing in another administration. Anchor items are also used to find out if the unique items (questions that are different on each examination) differ in difficulty from the unique items on the baseline examination (the first examination to use anchor items). A statistical process, called equating, adjusts for the differences in examination form difficulty. Examination marks may be adjusted slightly upward or downward, depending upon the difficulty of the examination written relative to the baseline examination. The resulting equated examination scores have the same meaning regardless of when and to whom the examination was administered. Equated diploma examination marks will be reported to students.

Because of the security required to enable fair and appropriate assessment of student achievement over time, some diploma examinations may have to be fully secured on occasion and will not be released at the time of writing. Please check the General Information Bulletin. You can also check the information bulletins for each diploma subject you teach to determine which, if any, examinations are fully secured. For more information about equating or linking, please go to the Alberta Education website under Maintaining Consistent Standards Through Equating.

Examination Security

All Science 30 Diploma Examinations will be held secure until they are released to the public by the Minister. No secure diploma examination is to be previewed, discussed, copied, or removed from the room in which the examination is being written. However, for the January and June examinations, teachers will be allowed access to a digital Teacher Perusal Copy for review purposes one hour after the examination has started. For more information about teacher perusal copies and examination security, please refer to the General Information Bulletin. Unused copies of the examination must be returned to Alberta Education.

As indicated in the Diploma Examinations Program General Information Bulletin, data booklets used by students may remain in the school after the administration of the examinations.
Field Testing

Online Field Testing

All Grade 12 science and mathematics field tests are offered exclusively through the Quest A+ online delivery system. In addition to digital field tests, hybrid field tests are also available this school year. With a hybrid field test, students receive a paper copy of the test but must respond to the questions online.

Students should use paper data booklets, data pages, or formula sheets for all science and mathematics field tests. These resources will also appear in the online delivery system. Students should also have scrap paper, which may be accessed and downloaded from the “Teacher Resources” section on the home page of the Field Test Request System. All paper data sheets or scrap paper with markings must be securely shredded at the end of the field test administration.

Teachers have a 24-hour window to peruse the digital or hybrid field test and are provided with data on how their students performed. These data include the proportion of students who chose each alternative on multiple-choice items and the proportion who left a numerical-response item blank. Test items are blueprinted to program of studies outcomes. This allows teachers to use field test results to learn more about their students’ strengths and weaknesses.

Once logged into the digital or hybrid field test on the online delivery system, teachers have the same length of time to peruse the test as their students did to write it. Teachers might choose to log into the field test, submit the confidentiality form, and then log out of the test, so that they can finish perusing the test after receiving their students’ data.

In addition, teachers have greater flexibility in selecting the time and date when students write, rather than being bound to a pre-determined date.

Finally, online administration enables every school, large or small, to participate. Historically, it was impractical to send field-test administrators to remotely located schools, or schools with small classes. Now, all Alberta schools can participate in field tests.

It is important to note that the security of field test items remains vital to the administration of diploma examinations. Participating teachers must commit to maintaining the security of field-test items. In the case of hybrid field tests, paper copies are mailed to schools and the questions are accessed in the same format as digital-format field tests. Prior to the hybrid field test, the paper copies must be kept secure by the school principal. After the administration of a hybrid-format field test, teachers must mail all paper copies back to Alberta Education.

Benefits of Field Tests

How do field tests help teachers and students?

Teachers receive each student’s score promptly, gaining useful, immediate information about their students’ levels of expertise and knowledge. Students also benefit from writing a test that duplicates some of the experience of writing a diploma examination. Field tests provide students and teachers with good examples of the style and content of questions that may appear on diploma examinations. Finally, because of field testing, students, teachers, and parents can be reassured that the questions on diploma examinations have undergone a rigorous process of development, improvement, and validation.

Why are field tests necessary?
Field testing is an absolutely essential stage in the development of fair, valid, and reliable provincial examinations. Field testing is basically a process of “testing a test” and “testing questions” before they become part of a diploma examination. Potential diploma examination questions are administered to students in diploma courses throughout the province to determine their difficulty level and appropriateness. Ideally, each field test requires a large student sample to provide the examination developers with reliable information (statistical data and written validation comments from teachers and students).

**How are field test data used?**

The data received from field tests show the reliability of each question. Sometimes, after one field test round, it is clear that certain questions work very well in terms of fairness, validity, and appropriateness to course content. These questions then move into the diploma examination bank to be used at a future date.

Other questions or sets of questions may not perform as well as we require. These questions are subject to revision and review, and retested in a second or third field test with the aim of generating questions that meet our standards. These changes are influenced by the written comments of students and teachers, who provide valuable advice about the appropriateness of the questions, adequacy of writing-time limits, test length, text readability, artwork/graphics clarity and suitability, and question difficulty.

**Further Information**

Teachers requesting field tests must have a Public Authentication System (PAS) account. All requests are made through the Field Test Request System. Further information, including the closing dates to request a field test, may be obtained by contacting Field.Test@gov.ab.ca, or from the General Information Bulletin. Practice tests are available online.

For more information, contact

Deanna Shostak  
Director, Diploma Programs  
780-422-5160 or Deanna.Shostak@gov.ab.ca

or

Pascal Couture  
Director, Exam Administration  
780-492-1462 or Pascal.Couture@gov.ab.ca
**Special-format Practice Tests**

To provide students an opportunity to practise diploma examination-style questions and content in Braille, audio, large print, or coloured print versions, Alberta Education is making special-format practice tests available. Tests are offered in all subjects with a corresponding diploma examination. Alberta schools with registered Alberta K–12 students may place orders for these tests. Braille tests are available in English, and by request in French. All tests are provided free of charge, but limits may be placed on order volumes to ensure access for everyone.

For more information or to place an order, contact

Laura LaFramboise  
Distribution Coordinator, Exam Administration  
780-492-1644 or Laura.LaFramboise@gov.ab.ca
**WHMIS 2015**

The workplace hazardous materials information system (WHMIS) has been used in Canada since 1988 for the labelling and classification of hazardous workplace chemicals. The Globally Harmonized System of Classification and Labelling of Chemicals (GHS) is being adopted by countries around the world in order to enable a consistent international chemical classification and labelling system. WHMIS 1988 in Canada was amended in February 2015 to incorporate the GHS. The new system is called WHMIS 2015.

*NEW* Any WHMIS pictograms that appear on provincial assessments will be WHMIS 2015 pictograms.

<table>
<thead>
<tr>
<th>WHMIS 2015</th>
<th>Flame</th>
<th>Flame Over Circle</th>
<th>Gas Cylinder</th>
</tr>
</thead>
<tbody>
<tr>
<td>For fire hazards</td>
<td>For oxidizing hazards</td>
<td>Gas Under Pressure</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exploding Bomb</th>
<th>Biohazardous Infectious Materials</th>
<th>Corrosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>For explosive or reactivity hazards</td>
<td>For organism that can cause diseases in people or animals</td>
<td>For corrosive damage to metals, as well as skin, eyes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exclamation Mark</th>
<th>Health Hazard</th>
<th>Skull and Crossbones</th>
</tr>
</thead>
<tbody>
<tr>
<td>May cause less serious health effects</td>
<td>May cause or suspected of causing serious health effects</td>
<td>Can cause death or toxicity with short exposure to small amounts</td>
</tr>
</tbody>
</table>
Publications and Supporting Documents

The following documents are produced to provide teachers with information about the Science 30 Diploma Examination:

- **Science 30 Released Items**
  Released materials are sent to schools but can also be found on the Alberta Education website. Additional practice tests are available online under the “Practice Tests” tab.
- **Science 30 Information Bulletin**
- **Instructional Group Reports** for January and June Diploma Examinations are here.

Item descriptions are located in Table 7 of the Instructional Group Report, which follows the January and June examination sessions. A sample of the format for Table 7 appears on the next page.
Instructional Group Report—Table 7

Table 7.1
Science 30
Raw Score Results, by Reporting Category for Machine-Scored Items

<table>
<thead>
<tr>
<th>Reporting Category</th>
<th>Total Marks Possible</th>
<th>Average Raw Score Prov.</th>
<th>Average Raw Score School</th>
<th>Standard Deviation Prov.</th>
<th>Standard Deviation School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circulatory and immune systems (GO A1/A2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genetics (GO A3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental chemistry (GO B1/B2/B3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field theory and electrical energy (GO C1/C2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electromagnetic spectrum (GO C3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy and the environment (GO D1/D2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7.2
Science 30
Results, Blueprint Classifications, and Item Descriptions, by Item

<table>
<thead>
<tr>
<th>Item #</th>
<th>% Correct Prov.</th>
<th>% Correct Sch.</th>
<th>Knowledge</th>
<th>Skill</th>
<th>STS</th>
<th>Item Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NR3</td>
<td>28.8</td>
<td>21.7</td>
<td></td>
<td>A2.2s</td>
<td></td>
<td>Match descriptions of a study with the manipulated, responding, and controlled variables.</td>
</tr>
<tr>
<td>9</td>
<td>75.0</td>
<td>78.3</td>
<td>A1.2k</td>
<td>A1.2s</td>
<td></td>
<td>Relate the activity of the heart to blood pressure readings.</td>
</tr>
<tr>
<td>10</td>
<td>76.9</td>
<td>76.5</td>
<td>A1.4k</td>
<td>STS</td>
<td></td>
<td>Identify a particular component of blood that is affected by a dietary substance in the context of A1.1sts.</td>
</tr>
<tr>
<td>11</td>
<td>80.7</td>
<td>69.6</td>
<td>B1.7k</td>
<td>STS</td>
<td></td>
<td>Predict the environmental effect of a particular technology; assessing B1.2sts.</td>
</tr>
</tbody>
</table>

Note: The reporting categories Knowledge (K); Skill (S); and Science, technology and society (STS) refer to curricular outcomes only. Items in each reporting category cover a range of cognitive levels.
Sample Instructions Pages from the Science 30 Diploma Examination

Some numerical-response questions that involve calculation may require students to indicate values expressed in scientific notation.

Scientific Notation Question and Solution

**Numerical Response**

1. The speed of light, expressed in scientific notation, is $a.bc \times 10^d \text{ m/s}$. The values of $a$, $b$, $c$, and $d$ are $\underline{\_\_\_\_}$, $\underline{\_\_\_\_}$, $\underline{\_\_\_\_}$, and $\underline{\_\_\_\_}$.

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

**Answer:** $c = 3.00 \times 10^8 \text{ m/s}$

$\underline{3, 0, 0, 8}$

**Record:** Record 3008 on the answer sheet

$\begin{array}{cccc}
\text{3} & \text{0} & \text{0} & \text{8} \\
\text{0} & \text{0} & \text{0} & \text{0} \\
\text{0} & \text{0} & \text{0} & \text{0} \\
\text{0} & \text{0} & \text{0} & \text{0} \\
\text{0} & \text{0} & \text{0} & \text{0} \\
\text{0} & \text{0} & \text{0} & \text{0} \\
\text{0} & \text{0} & \text{0} & \text{0} \\
\text{0} & \text{0} & \text{0} & \text{0} \\
\end{array}$
Some numerical-response questions will involve the sequencing or ordering of events or lists.

**Correct-order Question and Solution**

*Use the following information to answer numerical-response question 2.*

<table>
<thead>
<tr>
<th>Four Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Physics</td>
</tr>
<tr>
<td>2 Biology</td>
</tr>
<tr>
<td>3 Science</td>
</tr>
<tr>
<td>4 Chemistry</td>
</tr>
</tbody>
</table>

**Numerical Response**

2. When the subjects above are arranged in alphabetical order, their order is _____, _____, _____, and _____.

   (Record all four digits of your answer in the numerical-response section on the answer sheet.)

**Answer:**

2413

2, 4, 1, 3

**Record:**

Record 2413 on the answer sheet
A numerical-response format where more than one answer is accepted makes it possible for students to demonstrate knowledge and skills from different areas of the program of studies. Some questions using this format allow students to demonstrate knowledge of optional outcomes that are in italics in the program of studies.

Correct-order Matching Question and Solution

Use the following information to answer numerical-response question 3.

<table>
<thead>
<tr>
<th>Sense</th>
<th>Organ</th>
<th>Type of Stimulus Detected by Organ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hearing</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Smell</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Vision</td>
<td>6</td>
</tr>
</tbody>
</table>

Numerical Response

3. Using the numbers above, choose one sense and match it with the organ associated with that sense and with the type of stimulus detected by that organ. (There is more than one correct answer.)

   Sense  _________ (Record in the first column)
   Organ    _________ (Record in the second column)
   Stimulus _________ (Record in the third column)

   (Record your answer in the numerical-response section on the answer sheet.)

Answer: 169 or 248 or 357

1, 6, 9, ___

Record: Record 169 on the answer sheet

Record 248 or 357 in the same manner.
Assessment of Science, Technology, and Society (STS) Connections and Communication Skills

Examination questions measure students’ understanding of scientific concepts. Some questions also measure students’ development of the skills and thinking processes associated with scientific inquiry. Other questions have been designed to measure students’ understanding of the interrelationships between science, technology, and society (STS).

The term communication skills includes those processes by which information is expressed using appropriate conventions. These conventions include

- graphs, diagrams, tables
- mathematical formulas, mathematical and chemical equations
- significant digits, units of measurement, unit conversions

STS-based questions present a problem that requires students to make connections between scientific concepts, technology, and/or social issues. STS-based questions often assess more than one outcome. The sample question below assesses outcomes D1.5k, D2.4k, and D2.1sts.

Sample Question

Use the following information to answer numerical-response question 1.

Some Arguments Concerning Biomass Fuels

1. Farming can have negative impacts on ecosystems, including soil depletion and pesticide contamination of water systems.
2. Using supplies of corn, wheat, and other crops for biomass fuels may drive up the cost of food.
3. Growing crops for use in biomass fuels will rejuvenate the farming industries, bringing a return to more traditional ways of life.
4. Governments should require farmers to grow crops for use in biomass fuels.

Numerical Response

1. Match each of the arguments numbered above with the perspective that best describes the argument listed below. (Use each number only once.)

   Political
   Economic
   Societal
   Environmental

(Record in the first, second, third, and fourth columns, respectively.)

(Record your answer in the numerical-response section on the answer sheet.)

(The answer is 4231.)
Students may be asked to identify the graph that best represents a set of data or the appropriate formula to solve a problem.

Sample Question

2. One formula that can be used to determine the electric field strength at a given distance from a charged particle is

A. \( v = f\lambda \)

B. \( V = IR \)

C. \( |E| = \frac{kq}{r^2} \)

D. \( \Delta E = \Delta mc^2 \)

(The answer is C.)
Skill-based questions present a problem that requires students to utilize techniques and procedures developed during scientific inquiry. These questions may include descriptions of laboratory procedures or a synopsis of a research project or study for students to evaluate. Pertinent data may be provided in the form of graphs and/or tables. Students may be asked to identify the variables or constraints of a study or to identify a study that would be most appropriate to address a particular situation.

Sample Question

*Use the following information to answer numerical-response question 3.*

To determine the effect of acid deposition on corn plants, an acid solution with a pH of 4.3 was used to water a plot of two-month-old corn plants. More corn plants were grown on another plot under similar conditions but were watered with distilled water that had a pH of 7.0.

**Experimental Conditions**

1. Type of soil
2. Light exposure
3. Growth of plant
4. Substance used to water plants

**Numerical Response**

3. Match each of the experimental conditions numbered above with one of the variables given below. (There is more than one correct answer.)

<table>
<thead>
<tr>
<th>Conditions:</th>
<th>Manipulated variable</th>
<th>Responding variable</th>
<th>Controlled variable</th>
<th>Controlled variable</th>
</tr>
</thead>
</table>

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

(The answer is 4312 or 4321.)
Depth of Coverage

The current program of studies for Science 30 was implemented in the 2007–2008 school year. The Depth of Coverage section of this document is intended to guide teachers in their pacing and coverage of the topics in the Science 30 course. The following recommendations address the depth of coverage of the 10 general outcomes in the Science 30 Program of Studies. These recommendations were made by teacher committees working with members of the Provincial Assessment Sector of Alberta Education. Added to these recommendations are examples of the types of questions that demonstrate the required depth of coverage.

Regular-font items in the program of studies will be assessed on the diploma examination and although items in italics will not be specifically tested, students should still be capable of addressing ideas and skills described in the italicized concepts on open-ended items used for classroom assessment. On the diploma examination, the italicized items could appear as distractors or on numerical-response items where more than one answer is possible, as described on page 20 of this document.
Unit A, General Outcome 1

*Students will* analyze how the human circulatory system facilitates interaction between blood cells and the external environment and investigate cardiovascular health.

Students are required to understand the structure and function of the circulatory system, including the four chambers of the heart, the septum, where the valves are located, and how the valves work (specific names of valves are not required). Identification of the blood vessels connected to each of the chambers of the mammalian heart and an ability to relate their differences in structure to their specific function is necessary, along with a general understanding of the structure and function of the various types of blood vessels. The pathway of the blood throughout the circulatory system should be included.

A general description of what happens to the heart during systole and diastole is required.

Calculation of stroke volume is not required.

A general understanding of the structure and function of the main components of blood is required. It is reasonable to expect students to recognize the relationship between iron, hemoglobin, and oxygen transport. From observations of prepared blood slides or electronic images of blood, students should be able to compare the relative size and relative number of blood cells in blood.

General Outcome 1 can be completed within about 6 to 7 hours of class time.
Sample Questions

Students should be able to outline the pathway of blood through the circulatory system from any starting point in the circulatory system.

*Use the following information to answer numerical-response question 1.*

<table>
<thead>
<tr>
<th>Some Blood Vessels in the Human Circulatory System</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Vena cava</td>
</tr>
<tr>
<td>2. Vein in the arm</td>
</tr>
<tr>
<td>3. Pulmonary veins</td>
</tr>
<tr>
<td>4. Pulmonary artery</td>
</tr>
</tbody>
</table>

**Numerical Response**

1. A flu vaccination is typically administered into arm muscle and diffuses into blood capillaries. The pathway of the vaccine once it enters a capillary is numbered

   ____ → ____ → ____ → ____ → Aorta

   (Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

   (The answer is 2143.)
The ability to locate and understand the function of valves is important; however, naming them is not necessary.

Use the following information to answer question 2.

A faulty heart valve allows blood to flow back into the previous heart chamber. In the past, this condition has been treated by replacing the faulty valve with a mechanical one, like the one shown below.

2. In which of the following diagrams is the mechanical valve placed so that it would correct the backflow of blood through a faulty valve between the right atrium and right ventricle?

A.  
B.  
C.  
D.  

(The answer is D.)
Identifying blood components from diagrams and the effect of changes in relative numbers or functions of blood components is expected.

Use the following information to answer question 3.

Diagrams of Blood Slides Observed by a Laboratory Technician

3. Which blood sample was most likely taken from an individual who is fighting an infection?

A. I
B. II
C. III
D. IV

(The answer is C.)
Students should be aware that both platelets and blood plasma are involved in blood clotting (coagulation), but knowledge of the specific clotting-factor proteins is not required.

Use the following information to answer question 4.

Some pesticides that target rats and mice contain a chemical that disrupts an animal’s ability to use vitamin K. Without vitamin K, an animal is unable to produce blood clots and may die from internal bleeding.

4. The blood components **most directly** affected by the pesticide described above are
   
   A. red blood cells only  
   B. plasma and platelets  
   C. white blood cells and platelets  
   D. white blood cells and red blood cells  

   (The answer is B.)
The skills section of A1 may be used for contexts for items. A general understanding of scientific inquiry is required for these items. The following question is assessing outcome A1.1s.

Use the following information to answer question 5.

One hundred girls of the same age participated in a study to determine the effect of exercise on blood pressure. Fifty girls exercised for 60 min each day for one month. The other 50 girls did not participate in any exercise for one month. The blood pressure of each participant was taken at the beginning and at the end of the month.

5. Which of the following rows identifies the responding variable and the control group from the study above?

<table>
<thead>
<tr>
<th>Row</th>
<th>Responding Variable</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Exercise</td>
<td>Girls that exercised</td>
</tr>
<tr>
<td>B.</td>
<td>Exercise</td>
<td>Girls that did not exercise</td>
</tr>
<tr>
<td>C.</td>
<td>Blood pressure</td>
<td>Girls that exercised</td>
</tr>
<tr>
<td>D.</td>
<td>Blood pressure</td>
<td>Girls that did not exercise</td>
</tr>
</tbody>
</table>

(The answer is D.)
Unit A, General Outcome 2

Students will analyze the defense mechanisms used by the human body to protect itself from pathogens found in the external environment.

Students are required to understand the structure and functions of the body’s defence mechanisms, including the body’s first line of defence; however, students are not required to understand the detailed structure of skin. Comparing specific microscopic pathogens and their entry into the body cells is not required. The development of immunity, failure to develop immunity, autoimmune disorders, and the role of vaccines and antibiotics are important and current topics. Knowledge of the specific types of antibiotics or the intricate functioning of how they prevent bacteria from reproducing is not required; however, students should know that antibiotics can be used to treat bacterial infections. In General Outcome 3, students will extend this concept with the study of antibiotic resistance.

Suppressor T cells are now also known as regulatory T cells; however, the term suppressor T cells will continue to be used on diploma examinations in order to be consistent with the program of studies and approved-resource terminology. New information about their potential link to autoimmune disease caused some scientists to reclassify suppressor T cells.

General Outcome 2 can be completed within about 4 to 5 hours of class time.

Sample Questions

Identifying the components of the first line of defence against pathogens is required.

6. An example of a person’s non-specific or first line of defence against pathogens is

   A. tears
   B. antigens
   C. antibodies
   D. killer T cells

   (The answer is A.)
A general understanding of the roles of various white blood cells, like macrophages, helper T cells, B cells, killer T cells, suppressor (regulatory) T cells, and memory cells, is required.

7. Pathogens have unique proteins on their surface called \( \text{____i____} \). The type of white blood cell that uses these unique proteins to recognize and then engulf pathogens is a \( \text{____ii____} \).

The statements above are completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th>( i )</th>
<th>( ii )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>antigens</td>
<td>killer T cell</td>
</tr>
<tr>
<td>B.</td>
<td>antigens</td>
<td>macrophage</td>
</tr>
<tr>
<td>C.</td>
<td>antibodies</td>
<td>killer T cell</td>
</tr>
<tr>
<td>D.</td>
<td>antibodies</td>
<td>macrophage</td>
</tr>
</tbody>
</table>

(The answer is B.)
Unit A, General Outcome 3

Students will apply the principles of heredity and molecular genetics to explain how human diseases can arise from inherited traits, the risks and benefits of genetic technology, and the need for ethical considerations in the application of scientific knowledge.

The principles of heredity should be explained using simple Mendelian monohybrid crosses and their probabilities. It is reasonable to expect students to predict genotypic and phenotypic ratios and percentages that result from monohybrid crosses and to be able to analyze a pedigree chart. Students do not require knowledge of incomplete dominance or codominance.

Memorization of the names of the stages of mitosis and meiosis is not necessary, but a general description and ordering of the sequence of events in these processes is required. For example, students should know that chromosomes double, line up at the equator, separate, and migrate to opposite poles. The same depth should apply to meiosis and fertilization. It is reasonable to expect students to use the terms haploid (1n) and diploid (2n) and homozygous and heterozygous (carrier) in their descriptions. Students should be able to make the connection between meiosis, fertilization, and Mendelian crosses in Punnett squares.

Students should be able to interpret autosomal dominant/recessive and sex-linked dominant/recessive patterns of inheritance. Sex-linked genetic disorders include both X-linked and Y-linked genetic disorders, and it is reasonable for students to use and understand the terms X-linked and Y-linked.

The general characteristics of the structure and function of DNA should be understood. Students are expected to know the nitrogen base names and how the nitrogen bases pair. A general description of the main events of DNA replication (such as the molecule unzipping down the middle and new specific bases linking) and protein synthesis is required, but a detailed understanding of the processes and roles (such as transcription and translation, including the roles of tRNA, ribosomes, mRNA, and DNA enzymes) is not required.

Students should be able to use the table on page 13 of the data booklet (this table is different from the one used in Biology 30) for coding from a DNA sequence to an amino acid sequence. We have chosen to use a table that uses the “complementary” (5’→3’) strand of DNA as the code for determining the amino acid sequence. This strand was used because the scientific community often uses this strand to report on DNA sequences and mutations. This may cause some problems with students who take Science 30 along with Biology 30. Biology 30 resources have historically used the “template” (3’→5’) strand in order to show how that strand is transcribed into mRNA. The table that Biology 30 students use to determine the amino acid sequence is usually an mRNA table. The table for mRNA is the same as for the complementary strand of DNA that is used in the data booklet, except that in the data booklet, uracil (U) is replaced by thymine (T).

Students should understand that DNA has two functions: 1) to pass on information to offspring as the hereditary material; 2) to code for the production of proteins that regulate functions in cells and in the body.
The types of proteins produced by DNA are diverse; however, in Science 30 it should be sufficient to give students a general understanding of the role of certain proteins like those provided in the table below.

Some Proteins and Their Roles

<table>
<thead>
<tr>
<th>Type of Protein</th>
<th>Role of Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enzymes</td>
<td>Speed up chemical reactions in the body</td>
</tr>
<tr>
<td>Hormones</td>
<td>Act as signals to coordinate and regulate activities in the body</td>
</tr>
<tr>
<td>Structural</td>
<td>Support cells and provide frameworks for other proteins to attach to</td>
</tr>
<tr>
<td>Transport</td>
<td>Allow the movement of materials within cells or the body (for example, hemoglobin)</td>
</tr>
<tr>
<td>Defensive</td>
<td>Protect the body from pathogens (for example, antibodies)</td>
</tr>
<tr>
<td>Energy</td>
<td>Decomposition of certain proteins can serve as a source of energy</td>
</tr>
</tbody>
</table>
Diploma examinations will place emphasis on the risks and benefits of genetic technologies and their ethical considerations from a variety of perspectives.

General Outcome 3 can be completed within about 12 to 14 hours of class time.

**Sample Questions**

*Students have difficulty with matching chromosomal content to images of mitosis and meiosis, as shown below.*

*Use the following information to answer question 8.*

8. The change in chromosomal content from the parent cell to a daughter cell, as illustrated above, can be described as

A. \(4n \rightarrow 1n\)
B. \(4n \rightarrow 2n\)
C. \(2n \rightarrow 2n\)
D. \(2n \rightarrow 1n\)

(The answer is C.)
Identifying certain proteins and their functions is required of students; however, examples will include only those typically studied in a Science 30 class (antibodies, hemoglobin, and antigens).

Use the following information to answer numerical-response question 9.

<table>
<thead>
<tr>
<th>Protein</th>
<th>Function</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Antibody</td>
<td>3 Delivers oxygen</td>
<td>6 Defensive</td>
</tr>
<tr>
<td>2 Hemoglobin</td>
<td>4 Speeds up reactions</td>
<td>7 Enzyme</td>
</tr>
<tr>
<td></td>
<td>5 Attaches to pathogens</td>
<td>8 Transport</td>
</tr>
</tbody>
</table>

Numerical Response

9. Using the numbers above, choose one protein and match it with its corresponding function and the classification of that protein. (There is more than one correct answer.)

Protein _________ (Record in the first column)
Function _________ (Record in the second column)
Classification _________ (Record in the third column)

(Record your answer in the numerical-response section on the answer sheet.)

(The answers are 156 or 238.)
When identifying amino acids coded for by a DNA sequence, students should read the sequence from left to right.

Use the following information to answer numerical-response question 10.

The DNA strand fragment depicted below, when read from left to right, provides the code for part of an amino acid chain.

**Fragment of DNA**

| A | C | T | T | C | T | T | G | T | A | T | T |

**Partial List of Amino Acids**

<table>
<thead>
<tr>
<th></th>
<th>Phenylalanine</th>
<th></th>
<th>Proline</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Leucine</td>
<td>6</td>
<td>Alanine</td>
</tr>
<tr>
<td>2</td>
<td>Isoleucine</td>
<td>7</td>
<td>Threonine</td>
</tr>
<tr>
<td>3</td>
<td>Valine</td>
<td>8</td>
<td>Cysteine</td>
</tr>
<tr>
<td>4</td>
<td>Serine</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

**Numerical Response**

10. Match four of the amino acids numbered above with the order coded for by the DNA fragment. (Use each number only once.)

| Amino Acid: |   |   |   |   |
| Order:      | First | Second | Third | Fourth |

(Record all four digits of your answer in the numerical-response section on the answer sheet.)

(The answer is 8593.)
A specific outcome for STS includes assessing the risks and benefits of genetic technologies. The following question assesses outcomes A3.9k and A3.2sts.

Use the following information to answer question 11.

One strain of food plant has been genetically modified (GM) by inserting the gene from a bacterium into the genetic material of the plant. These GM plants produce a substance that is poisonous only to certain insects.

11. An environmental benefit of growing the GM strain of the plant is that

A. genes that code for the poisonous substance may be transferred from the GM plants to other organisms
B. less chemical pesticide may be required for crops of the GM plants
C. non-target insects who feed on the GM plants may be affected
D. the yield of food from crops of the GM plants may increase

(The answer is B.)
The ability to interpret pedigree charts and use appropriate symbols to describe the specific genotypes is a requirement of the course. The two questions that follow assess these skills using different approaches.

Use the following information to answer questions 12 and 13.

**Pedigree Chart Illustrating PKU Inheritance**

Phenylketonuria (PKU) is an autosomal recessive disorder.

12. The genotype of individual II-4 is
   
   A.  $PP$
   B.  $Pp$
   C.  $Pp$ or $PP$
   D.  $PP$ or $pp$

   (The answer is B.)

13. Which of the following people represented on the pedigree chart has a homozygous genotype?

   A.  I-1
   B.  I-2
   C.  II-3
   D.  II-4

   (The answer is C.)
Given a pedigree chart, students should be able to determine the mode of inheritance of autosomal dominant, autosomal recessive, X-linked dominant, X-linked recessive, or Y-linked traits or disorders.

Use the following information to answer question 14.

A widow’s peak is a type of hairline where a peak forms near the centre of a person’s forehead, as shown below.

A Pedigree Chart Illustrating the Incidence of Widow’s Peak in a Family

14. Based on the pedigree chart above, the mode of inheritance for widow’s peak is most likely

A. autosomal recessive
B. autosomal dominant
C. X-linked recessive
D. X-linked dominant

(The answer is B.)
A basic understanding of how natural selection could lead to bacterial, viral, or pesticide resistance is required.

Use the following information to answer question 15.

Resistance to antibiotic drugs in bacterial populations has been observed over time.

15. One of the reasons that bacterial populations have developed resistance to antibiotics is because

A. antibiotics biomagnify in the bacterial population  
B. some bacteria develop tolerance to large amounts of antibiotics  
C. plasmids with antibiotic-resistant genes are transferred between individual bacteria  
D. the more bacteria are exposed to antibiotics, the less resistant the population becomes  

(The answer is C.)

Use the following information to answer question 16.

Type 1 diabetes is an autoimmune disease that stops the pancreas from producing the hormone insulin. A lack of insulin decreases a person’s ability to regulate blood glucose levels.

Researchers are investigating the possibility of inserting the section of DNA that codes for insulin production into a virus as part of a possible cure for type 1 diabetes. In this method, patients swallow the virus containing the DNA fragment; the virus inserts the DNA fragment into the cells of the patient’s intestine, and then the patient’s intestinal cells begin to produce insulin.

16. The method described above is an example of

A. gene therapy  
B. plasmid transfer  
C. natural selection  
D. genetic screening  

(The answer is A.)
Unit B, General Outcome 1

Students will analyze the sources of acids and bases and their effects on the environment.

Most of the acid–base concepts, such as classification, indicators, buffers, and titrations, are covered in single proton transfer principles using conjugate acid–base pairs. The term Brønsted–Lowry is not used; instead, the terms proton acceptor (base) and proton donor (acid) are used. Titration calculations are limited to strong monoprotic acids and bases. Students do not need to calculate the hydronium ion concentration of a weak acid using $K_a$ values. It is reasonable to expect students to interpret but not to generate titration curves. Students should be able to determine the ranges of pH from the colour of indicators in solutions. Students should be aware of the logarithmic nature of the pH scale.

Students are expected to test for acidic, basic, neutral ionic, and neutral molecular solutions using a variety of diagnostic tests. Diagnostic tests could include conductivity meters, pH meters, indicators, and reactions with active metals like magnesium or zinc. Naming of ionic and molecular compounds or acids is not a focus in this general outcome; instead, the focus is on students classifying a solution using its chemical formula. For example, it is more important that students recognize that $\text{HNO}_3(\text{aq})$ is a strong acid and that $\text{NaCl}(\text{aq})$ is a neutral ionic solution than it is for students to provide the IUPAC names of these compounds.

Outcome B1.3s states that students are expected to “research and plot on a map the distribution of acid deposition as influenced by prevailing winds.” Therefore, students should be familiar with the fact that the prevailing wind direction across Alberta, and all of North America, is from west to east. Given cardinal directions, students should be able to apply their knowledge of prevailing winds to identify the location on a map that would be most affected by acid-forming emissions.

Students are expected to understand that metal leaching is a possible result of acid deposition as an extension of B1.9k and B2.1sts.

General Outcome 1 can be completed within about 9 to 11 hours.
Sample Questions

In order to accurately represent what happens in a buffer system, equilibrium arrows will be used in reaction equations. The concept of equilibrium will not be tested, but students should be aware that protons can be donated and accepted in both the forward and the reverse reactions. The term Brønsted–Lowry is no longer used for assessment, as shown below.

Use the following information to answer question 17.

Chemical Equation Representing Buffering Action

\[ \text{H}_2\text{O}(l) + \text{HCO}_3^-(aq) \rightleftharpoons \text{H}_3\text{O}^+(aq) + \text{CO}_3^{2-}(aq) \]

17. Which substances in the equation above donate a proton?

A. \( \text{H}_2\text{O}(l) \) and \( \text{H}_3\text{O}^+(aq) \)
B. \( \text{H}_2\text{O}(l) \) and \( \text{CO}_3^{2-}(aq) \)
C. \( \text{HCO}_3^-(aq) \) and \( \text{H}_3\text{O}^+(aq) \)
D. \( \text{HCO}_3^-(aq) \) and \( \text{CO}_3^{2-}(aq) \)

(The answer is C.)

Students should be aware of the logarithmic nature of the pH scale.

Use the following information to answer question 18.

The pH of a particular quantity of melted snow is 5.5 and changes to a pH of 7.5 when it enters a pond.

18. Which of the following statements describes the change in hydronium ion concentration, \( [\text{H}_3\text{O}^+(aq)] \), as the melted snow enters the pond?

A. The \( [\text{H}_3\text{O}^+(aq)] \) increased by a factor of 2.
B. The \( [\text{H}_3\text{O}^+(aq)] \) decreased by a factor of 2.
C. The \( [\text{H}_3\text{O}^+(aq)] \) increased by a factor of 100.
D. The \( [\text{H}_3\text{O}^+(aq)] \) decreased by a factor of 100.

(The answer is D.)
Students should be able to interpret the results of simple diagnostic tests such as conductivity and indicator colour, including intermediate indicator colours. Students should be able to classify compounds from chemical formulas.

Use the following information to answer question 19.

A sample solution is tested for conductivity and pH. The results of these tests compared with the results of similar tests using distilled water are shown in the table below.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Conductivity</th>
<th>Bromothymol Blue</th>
<th>Phenolphthalein</th>
<th>Bromocresol Green</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distilled water</td>
<td>No</td>
<td>Green</td>
<td>Colourless</td>
<td>Blue</td>
</tr>
<tr>
<td>Sample solution</td>
<td>Yes</td>
<td>Yellow</td>
<td>Colourless</td>
<td>Green</td>
</tr>
</tbody>
</table>

19. Based on the test data shown above, the sample solution above could be

A. NaCl(aq)
B. NaOH(aq)
C. H₂SO₃(aq)
D. CH₃OH(aq)

(The answer is C.)
Students should be able to make general interpretations of titration curves.

Use the following information to answer question 20.

A 10.0 mL sample of well water was titrated with a 0.100 mol/L solution of HCl(aq). As the titration progressed, the pH of the well water was measured and recorded on the following graph.

20. According to the graph above, the water sample initially had a pH that was _____i_____. As HCl(aq) was added, the hydronium ion concentration, [H_3O^+(aq)], of the water sample _____ii_____.

The statements above are completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th>i</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>greater than 7</td>
<td>increased</td>
</tr>
<tr>
<td>B.</td>
<td>greater than 7</td>
<td>decreased</td>
</tr>
<tr>
<td>C.</td>
<td>less than 7</td>
<td>increased</td>
</tr>
<tr>
<td>D.</td>
<td>less than 7</td>
<td>decreased</td>
</tr>
</tbody>
</table>

(The answer is A.)
The ability to write and predict combustion reaction equations resulting in acid deposition is required.

Use the following information to answer question 21.

Low-grade coal has a high sulfur content. The burning of low-grade coal contributes to harmful emissions that can undergo chemical reactions in the atmosphere.

21. When the sulfur present in low-grade coal is burned, it forms $\text{____}_i\text{,}$ which can react with water in the atmosphere to form $\text{____}_\text{ii}.$

The statement above is completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th>$i$</th>
<th>$\text{ii}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>SO$_2$(g)</td>
<td>H$_2$SO$_4$(aq)</td>
</tr>
<tr>
<td>B.</td>
<td>SO$_2$(g)</td>
<td>S$_8$(s)</td>
</tr>
<tr>
<td>C.</td>
<td>H$_2$S(g)</td>
<td>H$_2$SO$_4$(aq)</td>
</tr>
<tr>
<td>D.</td>
<td>H$_2$S(g)</td>
<td>S$_8$(s)</td>
</tr>
</tbody>
</table>

(The answer is A.)
Unit B, General Outcome 2

*Students will* analyze the sources of organic compounds and their effects on the environment.

The organic chemistry nomenclature should be kept simple and should focus on identifying a compound by its functional group (see *Science 30 Data Booklet*, page 9) rather than on drawing and naming complex compounds. Students are expected to recognize expanded, condensed, line structural diagrams, and molecular models that represent organic compounds. Aldehydes, ketones, and polymers are not part of the Science 30 Program of Studies.

The term *hydrocarbon* should be strictly limited to describing molecules composed of only carbon and hydrogen atoms. For organic molecules composed of other atoms, including oxygen and halogens, the term *hydrocarbon derivative* is appropriate.

The benzene ring may be represented in any of four ways, and students are expected to recognize any of the four representations shown in diagrams 1–4 below as being a diagram of a benzene molecule. Students are not expected to know the strengths and weaknesses of each representation.

Diagonal 1 and 2 represent ring structures, and due to resonance, the double bonds can appear in either format. Students do not need to understand resonance. Diagrams 3 and 4 represent line diagrams.

An extension of B2.1sts and Unit D of Science 10 will include climate change and connect with B2. Students should recognize that carbon dioxide, methane, and CFCs are greenhouse gases and that increased emission of these gases contributes to climate change.

Students should be able to recognize the structures of common halogenated hydrocarbons like CFCs, POPs (dioxins and furans), and PCBs. PCBs and many POPs can be recognized by looking for chlorinated benzene rings. Students should also understand the common sources, risks, and alternatives to these harmful halogenated hydrocarbons.

Ground-level ozone and particulates should also be recognized as components, but not the only constituents, of photochemical smog.

General Outcome 2 can be completed within about 6 to 7 hours.
Sample Questions

Naming complex benzene derivatives is not required; however, identifying functional groups attached to more complicated structures is expected, as shown below. Students do not need to know the order of precedence for functional groups.

Use the following information to answer question 22.

Aspirin is used to help the body cope with pain and to prevent blood clotting.

**Structural Formula of a Component of Aspirin**

22. Two functional groups present in the diagram shown above are the same as those found in

A. esters and alcohols
B. esters and carboxylic acids
C. halogenated hydrocarbons and alcohols
D. halogenated hydrocarbons and carboxylic acids

(The answer is B.)
Students should be able to recognize a variety of organic compound representations.

Use the following information to answer question 23.

A student uses a molecular model kit to build a model of an organic compound.

**Model of an Organic Compound**

23. The model that the student built is a representation of

   A. an ester  
   B. an alcohol  
   C. a carboxylic acid  
   D. a halogenated hydrocarbon

(The answer is A.)
The risks and sources of benzene derivatives, as well as the identification of compounds containing the benzene ring, should be understood by students.

Use the following information to answer question 24.

When some aquatic micro-organisms are exposed to benzene derivatives or heavy metals, they produce a particular type of protein, called a stress protein. The presence of the stress protein can be an indication of poor water quality.

24. Which of the molecules shown below would result in the production of the stress protein in aquatic micro-organisms?

A. \[ \text{Cl}_2\text{C} \equiv \text{C} \equiv \text{Cl} \]

B. \[ \text{OH} \]

C. \[ \text{CH}_3 - \text{C} = \text{O} \]

D. \[ \text{Cl} \]

(The answer is B.)
Students should be able to recognize the structures of common halogenated hydrocarbons like CFCs, dioxins, furans, and PCBs.

Use the following information to answer numerical-response question 25.

![Structural Diagrams of Some Halogenated Organic Compounds](image)

**Numerical Response**

**25.** Match each of the organic compounds numbered above with its classification listed below. (Use each number only once.)

<table>
<thead>
<tr>
<th>Compound:</th>
<th>Classification:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dioxin</td>
</tr>
</tbody>
</table>

(Record all three digits of your answer in the response boxes at the bottom of the screen.)

(The answer is 213.)
Students should have general ideas about the main sources, effects, and possible alternatives to the environmental pollutants described in B2.3k and B2.4k.

Use the following information to answer numerical-response question 26.

<table>
<thead>
<tr>
<th>Some Pollutants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
</tbody>
</table>

**Numerical Response**

26. Using the numbers above, match each pollutant with its associated source. (Use each number only once.)

Old refrigerators  __________ (Record in the first column)
Old transformers  __________ (Record in the second column)
Waste incineration  __________ (Record in the third column)
Agricultural runoff  __________ (Record in the fourth column)

(Record your answer in the numerical-response section on the answer sheet.)

(The answer is 2134.)
Unit B, General Outcome 3

*Students will* analyze, from a variety of perspectives, the risks and benefits of using chemical processes in meeting human needs and assess technologies for reducing the impact of chemical compounds on the environment.

The concepts in general outcome B3 will most often be assessed within the context of the substances and processes studied in General Outcomes B1 and B2. The major topic of this concept is the impact of certain chemicals on our environment from a local to a global level. The main sources, effects, and potential solutions to listed pollutants should be understood. For example, overuse of some pesticides leads to biomagnification and the death of species at the top of the food chain. It is not necessary for students to memorize a detailed series of chemical reactions to explain the cause and effect of certain air pollutants on our environment; simplified single-step chemical reaction equations are adequate. Students are expected to understand the basic water-quality tests as listed in B3.3s. Students are expected to identify the WHMIS 2015 pictograms.

An extension of A3.10k will include pesticide resistance.

Students are expected to evaluate environmental issues from more than one perspective and to answer questions in the context of the given perspective. These perspectives, or viewpoints, may be environmental, economic, ethical, political, scientific, technological, legal, or societal.

General Outcome 3 can be completed within about 8 to 10 hours of class time.

**Sample Questions**

*Students are expected to understand the basic water-quality tests as listed in B3.3s.*

27. **A researcher found the water of a particular river to be high in organic content, and would expect the BOD of the water to be __**i**__. Downstream of where the organic content is, the dissolved oxygen level is expected to be __**ii**__.**

The statements above are completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th>i</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>B.</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td>C.</td>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td>D.</td>
<td>high</td>
<td>high</td>
</tr>
</tbody>
</table>

(The answer is C.)
Students are expected to evaluate environmental issues from more than one perspective and to answer questions in the context of the given perspective.

28. From an environmental perspective, the **main** reason that sulfur should be removed from coal is to

A. reduce the $\text{SO}_2(g)$ emissions that occur when coal is burned  
B. make the coal burn hotter, which makes it more efficient  
C. purify the water released by coal-mining operations  
D. recover the sulfur for industrial purposes

(The answer is A.)

Students should be able to match each WHMIS 2015 pictogram to the hazard it represents. See page 15 for more information on WHMIS 2015.

**Use the following information to answer question 29.**

Painters should wear a mask to prevent them from breathing in chemicals from the paint that could cause long-term breathing problems.

29. Which of the following WHMIS pictograms is meant to warn people of the danger of breathing in paint fumes?

A.  
B.  
C.  
D.  

(The answer is A.)
Unit C, General Outcome 1

_Students will_ explain field theory and analyze its applications in technologies used to produce, transmit, and transform electrical energy.

The emphasis of this General Outcome is on the basic principles of field theory. Some problems may involve solutions that require more than one step. Students should understand that the strength of an electric or gravitational field is inversely proportional to the square of the distance from the point source of the field. One way for students to visualize this concept is graphically, as shown below.

In the section of the General Outcome that deals with electrical technology, students must know how to use the data booklet at a “science-literate” level. Students must learn to determine what is required by the question, to identify what is given, and then to apply the appropriate formula.

Students should be able to identify, compare, draw, and build series and parallel circuits. However, calculations involving circuits with complicated combinations of series and parallel formations are not required. It is reasonable for students to evaluate energy production and technological devices from an economic perspective; this may include determining the cost of electricity after calculating the energy consumed, comparing energy data from devices to identify the most cost-effective device, or analyzing the cost savings of increasing the efficiency of a device.

Students should be able to relate the concept of induction to generators and transformers.

Program of studies outcome C1.10k asks students to describe the advantage of using AC over DC for electrical energy transmission; however, with advances in ultra-high voltage (>500 V) electrical energy transmission using direct current (HVDC), there are now fewer advantages of using AC over ultra-high voltage DC for transmission. This distinction will be reflected in diploma examination questions.

General Outcome 1 can be completed within about 15 to 18 hours of class time.
Sample Questions

Students are expected to understand both the gravitational and electric field strength equations theoretically and mathematically.

Use the following information to answer question 30.

A charged metal sphere has an electric field strength of 22.4 N/C at a distance of \( r \) from the sphere.

30. The electric field strength of the sphere at a distance of \( 3r \) would be

A. 2.49 N/C  
B. 3.73 N/C  
C. 7.48 N/C  
D. 67.3 N/C  

(The answer is A.)

Students are expected to use constants provided in the data booklet, such as Earth’s mass, to help them solve problems.

31. Earth’s gravitational field strength 4.2 \( \times 10^7 \) m from the centre of Earth is

A. \( 2.3 \times 10^{-1} \) N/kg  
B. \( 9.5 \times 10^{-1} \) N/kg  
C. \( 2.3 \times 10^5 \) N/kg  
D. \( 9.5 \times 10^5 \) N/kg  

(The answer is A.)
Studies should understand that vector fields include direction (C1.3k).

32. Which of the following diagrams illustrates the direction of a magnetic field near the opposite poles of two magnets?

A.  

B.  

C.  

D.  

(The answer is A.)
Students find the concept of electromagnetic induction challenging.

Use the following information to answer question 33.

A coil of wire is rotated in a magnetic field created by a U-shaped magnet. A current is generated in the coil of wire and measured by an ammeter.

33. The diagram above illustrates the process of
   
   A. induction
   B. resistance
   C. stepping up voltage
   D. stepping down voltage

   (The answer is A.)
There is an emphasis on the general design, function, and comparison of DC motors and generators.

Use the following information to answer question 34.

34. Which of the following sequences identifies the energy changes that occur during operation of the electric motor?

A. chemical potential energy $\rightarrow$ kinetic energy of the spinning armature $\rightarrow$ electrical energy

B. chemical potential energy $\rightarrow$ electrical energy $\rightarrow$ kinetic energy of the spinning armature

C. kinetic energy of the spinning armature $\rightarrow$ electrical energy $\rightarrow$ chemical potential energy

D. kinetic energy of the spinning armature $\rightarrow$ chemical potential energy $\rightarrow$ electrical energy

(The answer is B.)
35. Which of the following designs would produce a working motor?

A. 

B. 

C. (The answer is C.) 

D.
Use the following information to answer question 36.

<table>
<thead>
<tr>
<th>Some Energy Conversion Devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
</tr>
<tr>
<td>II</td>
</tr>
<tr>
<td>III</td>
</tr>
<tr>
<td>IV</td>
</tr>
</tbody>
</table>

36. In the list above, a device that is used to convert kinetic energy into electrical energy is numbered

   A. I
   B. II
   C. III
   D. IV

(The answer is A.)

Rearranging field strength formulas to solve for radius, \( r \), demonstrates the Standard of Excellence for this outcome.

Use the following information to answer numerical-response question 37.

An airplane is at a position where the average gravitational field strength due to Earth, \( g \), is 9.79 N/kg.

**Numerical Response**

37. The distance, \( r \), of the airplane from Earth’s centre, expressed in scientific notation, is \( a.b \times 10^6 \) m. The values of \( a \), \( b \), and \( c \) are _____, _____, and _____.

\[ a \quad b \quad c \]

(Record all three digits of your answer in the numerical-response section on the answer sheet.)

(The answer is 6.38.)
Resistance for series and parallel circuits can be dealt with using a variety of approaches, including demonstration, laboratory investigation, computer simulation, and use of mathematical calculation. All approaches lie within the objectives described in the program of studies. Students should be provided with opportunities to investigate concepts using a balance of both qualitative and quantitative approaches.

Use the following information to answer numerical-response question 38.

![Diagrams of circuits](Image)

The resistors and batteries in each of the circuits above are identical.

**Numerical Response**

38. Listed in order from the circuit with least resistance to the circuit with greatest resistance, the four circuits above are

   __________, __________, __________, and __________.

   **Least resistance**  **Greatest resistance**

   (Record all four digits of your answer in the numerical-response section on the answer sheet.)

   (The answer is 4312.)
Unit C, General Outcome 2

Students will describe the properties of the electromagnetic spectrum and their applications in medical technologies, communication systems, and remote-sensing technologies used to study the universe.

Memorization of the various types of electromagnetic radiation (EMR) is not necessary. This information is in the data booklet. In comparisons of the various constituents of the electromagnetic spectrum on the basis of energy and their effect on living tissue, the term photon may be used. The term normal may be used to describe the relative direction in which the light is refracted or reflected. Students should also be aware that the angle of incidence is equal to the angle of reflection. Calculations using Snell’s Law are not required.

EMR can be compared in terms of penetrability of Earth’s atmosphere and living tissue. In the chart on page 3 of the data booklet, any EMR found to the right of visible light is a form of ionizing radiation, thus linking this specific outcome with D2.6k and A3.8k. Note that in the data booklet diagram of the electromagnetic spectrum, the scale for the wavelengths of EMR types is independent of the scale for the frequencies of EMR types, and that there is a logarithmic component to the scale. Students should use the universal wave equation to convert from frequency to wavelength, rather than move across scales on the diagram.

Students should be able to identify different types of spectra and their sources. C2.10k from the program of studies should indicate that Doppler-shift technology can be used to measure the velocity of distant stars, rather than the speed of distant stars. A general knowledge of the life cycle of stars is important, but using the Hertzprung–Russell diagram is not required, nor are students required to describe red giants and supergiant stars. Students should be aware that different stellar masses (low-mass, intermediate-mass, and high-mass) result in the production of white dwarfs, neutron stars, supernovas, and black holes.

General Outcome 2 can be completed within about 11 to 13 hours of class time.

Sample Questions

In comparisons of EMR on the basis of energy, the term photon may be used.

39. Which of the following types of EMR has photons that possess higher energy than photons of ultraviolet radiation?

A. X-ray  
B. Radio  
C. Infrared  
D. Microwave

(The answer is A.)
The term normal may be used to describe the direction, relative to the normal, in which the light is refracted or reflected.

Use the following information to answer question 40.

A. I
B. II
C. III
D. IV

(The answer is C.)
Use the following information to answer question 41.

An environmental technician monitoring a river from the shore noticed that the water in the river appeared to be only a few centimetres deep, but when she measured the depth of the water it was actually deeper.

41. The phenomenon described above is explained by the fact that light is ___i___ off the bottom of the river and then ___ii___ as it leaves the surface of the water.

The statement above is completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th>i</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>reflected</td>
<td>refracted</td>
</tr>
<tr>
<td>B.</td>
<td>reflected</td>
<td>reflected</td>
</tr>
<tr>
<td>C.</td>
<td>refracted</td>
<td>refracted</td>
</tr>
<tr>
<td>D.</td>
<td>refracted</td>
<td>reflected</td>
</tr>
</tbody>
</table>

(The answer is A.)
Students should be able to identify different types of spectra and their sources. Students should also be able to recognize that absorption spectra can be called dark-line spectra and that emission spectra can be called bright-line spectra.

Use the following information to answer question 42.

A diffraction grating can be used to observe the interaction of EMR and gases of the atmosphere.

<table>
<thead>
<tr>
<th>Row</th>
<th>Classification of Spectrum I</th>
<th>Relative Temperature of Gas II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Absorption</td>
<td>Hotter than Gas I</td>
</tr>
<tr>
<td>B.</td>
<td>Absorption</td>
<td>Cooler than Gas I</td>
</tr>
<tr>
<td>C.</td>
<td>Emission</td>
<td>Hotter than Gas I</td>
</tr>
<tr>
<td>D.</td>
<td>Emission</td>
<td>Cooler than Gas I</td>
</tr>
</tbody>
</table>

(The answer is C.)
A general knowledge of the evolution of stars is important.

Use the following information to answer numerical-response question 43.

<table>
<thead>
<tr>
<th>Some Stages in the Evolution of a Small Star</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

**Numerical Response**

43. As a low-mass star, such as the Sun, evolves from a collection of gas and dust, the sequence in which the stages numbered above occur is _____, _____, and _____.

(Record all three digits of your answer in the numerical-response section on the answer sheet.)

(The answer is 132.)
Unit D, General Outcome 1

Students will explain the need for balancing the growth in global energy demand with maintaining a viable biosphere.

Global energy issues are the focus of this unit. Specific examples of solutions to problems need to be incorporated into the discussion of these issues, including the concept of sustainable development. Students should also be able to visually determine trends in global energy use using graphs and tables.

The reactants for nuclear fusion are so plentiful in seawater and Earth’s crust that they have the potential to provide energy on a time span similar to the Sun; therefore, if nuclear fusion were to become a viable energy source, it may be considered a renewable source of energy.

Students should be able to classify sources of energy as renewable or non-renewable. Renewable energy is derived from natural processes that are constantly replenished. Renewable energy comes directly from the Sun or from heat generated deep within Earth. Sources of renewable energy are sunlight, wind, oceans, hydropower, geothermal, and biomass. Hydrogen and other fuels can be considered renewable if they are produced using renewable sources. Fossil fuels and nuclear fission are not considered renewable sources of energy.

General Outcome 1 can be completed within about 9 to 10 hours of class time.

Sample Questions

Connections with Unit B for pollutants and Unit C with electrical energy production can be made, as shown in the next three questions.

44. Which of the following concerns is associated with high levels of acid deposition?

A. Ozone depletion  
B. Heavy metal leaching  
C. Increase in skin cancers  
D. Changing global temperatures

(The answer is B.)
Use the following information to answer question 45.

One company is producing ethanol by fermenting grain and crop waste. The ethanol can be burned as an energy source in automobile engines.

45. **When the ethanol described above is classified as an energy source, it is considered 
   **i**. When the net carbon dioxide produced during burning of the ethanol 
is compared to the net carbon dioxide produced during burning of a fossil fuel, the
net carbon dioxide released from the ethanol is **ii**.**

The statements above are completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th>i</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>renewable</td>
<td>greater</td>
</tr>
<tr>
<td>B.</td>
<td>renewable</td>
<td>less</td>
</tr>
<tr>
<td>C.</td>
<td>non-renewable</td>
<td>greater</td>
</tr>
<tr>
<td>D.</td>
<td>non-renewable</td>
<td>less</td>
</tr>
</tbody>
</table>

(The answer is B.)
Use the following information to answer question 46.

### Actions That Can Affect Energy Use in Canada

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Upgrading insulation in homes</td>
</tr>
<tr>
<td>II</td>
<td>Converting vehicles to run on biofuels</td>
</tr>
<tr>
<td>III</td>
<td>Obtaining fossil fuels from oil sands deposits</td>
</tr>
<tr>
<td>IV</td>
<td>Providing rebates to consumers to lower the cost of gasoline</td>
</tr>
<tr>
<td>V</td>
<td>Modifying cars so that less gasoline will be required per kilometre</td>
</tr>
</tbody>
</table>

46. Two actions listed above that increase efficient energy use and therefore promote sustainable development are

A. I and II  
B. I and V  
C. II and III  
D. III and IV  

(The answer is B.)

*Methane gas may be discussed as a commonly used hydrocarbon (in the context of B2.2k), as a greenhouse gas that contributes to climate change (in the context of B2.3k), or as a biomass energy source (in the context of D2.4k).*

Use the following information to answer question 47.

### Description of a Fuel Source

- Main source of heating for homes in Alberta  
- Combustion of the fuel produces greenhouse gases  
- Can be renewable if collected from decomposing biomass  
- Release of this fuel into the environment contributes to climate change

47. The fuel source described above could be

A. low-sulfur coal  
B. uranium ore  
C. methane  
D. ethanol  

(The answer is C.)
Unit D, General Outcome 2

Students will describe the sun as Earth's main source of energy and explain the functioning of some conventional and alternative technologies that convert solar, nuclear, tidal, and other energy sources into useable forms.

Students must be able to calculate the energy changes from balanced chemical combustion equations, $\Delta H$, using standard molar heat (enthalpies) of formation, $\Delta_f H^\circ$, for substances. Students will not have to balance equations.

A clear understanding of the transformations of energy before its intended use is necessary to discuss efficiency comparisons. Mechanical energy is the sum of the potential and kinetic energy of an object or system. For example, the mechanical energy present in a hydroelectric turbine while the turbine is operational is entirely kinetic, so the energy transformations for this technology would be best represented as: solar radiant $\rightarrow$ gravitational potential (water behind the dam) $\rightarrow$ kinetic (spinning turbine) $\rightarrow$ electrical (generator).

Students should also spend considerable time in this unit debating the advantages, disadvantages, similarities between, and differences among various renewable and non-renewable energy-production technologies. The sample written response provided on pages 86 to 96 of this document may be useful in identifying some advantages and disadvantages of renewable-energy technologies.

Nuclear fusion in this unit can be related to EMR outcome C2.8k. Fission, fusion, and decay reactions release energy according to the mass-energy equivalency. Students should be able to use the formula $\Delta E = \Delta mc^2$ to calculate the quantity of energy available in nuclear reactions. Mass changes should be given in kilograms and energy in joules so that a simple application of the formula is used without conversions. Students should be able to determine missing nucleons in nuclear reaction equations and, given the reaction, predict the energy produced. Relative comparisons of the energy involved in nuclear reactions, chemical reactions, and phase changes are expected.

General Outcome 2 can be completed within about 11 to 13 hours of class time.
Sample Questions

Students must be able to calculate the energy change using a balanced equation.

Use the following information to answer numerical-response question 48.

\[ \text{C}_3\text{H}_8(\text{g}) + 5 \text{O}_2(\text{g}) \rightarrow 3 \text{CO}_2(\text{g}) + 4 \text{H}_2\text{O}(\text{g}) \]

Numerical Response

48. The energy released when one mole of C\textsubscript{3}H\textsubscript{8}(g) burns is _________ kJ.

(Record your **four-digit answer** in the numerical-response section on the answer sheet.)

(The answer is 2044.)

Teachers are encouraged to identify appropriate analogies for concepts.

49. In passive solar heating, the windows of a house have a function that is similar to that of

A. infrared rays
B. Earth’s surface
C. ultraviolet rays
D. Earth’s atmosphere

(The answer is D.)

Students should be able to generally describe the advantages and disadvantages of both renewable and non-renewable energy technologies.

Use the following information to answer question 50.

A prolonged period of abnormally low precipitation resulting in a shortage of water is called a drought.

50. Electricity-generating technologies that would have decreased output due to a drought are

A. photovoltaic cells and tidal dams
B. photovoltaic cells and hydroelectric dams
C. biomass-burning power plants and tidal dams
D. biomass-burning power plants and hydroelectric dams

(The answer is D.)
Students should recognize the energy conversion pathways for electrical-generating technologies that rely on different sources of energy.

Use the following information to answer question 51.

51. The production of electrical energy using photovoltaic panels would be **best** represented by the pathway numbered

A. 1  
B. 2  
C. 3  
D. 4

(The answer is A.)
Students should be able to calculate energy released from a given mass loss in a nuclear process.

Use the following information to answer numerical-response question 52.

The total mass of the products in a nuclear process is $3.1 \times 10^{-2}$ kg less than that of the reactants.

**Numerical Response**

52. The energy released by the reaction, expressed in scientific notation, is $a.b \times 10^{cd}$ J. The values of $a$, $b$, $c$, and $d$ are _____, _____, _____, and _____.

(Record all four digits of your answer in the numerical-response section on the answer sheet.)

(The answer is 2815.)
Data from previous diploma examinations indicate that students are much more successful when the change in mass is provided for nuclear reactions involving the equation $\Delta E=\Delta mc^2$, as shown in the previous question. In the next sample question, students must successfully determine the change in mass and then use $\Delta E=\Delta mc^2$ to answer this question. This question demonstrates the Standard of Excellence for this outcome.

Use the following information to answer numerical-response question 53.

**Reaction Equation Representing Hydrogen Fusion**

\[ ^1_4H \rightarrow ^2_2He + 2^0_1e \]

**Numerical Response**

53. In the reaction represented above, when one mole of $^4_2He$ is formed, the energy released is __________ $\times 10^{12}$ J.

(Record your three-digit answer in the numerical-response section on the answer sheet.)

(The answer is 2.58.)

54. One of the differences between nuclear fission and nuclear fusion is that

A. fission involves the splitting of nuclei, whereas fusion involves the joining of nuclei
B. fusion involves the splitting of nuclei, whereas fission involves the joining of nuclei
C. fission absorbs energy, whereas fusion releases energy
D. fusion absorbs energy, whereas fission releases energy

(The answer is A.)

Many students have difficulty discriminating between nuclear reactions that involve fission and those that involve fusion.

55. Which of the following equations represents a fission reaction?

A. $^3_2He + ^1_0n \rightarrow ^2_2He$
B. $^2_1H + ^2_1H \rightarrow ^3_2He + ^1_0n$
C. $^{60}_{27}Co \rightarrow ^{60}_{28}Ni + ^0_{-1}e$
D. $^{235}_{92}U + ^1_0n \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3^1_0n$

(The answer is D.)
Students should be able to distinguish between alpha, beta, and gamma decay reactions (see D2.6k) and also be aware that all three produce ionizing radiation.

Use the following information to answer numerical-response question 56.

### Types of Radioactive Decay

1. Alpha decay
2. Beta decay

### Numerical Response

56. Match the types of radioactive decay numbered above with the corresponding equations listed below. Numbers may be used more than once.

\[
\begin{align*}
\text{226}^{\phantom{0}}_{88}\text{Ra} & \rightarrow \frac{4}{2}\text{He} + \frac{222}{86}\text{Rn} \quad \text{(Record in the first column)} \\
\text{14}^{\phantom{0}}_{6}\text{C} & \rightarrow \frac{14}{7}\text{N} + \frac{0}{-1}\text{e} \quad \text{(Record in the second column)} \\
\text{40}^{\phantom{0}}_{19}\text{K} & \rightarrow \frac{0}{-1}\text{e} + \frac{40}{20}\text{Ca} \quad \text{(Record in the third column)} \\
\text{208}^{\phantom{0}}_{84}\text{Po} & \rightarrow \frac{204}{82}\text{Pb} + \frac{4}{2}\text{He} \quad \text{(Record in the fourth column)} \\
\end{align*}
\]

(Record your answer in the numerical-response section on the answer sheet.)

(The answer is 1221.)
Conventional geothermal power can only be produced in areas where hot water naturally rises to Earth’s surface. In an enhanced geothermal system (EGS), water is pumped as far as five kilometres down to rocks that have been shattered to make them porous. Rocks this deep can reach temperatures greater than 200° C. The cold water is warmed by the deep rocks and then it is pumped to the surface where it powers a turbine to generate electricity.

57. The thermal energy that the EGS relies on to generate electricity comes from

A. passive solar heating
B. nuclear fusion reactions
C. tidal action of the Moon and the Sun
D. radioactive decay of unstable isotopes

(The answer is D.)
**Assessment Highlights**

This section of the bulletin is intended to provide classroom teachers of Science 30 with information concerning student strengths and weaknesses as demonstrated on past Science 30 Diploma Examinations. These are trends in student performance as indicated by statistical analyses of the machine-scored examinations.

**General Strengths of Students on Past Science 30 Diploma Examinations**

Students do exceptionally well on questions that incorporate generic science skills, such as interpreting information from a graph or identifying the manipulated, responding, and controlled variables from descriptions of experiments. They are also proficient at carrying out single-step calculations using formulas included in the data booklet.

**General Outcome A1/A2: Circulatory and Immune Systems**

Students are very proficient at identifying the parts of the heart and the roles of the four major blood components, but find it difficult when asked to apply this knowledge to a context involving a disease or disorder affecting the circulatory system. Items regarding the specific roles of immune-system cells are typically easy for students, but ordering steps of the immune response or identifying a description of an autoimmune disease is more challenging.

**General Outcome A3: Genetics**

Most students can interpret a description of a genetic trait or construct a simple Punnett square in order to identify phenotypes and calculate the probability of inheriting particular disorders. Students struggle when interpreting pedigree charts and in differentiating between the processes of genetic engineering and gene therapy.

**General Outcome B1/B2/B3: Environmental Chemistry**

Students do well at predicting the colours of various indicators when the indicators are introduced into solutions of a given pH and placing acids in order of strength. Many students are able to calculate the concentration of hydronium ions, given the pH of a solution, but most struggle with calculations involving titrations. Students are easily able to name simple organic compounds given their structural diagrams. Students have difficulty distinguishing between the issue of ozone depletion and other environmental issues such as climate change, acid deposition, and biomagnification.

**General Outcome C1: Field Theory and Electrical Energy**

Most students are easily able to perform calculations related to Ohm’s law, power, and transformers, with the exception of transformer problems involving current. They have more difficulty when it comes to understanding the relationship between the field strength magnitude and the distance from the source. For example, a very difficult conceptual item would be recognizing that doubling the distance from a particular source would decrease the magnitude of the field strength to one-quarter. Students also typically struggle with defining electrical terms, particularly voltage; with understanding or applying analogies for circuits; and with the difference in energy conversions that occurs in motors or generators. Students have difficulty demonstrating an understanding of electromagnetic induction.
General Outcome C2: Electromagnetic Spectrum

Students do well at identifying the type of EMR from a description of its properties and at performing EMR calculations involving the universal wave equation. They struggle when asked to identify diagrams depicting the reflection, refraction, polarization, or diffraction of waves. Many students are unable to correctly match diagrams of situations that produce spectra to the type of spectrum produced (e.g., absorption spectrum, emission spectrum, blue-shifted spectrum), but have greater success when asked to identify the components of a gas mixture from reference spectra.

General Outcome D1/D2: Energy and the Environment

Most students are able to identify the main risks and benefits of particular energy-producing technologies and are able to interpret tables and graphs of trends in energy production. They are also able to perform calculations related to efficiency. Students are generally able to distinguish among societal, legal, ecological, and economic issues and distinguish between renewable and non-renewable energy sources. They are less successful at balancing nuclear equations and calculating the energy produced during nuclear reactions. Students have difficulty identifying the relationship between nuclear decay and geothermal energy. There appears to be a misconception that radiant solar energy from the Sun is the source of geothermal energy. The greatest difficulty for students is with numerical-response items related to General Outcome D1/D2, such as calculating molar heats of combustion or energy released in nuclear reactions.

Science 30 Sample Examinations

Diploma examinations, both previously released and self-scoring, can be found as Released Materials at education.alberta.ca.

The August 2015 Science 30 Diploma Examination has been posted in its entirety in a self-scoring format with pop-up hints. This examination, along with practice tests for each of the four units, can be found here under the “Practice Tests” tab.
Data Booklet

The data booklet currently being used will have “Updated 2010” on the cover. It is posted at education.alberta.ca. Permission is granted to Alberta educators to reproduce the data booklets for educational purposes and on a non-profit basis, so you are free to photocopy them.

Ordering Science 30 Print Resources

Print copies of the Science Data Booklets and the Science 20/30 textbooks are available from Alberta Queen’s Printer. Search by title or keyword within the online catalogue. Visa, MasterCard, and American Express are accepted. Many schools will already have an account with Alberta Queen’s Printer and can use this account to make a purchase order. Shipping charges will apply and orders can be shipped collect or on account with designated couriers. For ordering assistance, use the Alberta Queen’s Printer Contact Us feature.

Using Calculators

The Science 30 Diploma Examination requires the use of an approved calculator. The calculator policy, calculator criteria, expectations, and keystrokes required for clearing approved calculators can be found in the General Information Bulletin on the Alberta Education website.
## Website Links

<table>
<thead>
<tr>
<th>Publication</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Information Bulletin</td>
<td>education.alberta.ca</td>
</tr>
<tr>
<td>Science 30 Bulletin</td>
<td></td>
</tr>
<tr>
<td>Mathematics and Science Directing Words</td>
<td></td>
</tr>
<tr>
<td>Science Process Words</td>
<td></td>
</tr>
<tr>
<td>Released Materials</td>
<td></td>
</tr>
<tr>
<td>Data Booklet</td>
<td></td>
</tr>
<tr>
<td>Science 10, 20, and 30 Program of Studies</td>
<td></td>
</tr>
<tr>
<td>Quest A⁺</td>
<td><a href="https://questaplus.alberta.ca/">https://questaplus.alberta.ca/</a></td>
</tr>
<tr>
<td>Transition to WHMIS 2015</td>
<td>The link for this document is found at:</td>
</tr>
<tr>
<td></td>
<td><a href="https://education.alberta.ca/science-10-12/updates/">https://education.alberta.ca/science-10-12/updates/</a></td>
</tr>
</tbody>
</table>
Contacts 2018–2019

Provincial Assessment Sector
Dan Karas, Executive Director
Provincial Assessment Sector
780-422-4848
Dan.Karas@gov.ab.ca

Diploma Programs
Deanna Shostak, Director
Diploma Programs
780-422-5160
Deanna.Shostak@gov.ab.ca

French Assessment
Gilbert Guimont, Director
French Assessment
780-422-3535
Gilbert.Guimont@gov.ab.ca

Exam Managers
Gary Hoogers
English Language Arts 30–1
780-422-5213
Gary.Hoogers@gov.ab.ca

Philip Taranger
English Language Arts 30–2
780-422-4478
Philip.Taranger@gov.ab.ca

Monique Bélanger
Français 30–1, French Language Arts 30–1
780-422-5140
Monique.Belanger@gov.ab.ca

Dwayne Girard
Social Studies 30–1
780-422-5161
Dwayne.Girard@gov.ab.ca

Patrick Roy
Social Studies 30–2
780-422-4631
Patrick.Roy@gov.ab.ca

Shannon Mitchell
Biology 30
780-415-6122
Shannon.Mitchell@gov.ab.ca

Brenda Elder
Chemistry 30
780-427-1573
Brenda.Elder@gov.ab.ca

Delcy Rolheiser
Mathematics 30–1
780-415-6181
Delcy.Rolheiser@gov.ab.ca

Jenny Kim
Mathematics 30–2
780-415-6127
Jenny.Kim@gov.ab.ca

Marc Kozak
Physics 30, Examiner
780-427-6196
Marc.Kozak@gov.ab.ca

Stan Bissell
Science 30
780-422-5730
Stan.Bissell@gov.ab.ca

Exam Administration
Pascal Couture, Director
Exam Administration and Production
780-492-1462
Pascal.Couture@gov.ab.ca

Pamela Klebanov, Senior Manager
Business Operations and Special Cases
780-492-1443
Pamela.Klebanov@gov.ab.ca

Steven Diachuk, Coordinator
Field Testing, Special Cases, and GED
780-492-1453
Steven.Diachuk@gov.ab.ca

Inquiries about special cases, achievement test accommodations, and special-format materials can be sent by email to special.cases@gov.ab.ca

Inquiries about field testing can be sent by email to field.test@gov.ab.ca

Provincial Assessment Sector
Mailing Address
Provincial Assessment Sector, Alberta Education
44 Capital Boulevard
10044 108 Street NW
Edmonton AB T5J 5E6
Telephone: 780-427-0010
Toll-free within Alberta: 310-0000
Fax: 780-422-4200
Alberta Education website:
education.alberta.ca