This document was written primarily for:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<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>
<td></td>
</tr>
<tr>
<td>General Audience</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
</tr>
</tbody>
</table>

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You can find diploma examination-related materials on the Alberta Education website at education.alberta.ca. At the home page, click on the link “Teachers”; then click on the link “Teaching Resources,” and after that the link “Provincial Testing”. Next, click on “Diploma Examinations”, and then on one of the specific links listed under the “Diploma Examinations” heading.
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 requiring creativity and imagination. The course is 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 facts, 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 2010–2011 school year, more than 5,000 diploma examinations were administered, which represents an increase from the previous year. The increase in participation is mainly 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 examination manager, John Drader, at John.Drader@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 at education.alberta.ca, via this pathway: Teachers > Programs of Study > Science > Programs of Study.

Details regarding these learning outcomes are amplified in the Depth of Coverage section beginning on page 12 of this bulletin. These specific statements of standards are written primarily to inform Science 30 teachers regarding the extent to which students must master the Science 30 content and demonstrate the required skills in order to pass the examination.
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; they are also able to correctly answer questions involving concepts from a specified area of science. These students are able to follow correct laboratory procedures when given specific directions. They are able to make the connection between scientific concepts and laboratory activities when the data are used to verify known information. 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 in creative ways. 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.
Examination Specifications and Design

Each Science 30 Diploma Examination is designed to reflect the 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; 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 Learner 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 10–15%</td>
</tr>
<tr>
<td>A3</td>
<td>Genetics 10–15%</td>
</tr>
<tr>
<td>B1/B2/B3</td>
<td>Environmental chemistry 20–30%</td>
</tr>
<tr>
<td>C1</td>
<td>Field theory and electrical energy 13–18%</td>
</tr>
<tr>
<td>C2</td>
<td>Electromagnetic spectrum 7–12%</td>
</tr>
<tr>
<td>D1/D2</td>
<td>Energy and the environment 20–30%</td>
</tr>
</tbody>
</table>

Examination Content Formatting

NEW The formatting of content in some examination booklets has changed slightly. The instruction pages now begin on the inside front cover, and the side, top and bottom page margins are narrower than before. The changes are not a misprint. As a result of these changes, the total amount of paper used each year in printing the examinations will decrease by several tonnes.

The format changes do not apply to all diploma examination booklets. French-language booklets, Part A booklets, and Readings booklets still use the old format. Also, the size of the print and the font are unchanged in all booklets, except in Biology 30, where the font size inside context boxes has increased.
The 2011–2012 Science 30 Diploma Examinations are constructed to place the following approximate emphases on the Science 30 GOs.

### Knowledge

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

### Scientific Process and Communication Skills

The student can

- design, interpret, explain, analyze, and evaluate investigations
- organize data into tables, graphs, and diagrams, and predict relationships
- interpret, explain, analyze, and evaluate data to infer relationships
- use appropriate scientific terminology and mathematical language to communicate and explain scientific concepts

### Science, Technology, and Society Connections (STS)

The student can

- apply cause-and-effect reasoning to formulate relationships in which scientific evidence shapes or refutes a theory, and explain the limitations of science and technology in answering all questions and solving all problems
- describe and evaluate the design and function of technological solutions to practical problems by using scientific principles and theories, and relate the ways in which science and technology advance each other
- evaluate from a variety of perspectives how science and technology are influenced and supported by society, and assess the ability of society to interact responsibly with the environment
- apply the skills and knowledge acquired in Science 30 to everyday life and to both related and new concepts in post-secondary studies
The design of the 2011–2012 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.

In the past, groups of questions were arranged in scenarios or story-lines. These scenarios were introduced using one or two sentences enclosed in a grey box. Beginning with the January 2010 Diploma Examination, these scenarios were removed.

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

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

An additional format for answering numerical-response questions began to appear in diploma examinations in the 2005–2006 academic year. The format, similar to that used in physics, requires students to indicate values in scientific notation, including the exponent of the base 10, for a value expressed in scientific notation, as shown in the example that follows.
Sample Question

Numerical Response

The hydronium ion concentration, \([H_3O^+(aq)]\), for a solution with a pH of 5.500, expressed in scientific notation, is \(a.bc \times 10^{-d}\) mol/L. The values of \(a\), \(b\), \(c\), and \(d\) are \(\underline{a}\), \(\underline{b}\), \(\underline{c}\), and \(\underline{d}\).

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

Answer: 3.162 277 66 \(\times\) 10\(^{-6}\)

\[
\begin{align*}
3 & \; \; , \; \; 1 \; \; , \; \; 6 \; \; , \; \; 6
\end{align*}
\]

Record: Record 3166 on the answer sheet

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 Teacher Perusal Copy for review purposes one hour after the examination has started. For more information about teacher persual copies and examination security, please refer to the General Information Bulletin at education.alberta.ca via this pathway: Teachers > (Additional Programs and Services) Diploma Exams > Diploma 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.
Publications and Supporting Documents

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

- **Science 30 Released Items**
  (sent to schools) There will be no new Released Items this year; however, practice exams are available at https://questaplus.alberta.ca/ under the “Practice Tests” tab
- **Science 30 Assessment Highlights**
  available at education.alberta.ca, via this pathway:
  For Teachers > (Additional Programs and Services) Diploma Exams > Assessment Highlights
- **Science 30 Information Bulletin**
  available at education.alberta.ca, via this pathway:
  For Teachers > (Additional Programs and Services) Diploma Exams > Information Bulletins
- **Instructional Group Reports** for January and June Diploma Examinations
  available on the extranet at https://phoenix.edc.gov.ab.ca/login/default.asp

The Assessment Sector no longer produces Examination Manager’s Reports. Item descriptions and other information previously available in the Examination Manager’s Report is now located in the Assessment Highlights document and in Table 7 of the Instructional Group Report, both of which follow the January and June examination sessions. A sample of the format for Table 7 appears on the next page.
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</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circulatory and immune systems (GO A1/A2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genetics (GO A3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental chemistry (GO B1/B2/B3)</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>
</tr>
<tr>
<td>Electromagnetic spectrum (GO C3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy and the environment (GO D1/D2)</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</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>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>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>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>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.
Assessment of 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.

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

Students are expected to record responses in the appropriate units and use the correct number of significant digits, and this may require students to perform unit conversions. 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

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

   A. \( E_k = \frac{1}{2}mv^2 \)

   B. \( E_p = mgh \)

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

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

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 the next question.

To determine the effect of acid rain on corn plants, a solution of H$_2$SO$_4$(aq) 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.

<table>
<thead>
<tr>
<th>Experimental Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Type of soil</td>
</tr>
<tr>
<td>2 Substance used to water plants</td>
</tr>
<tr>
<td>3 Amount of light</td>
</tr>
<tr>
<td>4 Growth of plant</td>
</tr>
</tbody>
</table>

Numerical Response

2. Match each of the experimental conditions numbered above with one of the variables given below.

<table>
<thead>
<tr>
<th>Conditions:</th>
<th>Variables:</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 2413 or 2431.)
STS-based questions present a problem that requires students to make connections between scientific concepts, technology, and/or social issues.

Sample Question

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

**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**

3. Match the arguments numbered above with the perspective that **best** describes it as listed below. Use each number only once.

   - Political  ____________ (Record in the **first** column)
   - Economic  ____________ (Record in the **second** column)
   - Societal  ____________ (Record in the **third** column)
   - Environmental  ____________ (Record in the **fourth** column)

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

   (The answer is 4231.)
Depth of Coverage

A revised 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 revised 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 Curriculum and the 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, whereas items in italics will not be specifically tested on the diploma examination. While items in italics will not be specifically tested, students should still be capable of addressing the ideas and skills described in the italicized concepts on open-ended items.

We have also addressed this issue by introducing a numerical-response format where more than one answer is accepted, as shown in the example that follows.

Sample Question

Use the following information to answer the next question.

Electromagnetic radiation (EMR) is often used in the diagnosis and treatment of disease. Understanding the properties of EMR is important to ensure that it is used properly.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Type of EMR</th>
<th>Medical Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Fibre optics</td>
<td>4 Infrared</td>
<td>7 Performing endoscopic surgery</td>
</tr>
<tr>
<td>2 Magnetic resonance imaging (MRI)</td>
<td>5 Radio</td>
<td>8 Soft tissue imaging</td>
</tr>
<tr>
<td>3 Thermogram</td>
<td>6 Visible light</td>
<td>9 Showing temperature distribution in tissues</td>
</tr>
</tbody>
</table>

Numerical Response

4. Choose the number of one technology from the table above and match it with the number of the type of EMR associated with that technology and with the number of the medical application associated with that technology. (There is more than one correct answer.)

   Technology ____________ (Record in the first column)
   Type of EMR ____________ (Record in the second column)
   Medical application ____________ (Record in the third column)

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

(The answer is 167, 258, or 349.)
Unit A, General Outcome 1

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 included). Identification of the blood vessels connected to each of the chambers of the mammalian heart and an ability to relate their differences in structure with respect 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 from the vena cava, through the heart, to the lungs, back to the heart, and out of the aorta should be included.

A general description of what happens to the entire heart during systole and diastole is required. Calculation of stroke volume is not expected. 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 six hours of class time.
Sample Question

Identifying blood components from diagrams and the effect of changes in relative amounts or function of blood components is expected.

Use the following information to answer the next question.

Diagrams of Blood Slides Observed by a Laboratory Technician

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

   A. I
   B. II
   *C. III
   D. IV
Sample Question

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

Use the following information to answer the next question.

A faulty heart valve allows blood to flow back into a previous chamber. This condition may be treated by replacing the faulty valve with a mechanical one.

2. In some patients, blood flows backward through a defective valve into the right atrium. In which of the following diagrams is the mechanical valve placed so that it would correct this problem?

   A. ![Diagram A]

   B. ![Diagram B]

   C. ![Diagram C]

   *D. ![Diagram D]
Unit A, General Outcome 2

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 disease, 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.

General Outcome 2 can be completed within about four hours of class time.

Sample Question

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

3. 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

Unit A, General Outcome 3

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 use a pedigree chart.

Memorization of the stages of mitosis and meiosis is not necessary, but a general description of the sequence of events in these processes is required. For example, students should know that chromosomes double, line up at the equator, and separate and pull to opposite poles. The same depth should apply to gametogenesis and fertilization. Use of the biological terms (such as prophase and metaphase) for structure and function is not required, but it is reasonable to expect students to use the terms haploid (n) and diploid (2n), homozygous and heterozygous in their descriptions. Students should be able to make the connection between fertilization and Mendelian crosses in Punnett squares.

Students should be able to interpret autosomal and sex-linked patterns of inheritance. Although sex-linked genetic disorders include both X-linked and Y-linked genetic disorders, the focus will be on sex-linked genetic disorders associated with the X chromosome. 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 the detailed naming of the steps in the processes (such as tRNA, ribosomes, mRNA, transcription and translation) 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 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).

To understand the role of DNA, students need to know that proteins make up the structure of the cell and regulate the chemical reactions in the cell (enzymes). Diploma examinations will place more 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 hours of class time.

Sample Questions

*Identifying the amino acids that a DNA sequence codes for will be required.*

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

---

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

**Fragment of DNA**

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

**Partial List of Amino Acids**

| 1 | Phenylalanine | 6 | Proline |
| 2 | Leucine | 7 | Alanine |
| 3 | Isoleucine | 8 | Threonine |
| 4 | Valine | 9 | Cysteine |
| 5 | Serine |

---

**Numerical Response**

4. Match four of the amino acids numbered above with their order shown on the DNA strand depicted above. Use each number only once.

**Amino Acid: Order:**

<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>Order: First</th>
<th>Second</th>
<th>Third</th>
<th>Fourth</th>
</tr>
</thead>
</table>

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

(The answer is 8593.)
Use the following information to answer the next question.

Factors Associated with Plants That Are Genetically Modified to Be Pesticide Resistant

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Transfer of genetic material to other organisms</td>
</tr>
<tr>
<td>II</td>
<td>Decreased use of chemical insecticides</td>
</tr>
<tr>
<td>III</td>
<td>Non-target organisms are affected</td>
</tr>
<tr>
<td>IV</td>
<td>Increased crop yield</td>
</tr>
</tbody>
</table>

5. Two environmental risks that are associated with plants that are genetically modified to be pesticide resistant are numbered

*A.  I and III  
B.  I and IV  
C.  II and III  
D.  II and IV*
The ability to interpret pedigree charts and use appropriate symbols to describe genotype is a requirement of the course. The two questions that follow assess these skills using different approaches.

Use the following information to answer the next question.

Family Pedigree Illustrating PKU Inheritance

Phenylketonuria (PKU) is an autosomal recessive disorder.

6. The genotype of individual II-4 is

A. PP
*B. Pp
C. Pp or PP
D. PP or Pp

7. An individual on the pedigree who has a homozygous genotype is individual

A. I-1
B. I-2
*C. II-3
D. II-4
Unit B, General Outcome 1

The chemistry of solutions may have to be reviewed at the beginning of this unit (suggested time—three hours). Most of the acid–base concepts, such as classification, indicators, buffers, and titrations, are covered in simple proton transfer principles using conjugate acid–base pairs. The term Brønsted–Lowry is no longer used in the new program. Instead, the terms proton acceptor (base) and proton donor (acid) are used. Titration calculations are limited to strong monoprotic acids, should be kept simple, and should relate to solution stoichiometry as much as possible. 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 change in indicators. Students should be aware of the logarithmic nature of the pH scale.

Students are expected to test for acidic, basic, neutral ionic, and molecular solutions. It is reasonable to expect that they can also recognize these solutions from their formulas.

General Outcome 1 can be completed within about nine hours of class time.

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 reverse reactions. The term Brønsted–Lowry is no longer used for assessment, as shown below.*

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

<table>
<thead>
<tr>
<th>Chemical Equation for Buffering Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{H}_2\text{O}(\text{l}) + \text{HCO}_3^- (\text{aq}) \rightleftharpoons \text{H}_3\text{O}^+ (\text{aq}) + \text{CO}_3^{2-} (\text{aq}) )</td>
</tr>
</tbody>
</table>

8. Which chemicals in the equation above donate a proton?

A. \( \text{H}_2\text{O}(\text{l}) \) and \( \text{H}_3\text{O}^+ (\text{aq}) \)
B. \( \text{H}_2\text{O}(\text{l}) \) and \( \text{CO}_3^{2-} (\text{aq}) \)
*C. \( \text{HCO}_3^- (\text{aq}) \) and \( \text{H}_3\text{O}^+ (\text{aq}) \)
D. \( \text{HCO}_3^- (\text{aq}) \) and \( \text{CO}_3^{2-} (\text{aq}) \)
9. The pH of some melted snow is 5.5 and changes to a pH of 7.5 when it enters a pond. The hydronium ion concentration, $[\text{H}_3\text{O}^+(\text{aq})]$, of the melted snow has

A. increased by a factor of 2  
B. decreased by a factor of 2  
C. increased by a factor of 100  
*D. decreased by a factor of 100

Students should be able to interpret the results of simple diagnostic tests such as conductivity and indicator colour, including intermediate indicator colours.

Use the following information to answer the next question.

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>Colour After Addition of Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Bromothymol Blue</td>
</tr>
<tr>
<td>Distilled water</td>
<td>No</td>
<td>Green</td>
</tr>
<tr>
<td>Sample solution</td>
<td>Yes</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

10. Based on the test data shown above, the sample could be a solution of

A. NaCl(aq)  
B. NaOH(aq)  
C. CH$_3$OH(aq)  
*D. H$_2$SO$_3$(aq)
Sample Questions

Students should be able to make general interpretations from titration curves.

Use the following information to answer the next question.

A 0.0120 L 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.

Change in pH of Well-Water Sample Titrated with HCl(aq)

11. According to the graph above, the water sample initially had a __i__ pH. As HCl(aq) was added, the hydronium ion concentration, [H$_3$O$^+$](aq), __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>basic</td>
<td>increased</td>
</tr>
<tr>
<td>B.</td>
<td>basic</td>
<td>decreased</td>
</tr>
<tr>
<td>C.</td>
<td>acidic</td>
<td>increased</td>
</tr>
<tr>
<td>D.</td>
<td>acidic</td>
<td>decreased</td>
</tr>
</tbody>
</table>
Sample Question

The ability to reproduce combustion reactions resulting in acid rain is required.

Use the following information to answer the next question.

The burning of low-grade coal contributes to harmful emissions that can undergo chemical reactions in the atmosphere.

12. The sequence in which rainwater pollutants are formed when low-grade coal is burned is \( i \rightarrow ii \rightarrow iii \).

The statement above is completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th>i</th>
<th>ii</th>
<th>iii</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>sulfur</td>
<td>sulfur dioxide</td>
<td>sulfuric acid</td>
</tr>
<tr>
<td>B.</td>
<td>sulfur</td>
<td>sulfuric acid</td>
<td>sulfur dioxide</td>
</tr>
<tr>
<td>C.</td>
<td>sulfur dioxide</td>
<td>sulfur</td>
<td>sulfuric acid</td>
</tr>
<tr>
<td>D.</td>
<td>sulfur dioxide</td>
<td>sulfur</td>
<td>sulfur</td>
</tr>
</tbody>
</table>
Unit B, General Outcome 2

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 no longer included in the new Program of Studies.

An extension of B2.1sts and Unit D of Science 10 will include global warming/climate change. 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 2 can be completed within about six hours of class time.

Sample Questions

*Naming of benzene rings and complicated organic structures is not required; however, recognizing the benzene ring and functional groups attached to more complicated structures is expected, as shown below.*

Use the following information to answer the next question.

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

**Structural Formula of a Component of Aspirin**

13. The functional groups present in the structural formula above are

A. an alcohol and an ester

*B. a carboxylic acid and an ester

C. a halogenated hydrocarbon and an alcohol

D. a carboxylic acid and a halogenated hydrocarbon
Students should be able to recognize a variety of organic compound representations.

Use the following information to answer the next question.

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

Model of an Organic Compound

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

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

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

A. 
\[
\begin{array}{c}
\text{Cl} \\
\text{C} = \text{C} \\
\text{Cl} \\
\text{Cl} \\
\end{array}
\]

B. 
\[
\text{HO}
\]

C. 
\[
\begin{array}{c}
\text{CH}_3 \\
\text{O} \\
\text{OH}
\end{array}
\]

D. 
\[
\begin{array}{c}
\text{Cl} \\
\text{Cl}
\end{array}
\]
Unit B, General Outcome 3

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. Ground-level ozone and particulates should be recognized as components of photochemical smog. 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 should be able to identify pollutants, their sources, and effects. Students are expected to identify WHMIS symbols.

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 include the ecological, economic, ethical, political, scientific, technological, legal, and societal.

General Outcome 3 can be completed within about eight hours of class time.

Sample Questions

16. An environmentalist expected the water of a particular river to be high in organic content. High organic content in a river would result in

A. low BOD and clear water
B. high BOD and clear water
C. low BOD and cloudy water
*D. high BOD and cloudy water

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

*A. reduce the SO\textsubscript{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
Unit C, General Outcome 1

The emphasis of this General Outcome is on basic principles. 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.

![Graph showing field strength vs. increasing distance](Sci30_09 Field Graph)

The following formulas have been removed from the Program of Studies and the data booklet.

\[
|E| = \frac{V}{d} \quad F = \frac{kq_1q_2}{r^2} \quad P = \frac{V^2}{R}
\]

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. Since there is not enough class time to practise all types and variations of questions, 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, and build series and parallel circuits. However, calculations involving circuits with complicated combinations of series and parallel formations are not required.

The concept of induction in relation to generators and transformers is important.

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 hours of class time.
Sample Questions

*Students are expected to use the data booklet to help them solve problems.*

18. A satellite orbited Earth at a distance of $4.2 \times 10^7$ m from the centre of Earth. The gravitational field strength at this distance 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*

*Students should be able to determine the direction of vector fields (C1.3k).*

19. Which of the following diagrams demonstrates the direction of a magnetic field?

*A. [Diagram A]*
*B. [Diagram B]*
*C. [Diagram C]*
*D. [Diagram D]*
Sample Questions

There is an emphasis on the general design, function, and comparison of motors and generators.

Use the following information to answer the next question.

20. The diagram above would represent a generator if the part numbered 3 was ______, and ______ energy was converted to ______ energy.

The statement above is completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th>i</th>
<th>ii</th>
<th>iii</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>charging</td>
<td>electrical</td>
<td>chemical</td>
</tr>
<tr>
<td>B</td>
<td>charging</td>
<td>chemical</td>
<td>electrical</td>
</tr>
<tr>
<td>C</td>
<td>discharging</td>
<td>electrical</td>
<td>chemical</td>
</tr>
<tr>
<td>D</td>
<td>discharging</td>
<td>chemical</td>
<td>electrical</td>
</tr>
</tbody>
</table>
Resistance for series and parallel circuits can be dealt with using a variety of approaches, including demonstration, laboratory investigation, 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 the next question.

![Circuit Diagrams]

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

**Numerical Response**

21. 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

Memorization of the various types of electromagnetic radiation (EMR) is not necessary. This information is in the data booklet. When comparing the various constituents of the electromagnetic spectrum on the basis of energy and their effect on living tissue, the term *photon* may be used. Qualitative descriptions include demonstrating the direction EMR bends when moving from one medium to another. The term *normal* may be used to describe the 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. 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. Students should be aware that different stellar masses (low-mass, intermediate-mass, and high-mass) result in the production of white dwarves, neutron stars and black holes.

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

**Sample Questions**

22. Which of the following forms of EMR contains photons that possess **higher** energy than those of ultraviolet radiation?

   *A.  X-ray  
   B.  Radio  
   C.  Infrared  
   D.  Microwave*
23. Which diagram above depicts the correct pathway of a reflected light ray?

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

24. When Carol looks at a stone that is located under water, the image of the stone is slightly displaced. This is because

A. light from the stone is refracted toward the normal as it enters the air  
*B. light from the stone is refracted away from the normal as it enters the air  
C. polarized light from the water surface causes an apparent displacement of the position of the stone  
D. light from the stone is approaching the vertical angle for water to air, thus displacing the apparent position of the stone
Many students still have difficulty discriminating between nuclear reactions that involve fission and those that involve fusion.

25. Which of the following reactions represents a fission reaction?

A. \( ^{3/2}_{2}\text{He} + ^{1/0}_{0}\text{n} \rightarrow ^{4/2}_{2}\text{He} \)

B. \( ^{2/1}_{1}\text{H} + ^{2/1}_{1}\text{H} \rightarrow ^{3/2}_{2}\text{He} + ^{1/0}_{0}\text{n} \)

C. \( ^{3/2}_{2}\text{He} + ^{1/1}_{1}\text{H} \rightarrow ^{3/3}_{3}\text{Li} + ^{1/0}_{0}\text{n} \)

D. \( ^{235}_{92}\text{U} + ^{1/0}_{0}\text{n} \rightarrow ^{141}_{56}\text{Ba} + ^{92}_{36}\text{Kr} + ^{3/3}_{1}\text{n} \)
A diffraction grating can be used to observe the interaction of EMR and gases of the atmosphere.

26. Spectrum I is an example of an _____ spectrum, and the relative temperature of gas I is _____.

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>absorption</td>
<td>hot</td>
</tr>
<tr>
<td>B.</td>
<td>absorption</td>
<td>cool</td>
</tr>
<tr>
<td>*C.</td>
<td>emission</td>
<td>hot</td>
</tr>
<tr>
<td>D.</td>
<td>emission</td>
<td>cool</td>
</tr>
</tbody>
</table>
Some Stages in the Evolution of a Small Star

1. Fusion begins
2. White dwarf
3. Red giant

Numerical Response

27. A small star such as the Sun begins as a collection of dust and gas. As the star evolves, 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

Global issues are the focus of this unit. Specific examples of solutions to problems need to be incorporated into the discussion of these issues. Connections with Unit B for pollutants and Unit C with electrical energy production can be made. There will be more emphasis on biofuels than found in previous assessments.

General Outcome 1 can be completed within about nine hours of class time.

Sample Question

An environmental risk associated with burning coal is the production of acid rain.

28. A concern associated with acid rain is that it results in an increase in

A. ozone depletion
B. global temperatures
C. ultraviolet radiation
*D. heavy-metal leaching
29. *The burning of ethanol that has been produced by the fermentation of grain is considered a ____i__ energy source that results in the production of ____ii__ net carbon dioxide than fossil fuel combustion.*

The statement above is completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th></th>
<th></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>

Unit D, General Outcome 2

Students must be able to calculate the enthalpy change, $\Delta H$, for a chemical process using standard molar enthalpies of formation, $\Delta_f H^\circ$, for substances. Using Hess’s law to calculate the $\Delta_f H^\circ$ of an unknown substance goes beyond the intent of the program of studies. A clear understanding of the transformations of energy before its final use is necessary to discuss efficiency comparisons. There will be more emphasis on the advantages and disadvantages of hydrogen fuel cells than found in previous assessments (see D2.4k).

Geothermal energy and nuclear reactions in this unit can be used to refer back to EMR in Unit C. Fission, fusion, and decay reactions produce energy according to the mass-energy equivalency. Students should be able to use the formula $\Delta E = \Delta mc^2$ to calculate the amount 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 find missing nucleons in nuclear reactions and, given the reaction, predict the energy produced. Relative comparisons of the amount of energy involved in nuclear reactions, chemical reactions, and phase changes are expected.

General Outcome 2 can be completed within about 11 hours of class time.
Sample Question

Use the following information to answer the next question.

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

**Numerical Response**

30. The energy released when one mole of \( \text{C}_3\text{H}_8(g) \) 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.**

31. 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

**Numerical Response**

32. The total mass of the products in a nuclear process is \( 3.10 \times 10^{-28} \) kg less than that of the reactants. The energy released by the reaction is \___________\ \times 10^{-11} \) J.

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

(The answer is 2.79.)
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 $\Delta E=\Delta mc^2$. In the next example 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 the next question.

**Reaction Equation Representing Hydrogen Fusion**

\[ ^1_4\text{H} \rightarrow ^2_4\text{He} + ^0_1\text{e} \]

**Numerical Response**

33. In a fusion reaction, mass is converted into energy. In the reaction represented above, when one mole of $^2_4\text{He}$ is formed, the energy released is \( \underline{\text{\hspace{1cm}}} \times 10^{12} \text{ J} \).

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

(The answer is 2.58.)

34. The source of the Sun’s radiant energy is nuclear fusion reactions. The difference 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
Students should be able to distinguish clearly between alpha, beta, and gamma decay reactions (see D2.6k).

Use the following information to answer the next question.

<table>
<thead>
<tr>
<th>Types of Radioactive Decay</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Alpha decay ($\alpha$)</td>
</tr>
<tr>
<td>2  Beta decay ($\beta$)</td>
</tr>
</tbody>
</table>

**Numerical Response**

35. Match the types of radioactive decay numbered above with the appropriate reaction listed below. Numbers may be used more than once.

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

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

(The answer is 1221.)
Although open-ended questions are no longer part of the Science 30 Diploma Examination, open-ended questions should be used freely as part of classroom assessment. In this way, there can be a broad-based assessment of all the outcomes included in the Program of Studies.

Students’ answers can be scored using a holistic scoring guide. The guide describes the characteristics of students’ answers that correspond to one of five values: 4, 3, 2, 1, or 0.

The following section presents the short-answer question from Part A of the January 2008 Diploma Examination along with examples of students’ responses and the scoring guides that were used to score them.

**Short-Answer Question**

*January 2008 Diploma Examination*

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

In order to determine the concentration of a solution of NaOH(aq), a student titrates a 10.00 mL sample of NaOH(aq) with a 0.500 mol/L solution of HNO₃(aq).

The diagram below shows the volume of HNO₃(aq) added for each of three titration trials.

**Note:** The burette is not refilled after each trial.
a. Use the information on the previous page to complete the following table. The volume of HNO₃(aq) added in trial II has been provided for you.

<table>
<thead>
<tr>
<th></th>
<th>Trial I</th>
<th>Trial II</th>
<th>Trial III</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Final volume of HNO₃(aq) (mL)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Initial volume of HNO₃(aq) (mL)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Volume of HNO₃(aq) added (mL)</strong></td>
<td></td>
<td>11.40</td>
<td></td>
</tr>
</tbody>
</table>

Use the following additional information to answer the next part of the question.

The reaction that occurs during the titration is represented by the equation below.

\[
\text{NaOH(aq)} + \text{HNO}_3\text{(aq)} \rightarrow \text{H}_2\text{O(l)} + \text{NaNO}_3\text{(aq)}
\]

? mol/L  0.500 mol/L  
10.00 mL

b. Use the average volume of HNO₃(aq) from trials I through III to calculate the concentration of HNO₃(aq). Show your work.

Sample Response

a. Use the information on the previous page to complete the following table. The volume of HNO₃(aq) added in trial II has been provided for you.

<table>
<thead>
<tr>
<th></th>
<th>Trial I</th>
<th>Trial II</th>
<th>Trial III</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Final volume of HNO₃(aq) (mL)</strong></td>
<td>12.50</td>
<td>23.90</td>
<td>35.10</td>
</tr>
<tr>
<td><strong>Initial volume of HNO₃(aq) (mL)</strong></td>
<td>1.20</td>
<td>12.50</td>
<td>23.90</td>
</tr>
<tr>
<td><strong>Volume of HNO₃(aq) added (mL)</strong></td>
<td>11.30</td>
<td>11.40</td>
<td>11.20</td>
</tr>
</tbody>
</table>

b. Use the average volume of HNO₃(aq) from trials I through III to calculate the concentration of HNO₃(aq). Show your work.

Average Volume of HNO₃(aq) added = (11.30 + 11.40 + 11.20)/3 = 11.30 mL

\[ n = CV \]
\[ \text{mol of HNO}_3 = 0.01130 \text{ mol/L} \times 0.500 \text{ L} = 0.00565 \text{ mol} \]
\[ C = \frac{n}{V} \]
\[ C \text{ of NaOH} = \frac{0.00565 \text{ mol}}{0.0100 \text{ L}} = 0.565 \text{ mol/L} \]

OR

\[ C_1V_1 = C_2V_2 \]
\[ C_1 = \frac{C_2V_2}{V_1} \]
**Scoring Guide – Short-Answer Question**

<table>
<thead>
<tr>
<th>Score</th>
<th>Short-Answer Scoring Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td><strong>Standard of Excellence</strong>&lt;br&gt;The values in the table of burette readings are complete and accurate. The work is <strong>well organized and correct</strong>. The concentration of NaOH(aq) is <strong>correct</strong>.</td>
</tr>
<tr>
<td>3</td>
<td>The values in the table of burette readings are complete and <strong>mostly accurate</strong>. The work is <strong>organized and generally correct</strong>. The concentration of NaOH(aq) is <strong>correct or reflects minor errors in computation</strong> OR the answer is correct with little work shown.</td>
</tr>
<tr>
<td>2</td>
<td><strong>Acceptable Standard</strong>&lt;br&gt;<em>Most</em> of the values in the table of burette readings are entered and <strong>generally correct</strong>. The work is <strong>reasonably well organized</strong>. The concentration of NaOH(aq) is <strong>consistent with the results from the table and calculations presented in the work</strong>.</td>
</tr>
<tr>
<td>1</td>
<td>The table of burette readings is incomplete and inaccurate. The work is <strong>not organized</strong>. The concentration of NaOH(aq) is <strong>incorrect</strong>.</td>
</tr>
<tr>
<td>0</td>
<td>The response does not address any of the major points of the question at an <strong>appropriate level</strong> for a 30-level course.</td>
</tr>
</tbody>
</table>

**Student Response 1**

**Score—4**<br><br>**Rationale**

This example meets the requirements of the **standard of excellence**.

The data table is complete and mostly accurate. There is a minor error of using litres instead of millilitres, but it doesn’t interfere with the calculation. The calculation is correct and consistent with the data in the table.
**Student Response 2**

**Score—2**

**Rationale**

This example meets the *acceptable standard*.

The correct values are entered into the table for the burette volumes, and the calculations in the table are done properly. However, the data from the table are not carried over into part b. The response demonstrates minimal understanding of calculations related to determining the concentration of the NaOH(aq).
Long-Answer Questions as Part of Classroom Assessment

January 2008 Diploma Examination
Long-Answer Questions, Scoring Guides, Sample Responses, and Rationales

The following section presents two open-response long-answer questions with examples of students’ responses from Part A of the January 2008 Diploma Examination as well as the scoring guides that were used to score them.

Each student’s answer is scored using holistic scoring guides. The guide describes the characteristics of students’ answers that correspond to one of five values: 4, 3, 2, 1, or 0.
Environmentalists are concerned that manufacturers of herbicides are not required to list all of the ingredients that are in their products.Manufacturers are required to list only the active ingredients, which are the substances that kill the pest. Inert substances, which are often not listed, include solvents in which the herbicides’ active ingredients are dissolved and other additives.

In one study, a group of mice was exposed to an increasing concentration of only the active ingredient in a herbicide. A second group of mice was exposed to an increasing concentration of the complete herbicide. The level of sex hormones that were produced by each group of mice was monitored. The results of the experiment are graphed below.

Effect of a Particular Herbicide on the Level of Sex Hormones in Mice

Long Answer 1

a. Manufacturers are required to disclose the active ingredients in their herbicides. Explain how the information presented in the graph above supports the argument that manufacturers should disclose all of the ingredients in their herbicides.

b. State one major advantage and one major disadvantage of pesticide use. Describe two actions that you think society should take in dealing with pests, and explain the benefits of these actions.

Sample Response

a. Mice exposed to the complete herbicide experienced a decrease in sex hormone levels, but mice exposed to only the active ingredient from a pesticide preparation did not experience any decrease in sex hormone levels. These data appear to indicate that chemicals, other than the active ingredient, within the complete herbicide application have an effect on the ability of mice to produce sex hormones. Disclosing the list of all chemicals in the commercial pesticide will identify those ingredients that may have unknown effects, have been the focus of previous investigations, or require further testing.
b. One major advantage of herbicide use is that it reduces the size of pest populations and increases crop yield. One major disadvantage is that some herbicides are not target specific. One action for dealing with pests would be to control populations by exposing them to natural predators. Another action would be to use genetically modified species that are resistant to the pests. The benefits of both actions would be the reduction of chemical use and a decrease in potential harm to the environment through possible biomagnification or reactions with unknown additives.

The response should clearly provide one advantage or one disadvantage of herbicide use. The response should indicate two appropriate actions for dealing with pests. The benefits of each action should be identified and may be politically, economically, or environmentally focused.

Some other advantages are easy application and relatively low cost compared with non-chemical methods. Some other disadvantages of herbicide use are biomagnification, disruption of food chains and long-term, low-level exposure.

Some other actions society could take in dealing with pests (such as weeds, for example) would be to manually remove them. Insects have been successfully controlled through the use of pheromone attractants or the introduction of sterilized individuals into the population.

<table>
<thead>
<tr>
<th>Score</th>
<th>Long-Answer Scoring Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td><strong>Standard of Excellence</strong>  The response is <strong>well organized</strong> and addresses all the points of the question. The data from the graph are accurately interpreted. The response reflects a <strong>thorough</strong> understanding of pesticide use and presents a <strong>sophisticated</strong> description of how society should deal with pests.</td>
</tr>
<tr>
<td>3</td>
<td>The response is <strong>organized</strong> and addresses the major points of the question. The data from the graph are <strong>accurately</strong> interpreted. The response reflects a <strong>good</strong> understanding of pesticide use and presents a <strong>reasonable</strong> description of how society should deal with pests.</td>
</tr>
<tr>
<td>2</td>
<td><strong>Acceptable Standard</strong>  The response is <strong>generally organized</strong> and addresses most of the major points of the question. The data from the graph are <strong>adequately</strong> interpreted. The response reflects an <strong>adequate</strong> understanding of pesticide use and presents a <strong>simple</strong> description of how society should deal with pests.</td>
</tr>
<tr>
<td>1</td>
<td>The response is <strong>not well organized</strong> and does not address the major points of the question. The data from the graph are <strong>not accurately</strong> interpreted. The response reflects a <strong>poor</strong> understanding of pesticide use and presents a <strong>superficial</strong> description of how society should deal with pests.</td>
</tr>
<tr>
<td>0</td>
<td>The response does not address any of the major points of the question at an <strong>appropriate level</strong> for a 30-level course.</td>
</tr>
</tbody>
</table>
Student Response 1

Score—4
Rationale

This example meets the requirements of the standard of excellence.

The response is well organized and includes an accurate interpretation of the graph and study. The advantages and disadvantages of pesticide use are explained. Actions to reduce the use of pesticides are provided along with specific examples. The answer could have been improved by using phrases such as “target-specific pesticides” and “crop rotation for reducing the use of pesticides.”
Student Response 2

Use the following information to answer the next question.

Environmental ethics are concerned that manufacturers of herbicides are not required to list all of the ingredients that are in their products. Manufacturers are required to list only the active ingredients, which are the substances that kill the pest. Inert (diluent) substances, which are often not listed, include solvents in which the herbicides’ active ingredients are dissolved and other additives.

In one study, a group of mice was exposed to an increasing concentration of only the active ingredient in a herbicide. A second group of mice was exposed to an increasing concentration of the complete herbicide. The level of sex hormones that were produced by each group of mice was monitored. The results of the experiment are graphed below.

**Effect of a Particular Herbicide on the Level of Sex Hormones in Mice**

- **Mouse exposed to**
  - Active ingredient only
  - Complete herbicide

**Concentration of chemical administered**

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Mouse exposed to active ingredient only</th>
<th>Mouse exposed to complete herbicide</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Medium</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Low</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

**Long Answer—15%**

a. Manufacturers are required to disclose the active ingredients in their herbicides. Explain how the information presented in the graph above supports the argument that manufacturers should disclose all of the ingredients in their herbicides.

The mice that have only the active ingredient, have a higher sex hormone. They can reproduce and not have any problems. The mice with the complete herbicide don't have very high sex hormone. So they cannot reproduce as good. The higher the concentration of complete herbicide the lower the sex level of hormones. They should list all the ingredients on the label, so people know that it doesn't kill the animals. It makes them reproduce better.

Score—2

Rationale

This example meets the acceptable standard.

The response is organized and addresses all the points of the question. The interpretation of the graph is generally correct. Bioaccumulation is correctly described and given as a disadvantage of pesticide use. Development of resistance to pesticides is incorrectly presented as an advantage of pesticide use. Pesticides are incorrectly mentioned as a cause of algal bloom.
One major disadvantage of pesticide use is that it kills organisms. The pesticides get higher in concentration as they go up the food chain. The animals and organisms die from eating the plants sprayed with pesticides. As the pesticide moves up the food chain, it can harm the tertiary consumers. The animals in the highest trophic level suffer the worst. The pesticides being used will also cause pollution to the lakes or rivers. If the pesticides reach the lakes or rivers, it can cause an algal bloom. An algal bloom will kill off all the aquatic life.

One major advantage of using pesticides would be that the organisms that are reproduced could have a mutant gene. The pesticides would not hurt them. Organisms, because their mutation will allow them to withstand the pesticides. Two actions society should take in dealing with pests are to bring amphibians into the picture. The amphibians will kill the insects eating the crops or plants. They could also use a stronger fertilizer, or pesticide for the time being.
As oil, natural gas, and coal reserves become depleted, alternative energy sources will need to be significantly developed in order to provide the energy required to sustain the current standard of living. Decisions about the use of alternative energy technologies should include information from ecological, economic, societal, and political perspectives.

Alternative Energy Technologies

- Nuclear power plant
- Wind Turbine
- Hydroelectric power plant
- Photovoltaic cell
- Tidal power plant
- Geothermal power plant

Long Answer 2

From the list above, select one alternative energy technology used to produce electricity.

• List the energy conversions involved in using the technology.
• Explain the advantages and disadvantages of using the selected technology from two of the following perspectives: ecological, economic, societal, and political.
• Describe how the selected alternative energy technology should be used in the future.

Sample Response

The first part of the sample response is summarized in the table that follows.

Any future use of a selected technology should occur after the identification and analysis of the possible advantages and disadvantages, as well as emerging improvements on existing technology to ensure that actions can be taken to minimize risks as much as possible.

Students may indicate that the use of alternative technologies could be part of a balanced approach (use a variety of alternative technologies) or could be used to produce larger amounts of power (nuclear, hydroelectric).

Students may indicate the use of some technologies as supplementary sources to meet higher demand times on an individual scale or a large scale.

(Continued)
<table>
<thead>
<tr>
<th>Energy Resource</th>
<th>Conversions</th>
<th>Perspectives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Environmental</td>
</tr>
<tr>
<td>Nuclear</td>
<td>potential (intranuclear) → thermal → kinetic → electrical</td>
<td>Advantages</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• no gaseous emissions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• high energy-to-mass-of-fuel ratio</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• high energy content, uranium reserves are more plentiful than fossil fuel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• non-renewable</td>
</tr>
</tbody>
</table>

Disadvantages
- radioactive wastes
- thermal pollution
- risk of meltdown
- non-renewable
<table>
<thead>
<tr>
<th>Energy Resource</th>
<th>Conversions</th>
<th>Perspectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar</td>
<td>solar → electric (photovoltaic)</td>
<td>Environmental: Advantages</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Economic: Advantages</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Societal: Advantages</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Political: Advantages</td>
</tr>
<tr>
<td></td>
<td>solar → thermal → electric</td>
<td>Advantages: no gaseous emissions, renewable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Advantages: long lifespan, little maintenance, easily installed, plentiful, no fuel costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disadvantages: large amount of space required, photovoltaics require toxic metals such as cadmium and arsenic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disadvantages: more costly than conventional systems, each unit produces a small amount of energy, sunlight is intermittent and variable, conversion to electric energy is not very efficient</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disadvantages: cannot meet current energy demand, visual pollution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disadvantages: high cost of energy is not popular with consumers</td>
</tr>
</tbody>
</table>

Advantages
- no gaseous emissions
- renewable

Disadvantages
- large amount of space required
- photovoltaics require toxic metals such as cadmium and arsenic

Disadvantages
- more costly than conventional systems
- each unit produces a small amount of energy
- sunlight is intermittent and variable
- conversion to electric energy is not very efficient

Advantages
- perceived as environmentally friendly
- permits individuals or smaller scale facilities to generate power

Advantages
- is a means to reduce the emission of greenhouse gases
<table>
<thead>
<tr>
<th>Energy Resource</th>
<th>Conversions</th>
<th>Perspectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>solar → kinetic (wind) → kinetic (turbine) → electrical</td>
<td><strong>Environmental</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Advantages</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• no gaseous emissions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• plentiful</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• renewable</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Advantages</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• no fuel costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• long lifespan for turbines with minimal operating costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• self-sufficient</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• land can also be used for agriculture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• easily installed</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Advantages</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• perceived as environmentally friendly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• permits individuals or smaller-scale facilities to generate power</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Advantages</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• is a means to reduce the emission of greenhouse gases</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Disadvantages</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• large amount of land required</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• danger to birds and bats</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Disadvantages</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• few ideal sites</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• more costly than conventional systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• wind is variable and intermittent – often lowest during peak demand months</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• conversion to electric energy is not very efficient</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Disadvantages</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• cannot meet current energy demand</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• visual or noise pollution</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Disadvantages</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• high cost of energy is not popular with consumers (Denmark had to offer tax rebates to offset higher prices and maintain demand)</td>
</tr>
<tr>
<td>Energy Resource</td>
<td>Conversions</td>
<td>Perspectives</td>
</tr>
<tr>
<td>-----------------</td>
<td>-------------</td>
<td>--------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Environmental</td>
</tr>
<tr>
<td>Hydroelectric</td>
<td>solar $\rightarrow$ thermal $\rightarrow$ gravitational potential $\rightarrow$ kinetic (water) $\rightarrow$ electric</td>
<td><strong>Advantages</strong>&lt;br&gt;• no gaseous emissions&lt;br&gt;• renewable</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Disadvantages</strong>&lt;br&gt;• large amount of land is covered by reservoir&lt;br&gt;• impacts aquatic ecosystem&lt;br&gt;• can change chemical balance in waterways&lt;br&gt;• increases erosion&lt;br&gt;• changes water distribution patterns</td>
</tr>
<tr>
<td>Energy Resource</td>
<td>Conversions</td>
<td>Perspectives</td>
</tr>
<tr>
<td>-----------------</td>
<td>-------------</td>
<td>--------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Environmental</td>
</tr>
<tr>
<td>Tidal</td>
<td>gravitational → mechanical → electric</td>
<td><strong>Advantages</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• no gaseous emissions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• renewable</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Disadvantages</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• affects marine ecosystems (e.g., fish migration)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Resource</td>
<td>Conversions</td>
<td>Perspectives</td>
</tr>
<tr>
<td>-----------------</td>
<td>-------------</td>
<td>--------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Environmental</td>
</tr>
<tr>
<td>Geothermal</td>
<td>potential (intranuclear) → thermal → mechanical (turbine) → electric</td>
<td><strong>Advantages</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• source is renewable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• produces less pollution than fossil fuels</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Disadvantages</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• some gaseous pollution (H₂S and CO₂)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• acids formed from emissions can cause corrosion of metals in facility and acid deposition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• thermal pollution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• disruption to wildlife</td>
</tr>
</tbody>
</table>
### Scoring Guide – Long-Answer 2

<table>
<thead>
<tr>
<th>Score</th>
<th>Long-Answer 2 Scoring Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Standard of Excellence</td>
<td>The response is <strong>well organized</strong> and addresses <strong>all</strong> the points of the question. The list of energy conversions is <strong>accurate</strong>. The separate perspectives and the description of how energy should be used reflect a <strong>sophisticated</strong> understanding of energy issues.</td>
</tr>
<tr>
<td>3</td>
<td>The response is <strong>organized</strong> and addresses the major points of the question. The list of energy conversions is <strong>mostly accurate</strong>. The separate perspectives and the description of how energy should be used reflect a <strong>good</strong> understanding of energy issues.</td>
</tr>
<tr>
<td>2 Acceptable Standard</td>
<td>The response is <strong>somewhat organized</strong> and addresses <strong>most</strong> of the major points of the question. The list of energy conversions is <strong>adequate</strong>. The separate perspectives and the description of how energy should be used reflect a <strong>reasonable</strong> understanding of energy issues.</td>
</tr>
<tr>
<td>1</td>
<td>The response is <strong>not well organized</strong> and <strong>does not</strong> address the major points of the question. The list of energy conversions is <strong>incorrect</strong>. The separate perspectives and the description of how energy should be used reflect a <strong>poor</strong> understanding of energy issues.</td>
</tr>
<tr>
<td>0</td>
<td>The response does not address any of the major points of the question at an <strong>appropriate level</strong> for a 30-level course.</td>
</tr>
</tbody>
</table>
Student Response 1

Use the following information to answer the next question.

As oil, natural gas, and coal reserves become depleted, alternative energy sources will need to be significantly developed in order to provide the energy required to sustain the current standard of living. Decisions about the use of alternative energy technologies should include information from ecological, economic, societal, and political perspectives.

Alternative Energy Technologies

- Nuclear power plant
- Wind turbine
- Hydro power plant
- Photovoltaic cell
- Tidal power plant
- Geothermal power plant

Score—4
Rationale

This example meets the requirements of the standard of excellence.

The response is well organized and generally error-free. The list of energy conversions is accurate, including waste thermal energy. Separate perspectives are presented and a reasonable description of how energy should be used is given. The response demonstrates a fair degree of sophistication in presenting the solutions to the problems of energy production and use.
Student Response 2

Use the following information to answer the next question.

As oil, natural gas, and coal reserves become depleted, alternative energy sources will need to be significantly developed in order to provide the energy required to sustain the current standard of living. Decisions about the use of alternative energy technologies should include information from ecological, economic, societal, and political perspectives.

**Alternative Energy Technologies**
- Nuclear power plant
- Wind turbine
- Hydro power plant
- Photovoltaic cell
- Tidal power plant
- Geothermal power plant

**Long Answer—15%**

From the list above, select one alternative energy technology used to produce electricity.
- List the energy conversions involved in using the technology.
- Explain the advantages and disadvantages of using the selected technology from two of the following perspectives: ecological, economic, societal, and political.
- Describe how the selected alternative energy technology should be used in the future.

**Score—2**

**Rationale**

This example meets the acceptable standard.

The response is generally organized and addresses all points of the question. The advantages and disadvantages of using the selected technologies are generalized with few specific examples. Some of the future solutions for future energy use are unsophisticated or unrealistic.
Maintaining Consistent Standards Over Time in Diploma Examinations

Please note: As enrollment in Science 30 has reached a sufficient level, the process of equating will be initiated. We are currently conducting research that may require the scores of students who rewrite to be prorated.

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 at education.alberta.ca, via the pathway Teachers > (Additional Programs and Services) Diploma Exams > Diploma 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, please refer to the Alberta Education website at education.alberta.ca, via this pathway: Teachers> (Additional Programs and Services) Diploma Exams > Initiative to Maintain Consistent Standards on Diploma Examinations.

Science 30 Sample Examinations

Previously released diploma examinations are posted on the Alberta Education website. This includes the Previous Diploma Examinations and Answer Keys site with Science 30 interactive diploma examinations. After a student completes the examination online, he or she can click on the score button and receive immediate feedback.

Forms of the diploma examinations, both previously released and self-scoring, can be found at education.alberta.ca, via this pathway: Teachers > (Additional Programs and Services) Diploma Exams > Previous Diploma Examinations and Answer Keys.

The entire machine-scored portions of the January 2008 and January 2009 Science 30 diploma examinations have been posted on the Quest A+ website in a self-scoring format. These two examinations, along with practice tests for each of the four units, can be found at https://questaplus.alberta.ca/ under the “Practice Tests” tab.
Projects for Science 30

The following is a quotation from the Rationale and Philosophy section of the Program of Studies for the Science 20–30 program:

Science is an experimental discipline requiring creativity and imagination. Methods of inquiry characterize its study. In Science 20–30, students further develop their ability to ask questions, investigate and experiment; to gather, analyze and assess scientific information; and to test scientific laws and principles and their applications. In the process, students exercise their creativity and develop their critical thinking skills. Through experimentation, and problem-solving activities that include the integration of technology and independent study, students develop an understanding of the processes by which scientific knowledge evolves.

In order to promote the skills described in the above quotation, and in order to develop a standardized method of assessing these skills, Science 30 projects are available for students’ overall assessment.

The project components and their scoring rubrics have been designed by the Assessment Sector staff in collaboration with teachers. If teachers choose to use the posted projects, they will be responsible for scoring the project. The projects developed to this point incorporate activities suggested or already developed by teachers that focus on designing a study for data collection, synthesis, and application of scientific knowledge to practical situations. Students will be encouraged to use a broad range of tools and technologies.

The project is not intended to be an “add-on” to the expectations of students and teachers. The project activities will be developed and validated by teachers and can be used within their scheme of activities in place of, or to complement, existing activities.

Science 30 is a course that develops a broad range of knowledge and skills in the interest of promoting science literacy. Teachers and other stakeholders have mentioned that in order to accomplish this desirable outcome, they often must sacrifice the opportunity to pursue some concepts in depth. The project provides teachers with this opportunity.

Presently, there is no systematized plan that allows teachers to introduce ICT outcomes into Science 30. It is hoped that the inclusion of ICT components in the projects will promote the emphasis of ICT skills along with the science skills necessary to achieve science literacy.

Projects include suggested step-by-step instructions for the teacher, scoring rubrics, and enrichment ideas for extending the project.

Alberta Education has produced three projects for Science 30. Teachers are encouraged to access those projects, which can be found on the Alberta Education website at education.alberta.ca via this pathway: Teachers > (Additional Programs and Services) Diploma Exams > Projects. These projects are designed to be completed in three to five hours of student time. Use of these projects is optional, and teachers may choose to use them as part of their assessment. Projects include suggested step-by-step instructions for the teacher, scoring rubrics, and enrichment ideas for extending the project.

If you have comments regarding the project please contact John Drader, Science 30 Assessment Standards Team Leader, at John.Drader@gov.ab.ca or at (780) 422 5730.
Project Focus and Assessment Strategies

The focus of project work for Science 30 is to provide an opportunity for students to demonstrate their learning and use of skills in unique ways. This project provides an opportunity to develop and assess ICT and inquiry skills. Teachers may choose to use parts of this project, or certain assessment items, to articulate with the goals of their instruction, their assessment plan, or the resources available to them. Throughout the project, suggestions are made in the Teacher Guide regarding the suitability of questions for either formative or summative assessment. The inclusion of scoring guides in both the student and teacher materials should provide an opportunity to discuss the expectations and standards for responses both before the response is prepared and after it has been assessed.

Computer-based learning objects have been developed to accompany the projects. The student booklet, teacher guide, learning objects, and the Excel files required to complete the projects can be downloaded from www.learnalberta.ca. The student booklet is also available at the following Internet site: education.alberta.ca, via this pathway: Teachers > (Additional Programs and Services) Diploma Exams > Projects.

How to Get Involved

There are many ways in which teachers can become involved with the Science 30 program. Document and Examination Review Committees and item-writing sessions, in which teachers develop questions for the diploma examinations, are held throughout the year.

In order to participate on these committees, teachers must be nominated by their superintendents, normally in September. We encourage interested teachers to contact their principals and request that their names be included on these lists. Principals can then forward teacher names to their superintendents.

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 John Drader, Science 30 Assessment Standards Team Leader, at John.Drader@gov.ab.ca.

Development of Resources to Support the Program of Studies

A new Program of Studies for Science 30 was implemented in 2007–2008. It can be found at education.alberta.ca, via this pathway: Teachers > (Programs of Study, Core Curriculum) Science > Programs of Study. Alberta Education has developed a collaborative, innovative resource package to support the revised Science 20 and 30 programs (at present only in English). The package includes a variety of resources to support teaching and learning.

Resources are available at the LRC:
- Science 30: Student Textbook (includes CD-ROMs), 2007

The Science 30 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.

This new and innovative design is a result of feedback from the field, close collaboration among several Alberta Education branches (Assessment Sector, Learning Technologies, Learning and Teaching Resources, and Curriculum), and the support and guidance of the Alberta Education Science Interbranch Team.

**Data Booklet**

The current data booklet has “Updated 2010” on the cover. It is posted on the Internet at education.alberta.ca, via this pathway: Teachers > (Additional Programs and Services) Diploma Exams > (Data Booklets) Science 30. It is also available from the LRC.

**Online Field Testing**

Science 30 is continuing to offer digital field tests for the 2011–2012 year. Field tests for units A, B, C, and D will be available for digital administration only. The regular year-end field tests will be available in either paper/pencil or digital formats. Requests for all field tests should be made by the field test coordinator at the school using the appropriate forms. Further information about field testing may be obtained by contacting Field.Test@gov.ab.ca.

**Using Calculators to Write the Science 30 Diploma Examination**

The Science 30 diploma examination requires the use of a scientific calculator or an approved graphing calculator. The calculator policy, expectations, calculator criteria, and keystrokes required for clearing approved calculators can be found in the General Information Bulletin on the Alberta Education website at education.alberta.ca, via this pathway: Teachers > Additional Programs and Services > Diploma Exams > Diploma Information General Bulletin > Using Calculators & Computers.
**Website Links**

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<tr>
<td>Science 30 Bulletin</td>
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<td>education.alberta.ca, via this pathway: Teachers &gt; (Additional Programs and Services) Diploma Exams &gt; (Data Booklets) Science 30</td>
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<tr>
<td>Science 10, 20, and 30 Program of Studies</td>
<td>education.alberta.ca, via this pathway: Teachers &gt; (Programs of Study) &gt; Science &gt; Programs of Study</td>
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| Science 30 Self-Scoring Examinations             | www.learnalberta.ca  
There are two levels of access to Science 30 courses: a student version and a teacher version.  

**To access the student version**, you require a jurisdictional level username and password, which all schools should have. Once signed in, use the T4T tab to browse to the course. In this case, select “Grade 12,” then select “Science,” then click on “Show me resources.” You will find the Science 30 course in the resulting list.  

**To gain access to the Teacher version** of the Tools4Teachers and Learn EveryWare courses (which contain teacher-protected components), you must be signed into Learnalberta.ca with a personal teacher account. You can sign up on the site for a teacher account if you have a teacher certification number and a Learnalberta.ca jurisdictional username and password. Use the “Sign Up” link at the top right on Learnalberta.ca.  

Once you are signed into LearnAlberta.ca with your teacher account, you will be presented with both the student and teacher versions of the courses. Just use the same instructions above to search or browse to the courses.  

| Project Downloads | Electronic version of the Student Book and Teacher Guide | https://questaplus.alberta.ca/ |
# Contacts

## Diploma Testing Program

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tim Coates</td>
<td>Director</td>
<td><a href="mailto:Tim.Coates@gov.ab.ca">Tim.Coates@gov.ab.ca</a></td>
</tr>
<tr>
<td>Nicole Lamarre</td>
<td>Director</td>
<td><a href="mailto:Nicole.Lamarre@gov.ab.ca">Nicole.Lamarre@gov.ab.ca</a></td>
</tr>
</tbody>
</table>

## Assessment Standards Team Leaders

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barbara Proctor-Hartley</td>
<td>English Language Arts 30–1</td>
<td><a href="mailto:Barbara.Proctor-Hartley@gov.ab.ca">Barbara.Proctor-Hartley@gov.ab.ca</a></td>
</tr>
<tr>
<td>Philip Taranger</td>
<td>English Language Arts 30–2</td>
<td><a href="mailto:Philip.Taranger@gov.ab.ca">Philip.Taranger@gov.ab.ca</a></td>
</tr>
<tr>
<td>Monique Belanger</td>
<td>Français 30–1, French Language Arts 30–1</td>
<td><a href="mailto:Monique.Belanger@gov.ab.ca">Monique.Belanger@gov.ab.ca</a></td>
</tr>
<tr>
<td>Dwayne Girard</td>
<td>Social Studies 30–1</td>
<td><a href="mailto:Dwayne.Girard@gov.ab.ca">Dwayne.Girard@gov.ab.ca</a></td>
</tr>
<tr>
<td>Patrick Roy</td>
<td>Social Studies 30–2</td>
<td><a href="mailto:Patrick.Roy@gov.ab.ca">Patrick.Roy@gov.ab.ca</a></td>
</tr>
<tr>
<td>Shannon Mitchell</td>
<td>Biology 30</td>
<td><a href="mailto:Shannon.Mitchell@gov.ab.ca">Shannon.Mitchell@gov.ab.ca</a></td>
</tr>
<tr>
<td>Jack Edwards</td>
<td>Chemistry 30</td>
<td><a href="mailto:jedwards@gov.ab.ca">jedwards@gov.ab.ca</a></td>
</tr>
<tr>
<td>Deanna Shostak</td>
<td>Applied Mathematics 30</td>
<td><a href="mailto:Deanna.Shostak@gov.ab.ca">Deanna.Shostak@gov.ab.ca</a></td>
</tr>
<tr>
<td>Ross Marian</td>
<td>Pure Mathematics 30</td>
<td><a href="mailto:Ross.Marian@gov.ab.ca">Ross.Marian@gov.ab.ca</a></td>
</tr>
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## Assessment Sector

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>John Rymer</td>
<td>Executive Director</td>
<td><a href="mailto:John.Rymer@gov.ab.ca">John.Rymer@gov.ab.ca</a></td>
</tr>
</tbody>
</table>

## Examination Administration

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michele Samuel</td>
<td>Director</td>
<td><a href="mailto:Michele.Samuel@gov.ab.ca">Michele.Samuel@gov.ab.ca</a></td>
</tr>
<tr>
<td>Sylvia Lepine</td>
<td>Examination Administration</td>
<td><a href="mailto:exam.admin@gov.ab.ca">exam.admin@gov.ab.ca</a></td>
</tr>
<tr>
<td>Amanda Jackman</td>
<td>Coordinator</td>
<td><a href="mailto:field.test@gov.ab.ca">field.test@gov.ab.ca</a></td>
</tr>
<tr>
<td>Pamela Klebanov</td>
<td>Coordinator</td>
<td><a href="mailto:special.cases@gov.ab.ca">special.cases@gov.ab.ca</a></td>
</tr>
<tr>
<td>Dan Karas</td>
<td>Digital Systems &amp; Services</td>
<td><a href="mailto:Dan.Karas@gov.ab.ca">Dan.Karas@gov.ab.ca</a></td>
</tr>
</tbody>
</table>

## Assessment Sector Mailing Address:

Assessment Sector, Alberta Education  
44 Capital Boulevard  
10044 108 Street  
Edmonton AB  T5J 5E6  

Telephone: (780) 427-0010  
Toll-free within Alberta:  310-0000  
Fax: (780) 422-4200  
email: LAcontact@edc.gov.ab.ca  
Alberta Education website:  education.alberta.ca