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<tr>
<td>Students</td>
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<td>Teachers</td>
<td>✔ of Chemistry 30</td>
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<td>Others</td>
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Please note that if you cannot access one of the direct website links in this document, you can find diploma examination-related materials on the Alberta Education website.
**Time Limits on Diploma Examinations**

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

Extra time is available for diploma examinations in all subjects, but the time limits of other examinations may differ. For more information about accommodations and provisions for students, please refer to the *General Information Bulletin.*

**Online Field Testing**

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

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

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

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

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

Finally, online administration enables every school, large or small, to participate. Historically, it was impractical to send field test administrators to remotely located schools, or schools with small classes. Now, all Alberta schools can participate in field tests.
It is important to note that the **security of field test items remains vital** to the administration of diploma examinations. Participating teachers must commit to maintaining the security of field test items. In the case of hybrid field tests, paper copies are mailed to schools and the questions are accessed in the same format as digital-format field tests. Prior to the hybrid field test, the paper copies must be kept secure by the school principal. After the administration of a hybrid-format field test, teachers must mail all paper copies back to Alberta Education.

**Further Information**

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

For more information, contact

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

or

Joanne Neal  
Director, Examination Administration  
780-492-1495 or Joanne.Neal@gov.ab.ca
Special-format Practice Tests

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

For more information or to place an order, contact

Laura LaFramboise
Distribution Coordinator, Examination Administration
780-492-1644 or Laura.LaFramboise@gov.ab.ca

Course Objectives

Chemistry 30 is intended to develop students’ understanding of the interconnecting ideas and chemistry principles that transcend and unify the natural-science disciplines and their relationship to the technology that students use in their daily lives. It is of utmost importance to remember that Chemistry 30 is an experimental discipline that develops the knowledge, skills, and attitudes to help students become capable of and committed to setting career and/or life goals, make informed choices, and act in ways that will improve the level of scientific awareness essential for a scientifically literate society. Laboratory experience is an essential component of the Chemistry 30 course.

Students of Chemistry 30 are expected to develop an aptitude for collecting data, observing, analyzing, forming generalizations, hypothesizing, and making inferences from observations. The course is designed to promote students’ understanding of chemistry concepts, and their ability both to apply these concepts to relevant situations and to communicate in the specialized language of chemistry.

Success in Chemistry 30 requires the successful completion of Science 10, Chemistry 20, and concurrent mathematics courses that develop the requisite knowledge and skills.

Performance Expectations

Curriculum Standards

Provincial curriculum standards help to communicate how well students need to perform to be judged as having achieved the objectives specified in the Chemistry 20–30 Program of Studies, 2007 (Updated 2014). The specific statements of standards are written primarily to inform Chemistry 30 teachers about the extent to which students must know the Chemistry 30 content and demonstrate the required skills to pass the examination.
Acceptable Standard

Students who meet the acceptable standard in Chemistry 30 will receive a final course mark of 50% to 79%. These students demonstrate a basic understanding of the nature of scientific investigation by designing, observing, performing, and interpreting simple laboratory tests. They can readily interpret data that are presented in simple graphs, tables, and diagrams, and can translate symbolic representations into word descriptions. They are able to recognize and provide definitions for key chemical terms, and can predict the physical and chemical properties of compounds. They are able to balance simple equations (combustion, formation, neutralization, or oxidation–reduction) and can solve standard, single-step, stoichiometric problems based upon these equations. Following laboratory procedures does not present a problem for these students, nor does using the data booklet to extract relevant information. These students compose clear and logical descriptive or explanatory statements to answer closed-response questions that involve individual chemistry concepts.

Examples of Acceptable-standard Questions

*Use the following information to answer question 1.*

Dr. Richard Trotter has developed what could be the first cost-effective process for limiting methane emissions from underground coal mines. In this process, methane and oxygen are reacted at 800 °C in the presence of a catalyst. The products of this process are carbon dioxide gas and liquid water.

1. Which of the following enthalpy diagrams represents both the catalyzed (---) and uncatalyzed reactions (—) for this process?

*A.*

B.

C.

D.

--- Catalyzed

--- Uncatalyzed
Use the following information to answer question 2.

To determine the concentration of a Sn\(^{2+}\)(aq) solution, a student titrated a 50.00 mL sample of acidified Sn\(^{2+}\)(aq) with 1.44 mmol/L KMnO\(_4\)(aq). The titration required 24.83 mL of KMnO\(_4\)(aq) in order to reach a pale pink endpoint.

2. The balanced net ionic equation for this titration reaction is

* A. 2 MnO\(_4\)^{−}(aq) + 16 H\(^{+}\)(aq) + 5 Sn\(^{2+}\)(aq) \rightarrow 2 Mn^{2+}(aq) + 8 H\(_2\)O(l) + 5 Sn\(^{4+}\)(aq)

 B. 2 MnO\(_4\)^{−}(aq) + 16 H\(^{+}\)(aq) + 5 Sn\(^{2+}\)(aq) \rightarrow 2 Mn^{2+}(aq) + 8 H\(_2\)O(l) + 5 Sn(s)

 C. MnO\(_4\)^{−}(aq) + 8 H\(^{+}\)(aq) + Sn\(^{2+}\)(aq) \rightarrow Mn^{2+}(aq) + 4 H\(_2\)O(l) + Sn\(^{4+}\)(aq)

 D. MnO\(_4\)^{−}(aq) + 8 H\(^{+}\)(aq) + Sn\(^{2+}\)(aq) \rightarrow Mn^{2+}(aq) + 4 H\(_2\)O(l) + Sn(s)

**Standard of Excellence**

Students who achieve the standard of excellence in Chemistry 30 will receive a final course mark of 80% or higher. In addition to meeting the expectations for the acceptable standard of performance, these students demonstrate an interest in chemistry and can articulate chemistry concepts well. They can readily interpret interrelated sets of data such as complex graphs, tables, and diagrams. When presenting scientific data, they select the most appropriate and concise format. These students can analyze and evaluate experimental designs. They generate their own laboratory procedures when given a clearly defined problem, recognize weaknesses in laboratory work, and find ways to correct the weaknesses. They are able to formulate their own equations for formation, combustion, neutralization, redox, and equilibrium reaction expressions, and can solve many variations of stoichiometric problems based upon these equations. They transfer what they observe in a laboratory setting into equation form and express scientific ideas clearly. They solve problems that involve the overlapping of two or more concepts. The most significant characteristic of this group is that they solve problems of a new and unique nature, and extrapolate these solutions to higher levels of understanding. Open-ended questions do not pose problems for them. These students communicate clearly and concisely, using appropriate scientific vocabulary and conventions.
Examples of Standard of Excellence Questions

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

<table>
<thead>
<tr>
<th>Four Reaction Equations</th>
<th>Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>In(s) + La$^{3+}$(aq) → no reaction</td>
<td>1</td>
</tr>
<tr>
<td>Np(s) + La$^{3+}$(aq) → Np$^{3+}$(aq) + La(s)</td>
<td>2</td>
</tr>
<tr>
<td>Np(s) + Nd$^{3+}$(aq) → Np$^{3+}$(aq) + Nd(s)</td>
<td>3</td>
</tr>
<tr>
<td>La(s) + Nd$^{3+}$(aq) → no reaction</td>
<td>4</td>
</tr>
<tr>
<td>5 In$^{3+}$(aq)</td>
<td></td>
</tr>
<tr>
<td>6 Np$^{3+}$(aq)</td>
<td></td>
</tr>
<tr>
<td>7 Nd$^{3+}$(aq)</td>
<td></td>
</tr>
<tr>
<td>8 La$^{3+}$(aq)</td>
<td></td>
</tr>
</tbody>
</table>

**Numerical Response**

1. Arranged in order from **strongest** to **weakest**, the oxidizing agents above are numbered ___, ___, ___, and ____.

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

   **Answer:** 5876

Use the following information to answer question 3.

\[ 	ext{CO}_2(\text{g}) + \text{H}_2(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g}) \quad K_c = 0.137 \]

3. If the temperature of the system at equilibrium is increased, then the concentration of the carbon dioxide and the value of $K_c$ will

   A. decrease and stay the same, respectively
   B. increase and stay the same, respectively
   C. increase and decrease, respectively
   *D. decrease and increase, respectively

For more details on the relationship between the program of studies and the performance standards, see the Student-Based Performance Standards for Chemistry 30, available on the Alberta Education website.
Outcomes in the Chemistry 30 Program of Studies contain verbs that indicate the cognitive expectation of the outcome. Verbs typically classified under knowledge (K) are coded yellow in the chart below; verbs typically classified under comprehension and application (C/A) are coded green; verbs typically classified as higher mental actives (HMA) are coded blue; and those relating to skills are coded pink.

<table>
<thead>
<tr>
<th>Cognitive Expectations</th>
<th>Knowledge</th>
<th>Comprehension and Application</th>
<th>Higher Mental Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td><em><em>Choose, classify, define, describe, identify</em>, label, list, match, name, outline, predict</em>, recall, select, state, what, when, who**</td>
<td>Analyze*, apply, calculate, change, compare*, contrast, determine, estimate (extrapolate or interpolate), explain*, generalize, identify*, infer, interpret*, predict*, relate, solve, translate</td>
<td>Analyze*, assess, compare*, differentiate, compile, compose, conclude, create, defend, evaluate, explain*, interpret*, judge, justify, organize, plan, summarize</td>
<td></td>
</tr>
<tr>
<td><strong>Use memorized or algorithmic methods to solve problems</strong></td>
<td>Design a procedure for a known experiment</td>
<td>Transfer methods from one area to another</td>
<td></td>
</tr>
<tr>
<td><strong>Design a new procedure for an unfamiliar experiment</strong></td>
<td>Use generalized methods to solve problems</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Attitudes and Skills**
- Appreciate, collect, conduct, develop, gather, measure, observe, plot, work collaboratively

*NEW Cognitive Expectations*

*These expectations are ambiguous because they have multiple connotations. The cognitive expectation is communicated by the context. If it is a familiar context, the expectation is knowledge or comprehension and application; if it is unfamiliar, the expectation is comprehension and application or higher mental activity.*
The Cognitive Expectation graphic has been updated to align more closely with Bloom’s taxonomy, revised in 2001 by Lorin Anderson and David Krathwohl. The updated graphic is shown below, followed by a summary of changes.

**UNDERSTANDING**
Understand & make sense of information
Students will: communicate, hypothesize, illustrate, summarize

**APPLYING**
Use information in a new (but similar) situation
Students will: apply, calculate, determine, explain, predict, relate

**REMEMBERING**
Find or remember information
Students will: define, describe, identify, name, recall, recognize, select, state

**CREATING**
Use information to create something new
Students will: design, develop, devise, formulate, integrate, plan

**EVALUATING**
Critically examine information & make judgments
Students will: assess, evaluate, select

**ANALYZING**
Take information apart & explore relationships
Students will: analyze, compare, differentiate, explain, interpret, classify

**SKILLS**
Students will: build, compile, conduct, construct, draw, gather, investigate, measure, organize, perform, record, research, write

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


- The category names have been changed from nouns (e.g., Knowledge) to verbs (e.g., Remembering) to reflect student behaviours.
- The name of the Knowledge category has been changed to Remembering, to prevent confusion with knowledge outcomes written in the program of studies.
- The name of the Comprehension category has been changed to Understanding, and its colour coding has been changed from green to yellow. Understanding, defined as making sense of information, is at a lower cognitive level than Applying and therefore has a better fit with the category of Remembering. Therefore, the former Knowledge (K) category has been changed to Remembering and Understanding (R/U) and is coded yellow.
• The Application portion of Comprehension/Application (C/A) has been changed to Applying, and its colour-coding remains green.

• The category of Higher Mental Activities (HMA) remains colour-coded blue. HMA always included verbs related to Analyzing, Evaluating, and Creating. For clarity, these three subcategories are now explicitly shown in the graphic.

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

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

**NEW** **Trends in Student Performance**

In the thermochemistry unit, students show a basic competence in those questions that assess the calculations of enthalpies of formation and reaction, using either Hess’s law or data from a calorimetry experiment. However, in a calorimetry experiment the students often forget to subtract the final mass of a substance used in the calorimetry chemical reaction from the initial mass given in the design or observation table of the experiment. Students are able to interpret enthalpy diagrams that either include or exclude representations of the activation energy. However, they have more difficulty in relating these enthalpies to the breaking and forming of bonds. Students commonly use the heat of reaction of an equation instead of the molar enthalpy when determining the enthalpy change of a reaction after being given a specific mass or number of moles that react.

In the electrochemistry unit, students can identify redox reactions, and produce balanced equations for the overall reactions where there is no disproportionation. They can identify oxidizing and reducing agents, but have difficulty producing equations for half-reactions when presented with an overall reaction involving species that are not in the Table of Standard Electrode Potentials in the data booklet. They can calculate concentrations involved in redox titrations when the overall reaction equation is given, as well as the potential differences associated with overall reactions whose constituent half-reactions are in the Table of Standard Electrode Potentials. However, when half-reactions are not in the table, or a different reference half-reaction is used, students are much less successful in calculating electrode potentials or potential differences. Calculations involving Faraday’s Law are successful for most students if the relevant mole ratio is 1:1, but success is far less common with other mole ratios. Students are successful at identifying and labeling a voltaic cell, but have difficulty identifying and labeling electrolytic cells.

The organic chemistry unit is divided into three sections: the naming and classifying of compounds, the physical properties of organic compounds, and some chemical reactions involving selected organic compounds. Students are very successful at naming and classifying compounds, somewhat successful at questions involving physical properties, and less successful at questions involving chemical properties. Students also have difficulty relating variations in boiling point to differences in intermolecular bonding. Students are very successful at identifying the region where different hydrocarbons are collected in a fractional distillation tower, but are weak in identifying the processes that occur to separate the organic compounds from natural mixtures and solutions. They are not very successful with questions that involve solvent extraction. Students are successful at identifying polymers when the monomers are given, but have difficulty determining the monomers from a given polymer.

In the equilibrium unit, students have difficulty in identifying the criteria that apply to a chemical system in equilibrium. They are very successful in using Le Châtelier’s Principle to make predictions if the stresses are explicitly stated. They are less successful if the stresses are stated implicitly, as in the use of hydroxide ions as a means of removing hydronium ions, or the use of silver ions to remove chloride or bromide ions. In questions involving the use of ICE tables, students were able to use them to calculate equilibrium concentrations, but could not use them to calculate initial concentrations, especially for weak acids and bases whose pH and either $K_a$ or $K_b$ are given. Calculations linking pH and pOH, or linking $K_a$ and $K_b$, are completed successfully, but
students are less successful in linking pH with either concentration, $K_a$ or $K_b$ for weak acids or bases, respectively. From a graphical perspective, students can identify the regions of a titration curve, but find it difficult to make qualitative predictions of the pH at the equivalence points associated with weak acid–strong base and strong acid–weak base titrations. Students are able to choose an appropriate buffer when given a selection, but have difficulty determining the result of using the buffer.

In chemistry, experiments are performed, observations and measurements are made, and then either an inference is drawn, or values are calculated. Many students do not distinguish between an observation and an inference when they are asked to analyze a laboratory experiment. For example, if asked to list the observations made during the electrolysis of aqueous sodium bromide, NaBr(aq), students would list as observations that hydrogen gas was released at the cathode, that bromine liquid was formed at the anode, and that the hydroxide ion concentration in the electrolyte increased. These are not observations; these are inferences drawn from the observations of a gas being released at one electrode, an orange liquid being formed at the other electrode, and the solution turning red litmus paper blue.

When identifying the variables required to investigate a given problem statement or to test a given hypothesis, students often choose quantities that were derivable from measured quantities, rather than quantities that are directly measurable. For example, when testing a hypothesis related to acid–base equilibrium, students choose quantities such as $K_a$, $K_b$, or hydronium ion concentration as an appropriate responding variable, rather than pH. The variables $K_a$, $K_b$, and hydronium ion concentration are not directly measurable, as they have to be calculated from the observed pH. Thus pH is the responding variable in this investigation.

Students understand that controlled variables take on constant values during the course of an experiment. However, they do not understand the concept that a controlled variable is a variable that the experimenter could have varied, but chose not to. For example, in an experiment investigating the boiling points of alcohols as a function of the molar mass, one possible controlled variable is the atmospheric pressure, another might be the number of branches in the structure of the alcohol, and another might be the location of the hydroxyl functional group in the alcohol. The older term for controlled variables, *variables held constant*, shows the meaning in the two steps. First the quantity is selected, and it could possibly vary. Secondly, the experimenter arranges his or her experimental setup so that this variable can be shown to remain fixed in value. Controlled variables cannot include any parameter that is not under the direct control of the experimenter. In this instance, the type of compound, alcohol, cannot be considered a controlled variable, as varying this parameter will change the essential nature of the hypothesis being investigated.
*NEW Clarifications

All Units

- Chemistry is a laboratory science, and an essential part of laboratory activity is the design of effective tests for different hypotheses. The truth of some hypotheses will be within the scope of the program of studies, while the truth of others may be slightly beyond the program of studies. However, for all hypotheses, the design elements of the laboratory experiment will be within the program of studies. An example of a multiple-choice item and an example of a numerical-response item follow.

Outcomes being assessed: C1.3k, C1.1s

Use the following information to answer question 4.

A student looked at the structural formulas of different hydrocarbons and proposed the following hypothesis:

*The more unsaturated a hydrocarbon is, the more carbon dioxide is released when the hydrocarbon is burned.*

4. To test this hypothesis, the best set of hydrocarbons to use is

A. propane, butane, and pentane
B. butane, pent-1-ene, and hex-1-yne
C. butane, but-1-ene, and but-1-yne
D. pentane, 2-methylbutane, and 2,2-dimethylpropane

Rationales:
For A, longer chains will give more carbon dioxide, but cannot be used for testing this hypothesis about saturation levels, as all three are saturated hydrocarbons.
For B, these have different degrees of saturation, but the length of the carbon chain is not controlled.
For C, this is correct, with the controlled variable being equal lengths of carbon chain.
For D, these hydrocarbons are all isomeric forms of each other, so they have the same degree of saturation.
Outcomes being assessed: D1.4k, D1.1s

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

A student wants to test the following hypothesis about the strength of chlorinated carboxylic acids:

If the number of chlorine atoms in a chlorinated carboxylic acid increases, then so does the strength of the acid.

She identifies the following possible variables:

1. The pH of the acid sample
2. The molar mass of the acid
3. The mass of acid in the sample
4. The volume of acid in the sample
5. The molar concentration of the acid sample
6. The number of carbon atoms in the acid molecule
7. The number of chlorine atoms in the acid molecule

Numerical Response

2. In an effective experimental design for testing this hypothesis,

the manipulated variable is numbered 7 (Record in the first column)
the responding variable is numbered 15 (Record in the second column)
one controlled variable is numbered 6 (Record in the third column)
another controlled variable is numbered 5 (Record in the fourth column)

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

Answer: 7156 or 7165

- A controlled variable is defined as a quantity that could be varied in the context of the given experimental design or hypothesis statement, but which the experimenter chose to hold constant, as any changes in the variable could affect the validity of any final conclusions.

- Observations made during an experiment must be distinguished from conclusions and inferences made as a result of the observations. For an example such as the electrolysis of aqueous sodium iodide, NaI(aq), the observation of drops of a brown liquid close to one electrode leads to the inferences that the aqueous iodide ion, I^–(aq), has been oxidized to iodine, I_2(aq), at that electrode, and that the electrode is the anode.
• Evidence collected during an experiment must be distinguished from data used in calculations. For example, during a calorimetry experiment, the temperature change of the calorimeter water would be data required to calculate a molar enthalpy of reaction. However, the evidence collected in the lab would be the initial and final temperatures of the calorimeter water, and this information would be used to produce the data necessary for the calculation.

**Unit A**

In the assessment of outcomes A1.8k and A1.1s:

• The term *calorimeter* does not always refer to a bomb calorimeter. Students should be familiar with different designs that can be used for the measurement of energy changes in a chemical system. These include designs where the temperature change of the container is accounted for, not just that of its contents.

• Some detailed calculations will include the temperature change of the calorimeter, but many should be answered qualitatively. As one example, a calorimeter composed of a material with a large specific heat capacity will undergo a smaller temperature change than a calorimeter composed of a material with a significantly lower specific heat capacity. Another example relies on the insulating properties of polystyrene to predict that any temperature change of the cup calorimeter can be assumed to be negligible.

• In experiments using polystyrene calorimeters, the limiting measurement is the measurement of temperature using liquid-in-glass thermometers, where the errors can be on the order of 10%. When measuring volumes of liquids used in calorimetry, any error reduction due to the precision obtained by using a volumetric pipette rather than a graduated cylinder is of less consequence than error introduced due to temperature measurements. Accordingly, the use of a volumetric pipette is not necessary and is not considered standard practice for calorimetry experiments.

• When a small amount (less than 10% of the mass of the solvent) of solute is added to a solvent, the mass \( m \) in the formula \( Q = mc\Delta T \) or \( \Delta H = mc\Delta T \) can be taken as the mass of the solvent, and \( c \) taken as the specific heat capacity of the solvent. Answers that use the mass of the solution for \( m \) require the use of the specific heat capacity of the solution for \( c \), and this quantity may or may not be similar to the specific heat capacity of the solvent.

In the assessment of outcomes A1.8k and A1.9k:

• There appears to be some confusion as to whether an enthalpy of combustion involves \( \text{H}_2\text{O(l)} \) or \( \text{H}_2\text{O(g)} \). When enthalpies of combustion are determined empirically, they are determined in a bomb calorimeter, and because of the small temperature change, the water produced is in liquid form. In the open environments that are familiar in everyday life, the combustion of most substances releases heat sufficient to convert any water produced from the reaction into water vapour. Often, a diploma examination question refers to an enthalpy of combustion for a fuel such as propane in a barbecue or butane in a lighter. Since these examples represent reactions that are performed in an open environment, students should use water vapour as a product to determine acceptable values for the enthalpy of combustion.
• On diploma examinations, the general principle that will be followed is that if combustion reactions are performed empirically in a bomb calorimeter, liquid water will be the product; and if the combustion occurs in an ambient environment and a theoretical enthalpy of combustion is to be determined, the product will be water vapour. Students are not required to have existing knowledge or exposure to a bomb calorimeter.

In the assessment of outcomes A2.3k, A1.3s, and A2.3s:

• On the diploma examination, enthalpy diagrams will be similar to the two figures shown below. Enthalpy diagrams can be used to indicate relative positions for exothermic or endothermic reactions (refer to Figure 1). We cannot determine an exact value for the potential energy of a substance, but we can determine values for enthalpies of reaction, using enthalpies of formation (refer to Figure 2). For the French translation of the diploma examination, the term évolution de la réaction will be used on the x-axis of enthalpy diagrams.

![Figure 1](image1)

![Figure 2](image2)

In the assessment of outcome A2.3s:

• Students will be expected to calculate the efficiency of a thermal energy source and to explain the discrepancies between theoretical and measured values obtained from calorimetry experiments. They are expected to predict whether a given source of error will lead to a lower or to a higher calculated value for an enthalpy of reaction, as well as to predict whether an observed enthalpy or temperature change is lower or higher than the theoretical enthalpy or temperature change.

• Teachers should use all the approved resources to cover this outcome, and not rely wholly on any single source for information.

In the assessment of outcome A2.4k:

• Catalyst questions may involve biological enzymes as well as catalysts in nonliving systems, but any discussion of enzyme mechanisms is beyond the scope of the program of studies.
**Unit B**

In the assessment of outcome B1.2k:

- Only the term *disproportionation* will be used to describe a substance undergoing both an oxidation and a reduction. For the French translation of the diploma examination, the term *dismutation* will be used.

In the assessment of outcomes B1.2k and B1.7k:

- The term *oxidation number* will be the only term used.
- For assigning oxidation numbers, the Provincial Assessment Sector will use the following guidelines:
  - Oxygen always has an oxidation number of –2, except for peroxides, where its oxidation number is –1.
  - Hydrogen always has an oxidation number of +1, except for hydrides of metals in Groups 1 and 2 of the Periodic Table, where its oxidation number is –1.
  - Carbon can have fractional oxidation numbers, and the oxidation number of carbon in any of its compounds will represent an average oxidation number. For example, in the case of propane, C\(_3\)H\(_8\), the oxidation number is taken as \(-\frac{8}{3}\). Considering the oxidation number of each of the two end carbons as –3, and of the middle carbon as –2, is beyond the scope of the program of studies.

In the assessment of outcome B1.7k:

- Students are expected to devise a balanced half-reaction in an acidic or neutral, but *not* basic, solution. They are expected to balance chemical equations that occur in basic environments given the species, but not to devise their own half-reactions. Students are expected to balance disproportionation reaction equations.

In the assessment of outcome B1.2s:

- Students are expected to select glassware as it is used in standard best-practice volumetric analysis. Shortcuts, such as the use of burettes or graduated cylinders in place of volumetric pipettes, are *not* considered best practice.

In the assessment of outcomes B2.1k and B2.3k:

- Line or cell notation is used to describe electrochemical cells. The convention that is used is that the substance constituting the anode is listed at the far left, and the substance constituting the cathode is listed at the far right.
In the assessment of outcome B2.1s:

- In addition to a labelled diagram, students are expected to predict the observations (e.g., pH changes and colour changes in the electrolyte, mass changes and colour changes of the electrodes) for the electrochemical cell that they design.

In the assessment of outcome B2.3k:

- For half-cells containing acidified solutions (such as acidified potassium permanganate and an inert electrode), each half-cell should include all the active components in their standard state; that is, 1.0 mol/L H\(^+\)(aq) and 1.0 mol/L MnO\(_4^-\) (aq). Together with an iron–iron(II) half-cell, the line notation is represented as

\[
\text{Fe(s) \mid Fe}^{2+}(aq) \mid \mid \text{MnO}_4^- (aq), \text{H}^+(aq) \mid \text{Pt(s)}
\]

In the assessment of outcome B2.4k:

- One of the most common and demonstrable examples to illustrate this objective is the chloride anomaly. It is reasonable to expect students to be familiar with this. For further clarification please review the explanation below (taken from the Archived Chemistry 30 Information Bulletin).

- Students are expected to recognize that predicted reactions do not always occur; for example, the chloride anomaly occurs during the electrolysis of solutions containing chloride ions and water as the strongest reducing agents. A common misconception is that if the minimum voltage for the electrolysis of water were applied, then the oxidation of water would occur rather than the oxidation of chloride ions. **This is not correct.** The reduction potentials found on the reduction potential table are determined by comparing the reduction potential of a given half-cell to the standard hydrogen half-cell. The standard hydrogen reduction potential is the reference potential against which all half-reaction potentials are assigned. This is how the reduction potentials for oxygen and hydrogen ions (+1.23 V) and chlorine (+1.36 V) half-cells are obtained. During electrolysis, the theoretical minimum voltage is the difference in reduction potential between the oxidizing agent and the reducing agent. An excess voltage, called the overvoltage, is required in order for a reaction to occur. For example, as the voltage to a standard sodium chloride electrolytic cell is increased, the chloride ions are oxidized first. The reason for this is that the overvoltage for the oxidation of water is greater than the overvoltage for the oxidation of chloride ions. A much higher potential than expected is required to oxidize water. Basically, the phenomenon is caused by difficulties in transferring electrons from the species in the solution to the atoms of the electrode across the electrode-solution interface. Because of this situation, \( E^\circ \) values must be used cautiously when one is predicting the actual order of oxidation or reduction of species in an electrolytic cell.

In the assessment of outcomes B2.5k and B2.6k:

- All \( E^\circ \) values refer to reduction potentials, whether associated with an oxidation half-reaction equation or a reduction half-reaction equation.
In the assessment of outcomes B2.5k and B2.3s:

- Standard state conditions and corresponding potential difference values imply the use of 1.0 mol/L reagents. The larger the concentration of the reactants, the larger the potential difference value. The Nernst equation would be required to calculate potential difference values as a function of reactant and product concentrations in a redox reaction and is beyond the scope of the Chemistry 30 Program of Studies, 2007 (Updated 2014). However, students should know that as the reaction proceeds, the voltage generated will decrease as reactants are converted to products until reaching equilibrium, at which point the battery does not deliver any noticeable current.

- Biological systems involve species that are not at 25 °C and 1.0 mol/L. Therefore, the $E^\circ$ values given in any question involving biological systems may not be the same as those shown in the data booklet, where standard temperature is 25 °C and standard concentration is 1.0 mol/L.
Unit C

Questions in all units of the course may include contexts involving organic compounds.

In the assessment of outcome C1.3k:

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

- For all halogenated hydrocarbons, the halogen atoms will be considered as substituents on the parent hydrocarbon. Using the endings -chloride and -bromide, as in vinyl chloride or ethyl bromide, gives the impression that the chemistry of the compound is dominated by the halogen atom, even though the type of hydrocarbon is the dominant factor. For example, 3-chloropentane has one chlorine substituted for hydrogen at the third carbon atom of the chain; 3-chloropropene has a three-carbon parent chain, with a double bond between the first and second carbon atoms, and one chlorine substituted for hydrogen at the third carbon atom of the chain.

- An aromatic molecule is a molecule containing one or more benzene rings. The benzene ring may be represented in any of four ways, and students are expected to recognize any of the four representations shown in Diagrams 1–4 below as being a diagram of a benzene molecule. However, students are not expected to know the strengths and weaknesses of each representation.

- Diagram 1 uses a ring structure, and the bonding capacity of four for each carbon atom is satisfied by having alternating double and single bonds. As it stands, this compound would be named cyclohexa-1,3,5-triene, and the compound would undergo addition reactions easily. The compound, if it existed in this single form, would be highly unstable.

- Diagram 2 uses a ring structure, and the bonding capacity of four for each carbon atom is satisfied by having alternating double and single bonds. Diagram 1 and 2 with the double-headed arrow labelled “resonance” are used to depict one and the same state. There are no isolated single or double bonds and the overall structure of benzene can be thought of as an average of the two diagrams, thus making the electrons more evenly distributed. This
resonance model provides for a benzene molecule that is stable and extremely resistant to possible addition reactions.

- Diagram 3 is a line diagram that is commonly used in reference indexes and outside publications when showing representations of aromatic compounds.

- Diagram 4 is a line diagram that is used in both approved resources. This representation does indicate that all bonds in the ring are equivalent and are distinct from single bonds or double bonds.

• When naming esters such as methyl pentanoate, a space is left between methyl and pentanoate, whereas for the organic compound methylcyclohexane, no space is left between methyl and cyclohexane. This is done because, with the ester methyl pentanoate, methyl is not considered a prefix but part of the naming system for this class of organic compounds.

• When one of the hydrogen atoms in a hydrocarbon is replaced by a hydroxyl group, either an alcohol or a phenol may be produced. The term alcohol will be used whenever the original hydrocarbon is aliphatic. The term phenol will be used whenever the hydroxyl group is attached directly to the benzene ring. Benzyl alcohols, where there is both a benzene ring and a hydroxyl group attached to a straight side chain, and not to the benzene ring, are outside the scope of the program of studies.

• For the Chemistry 30 Diploma Examination, when determining whether a compound is saturated or unsaturated, only the presence of carbon-carbon double or triple bonds makes a compound unsaturated. Double bonds in a functional group will not characterize a compound as being unsaturated. For example, propanoic acid is classified as a saturated compound because all of its carbon atoms are joined to each other by single bonds. The double bond between carbon and oxygen does not make propanoic acid unsaturated.

• The bromine test will be negative for cyclohexane, \( \text{C}_6\text{H}_{12} \text{(l)} \), and positive for cyclohexene, \( \text{C}_6\text{H}_{10} \text{(l)} \), where the double bond is carbon–carbon, but will be negative for ethanoic acid, \( \text{CH}_3\text{COOH(aq)} \), where the double bond is carbon–oxygen, not carbon–carbon.

• A negative bromine test with a saturated organic compound does not mean that there is no reaction with bromine. It means that there is no immediate or fast reaction between the saturated compound and the bromine. However, there will be a slow substitution reaction if the bromine reacts in the presence of UV light. For most saturated compounds, this substitution reaction will take 24 hours or more to go to completion.

• Aromatic compounds are not considered to be either saturated or unsaturated. Compounds with both benzene rings and carbon-carbon double bonds, such as phenylethene, are outside the scope of the program of studies.

• The wording of outcome C1.3k puts clear limits on the compounds that can be named or drawn. However, these limits do not apply to outcomes C1.4k, C1.5k, C1.6k, C2.1k, and C2.2k. In assessing these outcomes, students will be asked to consider compounds outside the limits set by outcome C1.3k, but only when both a name and a structural formula (or line diagram) have been given.
In the assessment of outcome C1.4k:

- R represents any saturated chain of carbon and hydrogen atoms. For example, propanol can be represented by R–OH; R–OH could also represent any other alcohols containing a saturated chain of carbon and hydrogen atoms.

In the assessment of outcome C1.5k:

- Formulas such as $\text{C}_2\text{H}_6(\text{g})$, $\text{C}_2\text{H}_5\text{Cl}(\text{l})$, and $\text{C}_6\text{H}_6(\text{l})$ will be referred to as *molecular formulas*.

In the assessment of outcome C1.6k:

- For an organic compound to be highly soluble in water, there must be significant hydrogen bonding present. It is **not** sufficient for the molecule to be polar. For example, the polar molecule 1-chloropropane cannot form hydrogen bonds, so it will not be soluble in water. The solubility rules based on an empirical generalization, such as *like is soluble in like*, are reasonable only with a three-way classification such as nonpolar, polar, and hydrogen-bonded. However, on the diploma examinations students are expected to predict the solubility of organic molecules only in nonpolar solvents such as hexane and in hydrogen-bonded solvents such as water.

In the assessment of outcomes C2.1k and C2.2k:

- For the diploma examination, *elimination* is considered a type of chemical reaction in which atoms are removed from adjacent carbons in a single reactant. The organic product of an elimination reaction will have a carbon-carbon double bond. Cracking reactions, in which alkanes are reduced to alkenes, are included as elimination reactions, as the alkenes all have carbon-carbon double bonds. The definition distinguishes this reaction type from a condensation reaction, in which two molecules react and their interaction produces a water molecule.

In the assessment of outcome C2.2k:

- For the diploma examination, students are expected to know two types of substitution reaction. The first is a reaction in which a hydrogen atom in a hydrocarbon or a hydrocarbon derivative is replaced by another atom or by a functional group. One such example is the production of chloromethane and hydrogen chloride from the reaction of methane and chlorine. The second is a reaction in which an atom or functional group in a hydrocarbon derivative is replaced by another atom or functional group. One such example is the hydrolysis of 1-bromoethane in alkaline solution to produce ethanol and hydrogen bromide.

- The term *nucleophilic substitution* given to this second type of reaction will **not** be part of the diploma examination.

- Students will be expected to know that the substitution reactions involving aromatic hydrocarbons require a suitable catalyst before the reaction can occur. This is due to the stability of the bonding within the benzene ring. However, the names of the specific catalysts will **not** be part of the diploma examination.
In the assessment of outcome C2.3k:

- Knowledge of both types of polymerization reaction (addition and condensation) will be tested, either by identifying the monomers involved in the production of a given polymer or by identifying the polymer formed from given monomers.

- The naming of polymers on the diploma examination will be limited to the monomer name being given (e.g., the given monomer name of chloroprene will result in the polymer name polychloroprene) or the monomer represented will be one that the students will be expected to name

\[
\begin{align*}
\text{H} & \quad \text{H} \\
\text{H} & \quad \text{H}
\end{align*}
\]

(e.g., the given monomer \(\text{H} - \text{C} - \text{C} = \text{H}\) will result in the polymer name polypropene).

**Unit D**

In the assessment of outcome D1.3k:

- There is some confusion about the ways in which pressure can be increased and how it will affect an equilibrium system. Three methods to increase pressure are reducing the volume of the reaction container, adding an inert gas, and adding a reactant or product gas.

  - Increasing the pressure by reducing the volume of the container causes the system to alleviate the increased pressure by reducing the total number of gaseous molecules in the system. Equilibrium will therefore shift to the side with the lesser number of gas molecules.

  - Adding an inert gas increases the total pressure but has no effect on the concentration or partial pressures of the individual reactants or products. Therefore, there is no shift in the equilibrium.

  - Adding a reactant or product gas will shift the equilibrium away from what is added, whereas removing a reactant or product gas will shift the equilibrium toward what is removed.

- If the total volume available to an equilibrium system is adjusted, the value of the equilibrium constant for that system will not change, provided there is no change in temperature. The only stress that can change the value of the \(K_c\) for an equilibrium is a change in the system temperature. Although the equilibrium constant does not change when a system undergoes a change in pressure due to a change in volume, the position of the equilibrium can still change. A particular equilibrium set of reactant and product equilibrium concentrations is called an equilibrium position. At any particular temperature, there are many equilibrium positions but only one value for \(K_c\).

- A change in temperature of an equilibrium system changes the value of the equilibrium constant, which is a measure of the extent to which a given reaction occurs. If the temperature of the equilibrium system below is decreased, the equilibrium constant value will increase.

\[
\text{A(g)} + \text{B(g)} \rightleftharpoons \text{C(g)} + \text{energy}
\]

If temperature of the equilibrium system above is increased, the equilibrium constant value will decrease.
In the assessment of outcomes D1.3k and D1.4k:

- There is a common misconception that when the total pressure of a gaseous equilibrium is changed, the value of the $K_c$ for that equilibrium will also change.

In the assessment of outcome D1.4k:

- Students are expected to predict how a wide range of factors affect equilibrium and/or the equilibrium constant.
- Students are expected to write equilibrium constant expressions for homogeneous and heterogeneous (Brønsted–Lowry acids and bases) equilibria. The diploma examination will employ the convention of including in equilibrium expressions only substances that can vary in concentration. Gases must be included since the concentration of a gas can be altered by varying the pressure on it. For example,

$$
CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)
$$

$$
K_c = \frac{[H_2(g)][CO_2(g)]}{[CO(g)][H_2O(g)]}
$$

- Aqueous ions and/or gases in solution must be included since the concentration of aqueous ions and/or gases can be altered by varying the volume of solvent.
- Pure liquids are not included since their concentration (density) cannot be varied significantly. For example,

$$
CH_3COOH(aq) + H_2O(l) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)
$$

$$
K_c = \frac{[CH_3OO^-(aq)][H_3O^+(aq)]}{[CH_3COOH(aq)]}
$$

In a homogeneous mixture of liquids, they are all included since the concentration can be varied by changing the relative amounts of the mixed liquids. For example,

$$
C_6H_6(l) + Br_2(l) \rightleftharpoons C_6H_5Br(l) + HBr(l)
$$

$$
K_c = \frac{[C_6H_5Br(l)][HBr(l)]}{[C_6H_6(l)][Br_2(l)]}
$$

- When predicting whether reactants or products are favoured in reversible reactions, the magnitude of the $K_c$ value is only a general guideline. In a number of chemistry textbooks, there is a statement to the effect that a value of $K_c$ greater than 1 means that the products are favoured and a $K_c$ less than 1 means reactants are favoured. This is valid if a reaction has the same number of reactant and product molecules in the balanced chemical equation. When the numbers of reactant and product molecules are not the same, the value of the $K_c$ may be misleading in determining the extent of reaction. An analysis of the extent to which reactants are converted to products may be a better indication of whether reactants or products are favoured.
• Students are not expected to be able to predict whether or not a reaction is quantitative. However, this is not meant to discourage the teaching of this concept.

In the assessment of outcome D1.6k:

• The terms monoprotic and polyprotic need to be used with care with amphiprotic species, as such a species may be polyprotic as an acid yet monoprotic as a base. For example, the dihydrogen phosphate ion $\text{H}_2\text{PO}_4^-$ (aq) is polyprotic as an acid, capable of donating two protons, yet monoprotic as a base, because it can accept only one proton. In contrast, the hydrogen phosphate ion $\text{HPO}_4^{2-}$ (aq) is monoprotic as an acid, capable of donating one proton, yet polyprotic as a base, because it can accept two protons. In diploma examinations, every attempt will be made to define the context in which amphiprotic species are reacting, so that it can be determined precisely whether a species is monoprotic or polyprotic. The terms monobasic and polybasic, although less ambiguous than the terms monoprotic and polyprotic, will not be used on any diploma examination.

• Some titrations between polyprotic acids and polyprotic bases may go to completion, and stoichiometric methods can then be used to calculate concentrations of acids and bases from the volumes at the equivalence points. Other such titrations do not go to completion, as the acid may not be strong enough to complete all possible proton donations. The words titrated to completion will be used in diploma examinations to indicate that all possible proton donations have been made.

• Quantitative calculations of the pH of a buffer using the Henderson–Hasselbalch equation are beyond the program of studies and will not be asked. A qualitative understanding that the $K_a$ value of the buffer must approximate the desired $K_a$ value of the environment to be buffered is required.

In the assessment of outcome D1.7k:

• The terms amphiprotic substances and amphoteric substances are used synonymously to describe substances that can act as either proton acceptors or proton donors. In the diploma examinations, the term amphiprotic will be used.

• Amphiprotic species are species that have an ability to act as either an acid or a base: for example, $\text{H}_2\text{PO}_4^-$ (aq) or $\text{HCO}_3^-$ (aq). Because of this property, the pH of an amphiprotic species cannot be determined with the simple $K_a$ expression used to determine the pH of a weak acid. Students are not expected to determine the pH of an amphiprotic species, and will not be asked to do so on the diploma examination.

In the assessment of outcome D1.8k:

• Students are required to recognize that a buffer system is composed of relatively equal amounts of a weak acid and its conjugate base and maintains a nearly constant pH when diluted or when small amounts of strong acid or strong base are added. Students are not expected to calculate the pH of a buffer solution given the concentration of the conjugate acid and its base pair and/or utilizing the value of $K_a$. 
In the assessment of outcomes D1.8k and D1.3s:

- On a titration curve representing the titration of a weak acid with a strong base (or a strong acid with a weak base), one or more buffer regions occur. This is the flatter portion of the titration curve that occurs before the equivalence point when a buffer is present. In this region, the acid and its conjugate base are present in similar concentrations. Prior to this region, as strong base is added to the weak acid, the acid is converted to its conjugate base, until both are present in similar concentrations. The buffer region does not occur at the start of the titration, but only when a significant amount of strong base has been added to convert the weak acid to its conjugate base (the flat portion of the titration curve).

- Originally, a buffer was defined operationally as being any area on a pH graph where the titration graph of pH as a function of added titrant was essentially flat. With that definition, a strong monoprotic acid–strong monoprotic base titration would exhibit buffering regions at the beginning of the titration and at the end, separated by a near-vertical portion containing the single equivalence point. However, the only reason that these are flat is that pH is a logarithmic scale. If we have 50.0 mL of 1.00 mol/L NaOH, the pH is essentially 14, and adding 10.0 mL of 1.00 mol/L HCl will produce a pH of 13.82 as the molar concentration of NaOH is now (40.0 mL/60.0 mL) mol/L because 10.0 mL of the NaOH has been neutralized, and the new total volume is 60.0 mL. There is no equilibrium established near the reaction equivalence point, and the pH change is strictly a dilution effect.

- Following the Brønsted–Lowry approach to acid–base equilibrium, the buffer was redefined in terms of requiring the presence of a conjugate acid–base pair that is in an equilibrium state, and which reacts to the stresses applied in the form of small amounts of a strong base or a strong acid. With this more modern and complete definition of buffering, there would be no buffering regions in any strong monoprotic acid–strong monoprotic base titration.

In the assessment of outcomes D2.1k, D2.2k, and D2.4s:

- The values of $K_a$ provided in the Relative Strengths of Acids and Bases at 298.15 K table in the data booklet are experimental values that have two significant figures. As a result, calculated values resulting from the use of these data will generally only be good to two significant figures for a calculation of $K_b$ and to two decimal places for a calculation of pH or pOH.

- Teachers may find it necessary to review the proper use of scientific notation, and the use of the quantities millimoles and millimoles per litre, when completing calculation-based problems.

In the assessment of outcome D2.2k:

- Students are expected to be as familiar with calculations involving $K_b$ as they are for calculations involving $K_a$.

- Students are expected to know that $K_a \times K_b = K_w$. 
In the assessment of outcome D2.3k:

- Students will **not** be expected to solve questions involving the pH of weak acids and bases by using the quadratic equation. When such questions are asked in numerical-response form, the question will be double-keyed, so both the exact answer and the approximate answer would be marked as correct.

- The use of the approximation to solve acid–base equilibrium expressions is acceptable only when solving the equilibrium law equation results in a quadratic expression and the original concentration of the acid or base is one-thousand-fold greater than the value of $K_a$ or $K_b$.

- If the student is given the pH or pOH of an acid or base whose value of $K_a$ or $K_b$ is known, both the equilibrium concentration and the initial concentration can be calculated exactly. To find the equilibrium concentration, the equilibrium law expression is used. To find the initial concentration, the equilibrium concentration is calculated first, and the ICE table is then used to determine the initial concentration.

- The approximation may be considered when calculating the pH or pOH of a solution; it is never a factor when the pH or pOH is known and any of $K_a$, $K_b$, equilibrium concentration, or initial concentration have to be determined.

In the assessment of outcome D1.3s:

- Students are expected to know the terms *equivalence point* and *endpoint*. *Equivalence point* refers to the point at which stoichiometric amounts of reactants are added together. Thus, students may be asked to indicate on a graph where the equivalence point for a reaction occurs. The term *endpoint* will be used within the context of an indicator; for example, 40.2 mL was used to titrate a sample to the bromothymol blue (indicator) endpoint.

- Students are expected to know that the pH at the equivalence point is not always equal to 7. They should be able to explain when and why the pH at the equivalence point will be equal to 7 (strong acid–strong base), greater than 7 (weak acid–strong base), and less than 7 (strong acid–weak base). The computation of the exact pH at the equivalence point is beyond the scope of the program of studies.

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**Diploma Examinations Program Calculator Policy**

**Using Calculators**

The Chemistry 30 Diploma Examination requires the use of a scientific calculator or an approved graphing calculator. The calculator directives, expectations, criteria, and keystrokes required for clearing approved calculators can be found in the *General Information Bulletin* on the Alberta Education website.
*NEW Changes to WHMIS 1988

The Workplace Hazardous Materials Information System (WHMIS) has been used in Canada since 1988 for the labelling and classification of hazardous workplace chemicals. The Globally Harmonized System of Classification and Labelling of Chemicals (GHS) is being adopted by countries around the world in order to enable a consistent international chemical classification and labelling system. In Canada, WHMIS 1988 was amended in February 2015 to incorporate GHS. The new system will be called WHMIS 2015. The transition period for compliance will continue until 2018. Both WHMIS 1988 and WHMIS 2015 will be in effect during this time.

**WHMIS 2015**

- **Flame**
  - For fire hazards
- **Flame Over Circle**
  - For oxidizing hazards
- **Gas Cylinder**
  - For gases under pressure
- **Exploding Bomb**
  - For explosion or reactivity hazards
- **Biohazardous Infectious Materials**
  - For organisms or toxins that can cause diseases in people or animals
- **Corrosion**
  - For corrosive damage to metals, as well as skin, eyes
- **Exclamation Mark**
  - May cause less serious health effects
- **Health Hazard**
  - May cause or suspected of causing serious health effects
- **Skull and Crossbones**
  - Can cause death or toxicity with short exposure to small amounts
Examination Specifications and Design

Each Chemistry 30 Diploma Examination is designed to reflect the core content outlined in the Chemistry 30 Program of Studies, 2007 (Updated 2014).

**General Outcomes (GOs)**

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

Students will

• explain that technological problems often require multiple solutions that involve different designs, materials, and processes, and that have both intended and unintended consequences

• explain that scientific knowledge may lead to the development of new technologies and new technologies may lead to or facilitate scientific discovery

• explain that the goal of technology is to provide solutions to practical problems

• explain that scientific knowledge and theories develop through hypotheses, the collection of evidence, investigation, and the ability to provide explanations

• explain that the goal of science is knowledge about the natural world

• explain that the products of technology are devices, systems, and processes that meet given needs; however, these products cannot solve all problems

• explain that the appropriateness, risks, and benefits of technologies need to be assessed for each potential application from a variety of perspectives, including sustainability

• describe science and technology applications that have developed in response to human and environmental needs

• explain that science and technology have influenced, and have been influenced by, historical development and societal needs

• explain how science and technology are developed to meet societal needs and expand human capability

• explain how science and technology have both intended and unintended consequences for humans and the environment

• explain that technological development may involve the creation of prototypes, the testing of prototypes, and the application of knowledge from related scientific and interdisciplinary fields

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**Scientific Process and Communication Skills**

Students will

• formulate questions about observed relationships and plan investigations of questions, ideas, problems, and issues

• conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

• analyze data and apply mathematical and conceptual models to develop and assess possible solutions

• work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results
Examination Specifications

<table>
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<td>73%</td>
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<tr>
<td>Numerical Response</td>
<td>16</td>
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Program of Studies Outcomes

The design supports the integration of all Chemistry 30 general outcomes (GOs) as mandated in the Chemistry 20–30 Program of Studies, 2007 (Updated 2014).

Adjustments in the emphasis may be necessary because the examination includes machine-scored scenarios or contexts that cover more than one general or specific outcome. As a result, the examination may not necessarily be arranged sequentially by units but is instead built around scenarios or contexts that support STS connections; a set of questions may assess students’ ability to integrate several GOs.

Emphasis

The approximate emphasis of each unit in the examination is given below. The examination is limited to those expectations that can be measured by a machine-scored paper-and-pencil test. Therefore, the percentage weightings shown below will not necessarily match the percentage of class time devoted to each unit.

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<thead>
<tr>
<th>Machine-scored Content</th>
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<tr>
<td>Chemical Changes of Organic Compounds</td>
<td>18%–20%</td>
</tr>
<tr>
<td>Chemical Equilibrium Focusing on Acid–Base Systems</td>
<td>29%–32%</td>
</tr>
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Diploma Examinations: Multiple Forms

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

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

For more information, contact

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Assessment of Skills and STS Connections

Chemistry 30 Diploma Examination questions are intended to measure students’ understanding of chemistry concepts. It is important to remember that some questions will measure students’ understanding and use of skills associated with scientific inquiry, and some questions have been designed to measure students’ understanding of the connections between science and technology, and between science, technology, and society. As a result, many questions measure how well students can apply the skills and knowledge they have acquired in science to everyday life.

Teachers may find it helpful to use the following acronym when interpreting the program of studies document and planning instruction.

A – attitudes (for learning and inquiry in chemistry, skills, and knowledge)
S – skills
K – knowledge

Specific skills and STS concepts that can be tested are identified within the program of studies in regular typeface.
Teachers and individuals in industries, businesses, and post-secondary institutions have been helpful both in providing real-life contexts for STS questions and in making connections between real life and the program of studies. The development of test questions, from the writing stage until they appear on an examination, may take a number of years.

**Machine-scored Questions**

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

Some examination questions are organized into sets that relate to broad contexts; therefore, a set of questions may assess students' ability to integrate several GOs. Some questions will measure achievement of knowledge and/or skills; some will also measure achievement of scientific process and communication skills outcomes and/or STS outcomes.

Answers for multiple-choice questions are recorded in the first section of the machine-scored answer sheet, and answers for numerical-response questions are recorded in the second section on the same side of the same 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. It may take the form of a question or an incomplete statement. A context-dependent question provides information separate from the question stem. Many 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 one or more numerical-response questions.
Numerical-response questions are of three types: calculation of numerical values, selection of numbered events or structures from a list or diagram, and determination of the sequence of listed events. Students should remember that in some numerical-response questions, a number may be used more than once in an answer and there may be more than one correct answer. Please refer to the questions below as examples of changes to existing numerical-response question types.

Outcomes being assessed: B1.5k, B1.3s

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

<table>
<thead>
<tr>
<th>Reduction Half-Reaction</th>
<th>( E^\circ )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{Am}^{4+}(aq) + e^- \rightleftharpoons \text{Am}^{3+}(aq) )</td>
<td>+2.60 V</td>
</tr>
<tr>
<td>( \text{Tl}^{3+}(aq) + 2e^- \rightleftharpoons \text{Tl}^+(aq) )</td>
<td>+1.25 V</td>
</tr>
<tr>
<td>( \text{Ac}^{3+}(aq) + 3e^- \rightleftharpoons \text{Ac}(s) )</td>
<td>-2.20 V</td>
</tr>
<tr>
<td>( \text{Cs}^+(aq) + e^- \rightleftharpoons \text{Cs}(s) )</td>
<td>-3.03 V</td>
</tr>
</tbody>
</table>

Species

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( \text{Am}^{4+}(aq) )</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>( \text{Tl}^{3+}(aq) )</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>( \text{Ac}^{3+}(aq) )</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>( \text{Cs}^+(aq) )</td>
<td>8</td>
</tr>
</tbody>
</table>

Numerical Response

3. Match the species numbered above with the descriptors given below. You may use a number more than once.

- Strongest oxidizing agent
- Weakest reducing agent
- Species with the greatest attraction for electrons
- Species that loses three electrons

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

Answer: 1517
Outcome being assessed: C1.1k

*Use the following information to answer numerical-response question 4.*

<table>
<thead>
<tr>
<th>Carbon-containing Compounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
</tbody>
</table>

**Numerical Response**

4. The compounds above that can be classified as organic are numbered _____, _____, _____, and _____.

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

Answer: 1346 (These digits can be recorded in any order.)

Outcome being assessed: D2.2k

*Use the following information to answer numerical-response question 5.*

Chlorophenol red is an indicator used to determine the amount of chlorine dioxide disinfectant present in drinking water. The colour change of the indicator allows for an accurate determination of the amount of chlorine dioxide present.

**Numerical Response**

5. The value of $K_b$ for the conjugate base of chlorophenol red, $\text{Ch}^{-}(\text{aq})$, expressed in scientific notation, is $a.b \times 10^{-c}$. The values of $a$, $b$, and $c$ are _____.  

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

Answer: 188

**Note:** The value of $K_a$ found in the data booklet sets a limit of two significant digits for any calculated value of $K_b$. As a result, only three boxes can be filled.
Diploma Examination Instructions Pages

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January 2018
Chemistry 30
Grade 12 Diploma Examination

Description

Time: 3 hours. This closed-book examination was developed to be completed in 3 hours; however, you may take up to 6 hours to complete the examination, should you need it.

- This examination consists of 44 multiple-choice and 16 numerical-response questions, of equal value.
- This examination contains sets of related questions. A set of questions may contain multiple-choice and/or numerical-response questions.
- A chemistry data booklet is provided for your reference.

Instructions

- Turn to the last page of the examination booklet. Carefully fold and tear out the machine-scored answer sheet along the perforation.

Note: The perforated pages at the back of this booklet may be torn out and used for your rough work. No marks will be given for work done on the tear-out pages.

- Use only an HB pencil for the answer sheet.
- Fill in the information on the back cover of the examination booklet and the answer sheet as directed by the presiding examiner.
- You are expected to provide your own calculator. You may use any scientific calculator or a graphing calculator approved by Alberta Education.
- You must have cleared your calculator of all information that is stored in the programmable or parametric memory.
- You may use a ruler and a protractor.
- Read each question carefully.
- Consider all numbers used in the examination to be the result of a measurement or an observation.
- When performing calculations, use the values of the constants provided in the data booklet.
- If you wish to change an answer, erase all traces of your first answer.
- Do not fold the answer sheet.
- The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education.
- Now read the detailed instructions for answering machine-scored questions.
**Multiple Choice**

- Decide which of the choices **best** completes the statement or answers the question.
- Locate that question number on the separate answer sheet provided and fill in the circle that corresponds to your choice.

**Example**

This examination is for the subject of

A. chemistry  
B. biology  
C. physics  
D. science

Answer Sheet

[Circle selection]

---

**Numerical Response**

- Record your answer on the answer sheet provided by writing it in the boxes and then filling in the corresponding circles.
- If an answer is a value between 0 and 1 (e.g., 0.25), then be sure to record the 0 before the decimal place.
- Enter the first digit of your answer in the left-hand box. Any boxes on the right that are not needed are to remain blank.

**Examples**

**Calculation Question and Solution**

The average of the values 21.0, 25.5, and 24.5 is _______

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

Average = (21.0 + 25.5 + 24.5)/3
= 23.666…
= 23.7 (rounded to one decimal place)

Record 23.7 on the answer sheet

[Answer sheet representation]
**Correct-order Question and Solution**

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

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

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

Answer: 2413

Record 2413 on the answer sheet

**Selection Question and Solution**

<table>
<thead>
<tr>
<th>Five Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Carbon</td>
</tr>
<tr>
<td>2  Iron</td>
</tr>
<tr>
<td>3  Nitrogen</td>
</tr>
<tr>
<td>4  Potassium</td>
</tr>
<tr>
<td>5  Tin</td>
</tr>
</tbody>
</table>

The metals in the list above are numbered ____, ____, and ____.

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

Answer: 245

Record 245 on the answer sheet

**Scientific-notation Question and Solution**

\[
X(g) + Y(g) \rightarrow XY(g) \quad \Delta H^\circ = +1.61 \times 10^9 \text{kJ}
\]

The energy transferred when 1.00 mol of X(g) is consumed during the reaction represented by the equation above is \(a.bc \times 10^d\) kJ. The values of \(a\), \(b\), \(c\), and \(d\) are ____, ____, ____, and ____.

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

Answer: 1.61 \(\times 10^9\) kJ

Record 1619 on the answer sheet
Examination Development and Teacher Involvement

Working groups of classroom teachers develop questions that meet the program of studies and the technical standards incorporated into the examination blueprint. The diploma examinations are composed of questions and/or question sets that have proven to be valid in field testing.

After a question has been field tested, feedback provided by students and teachers is reviewed along with field testing statistics to determine whether the question is acceptable for a diploma examination. Before a question appears on an examination, it is reviewed and edited internally, and then reviewed externally by a working group of teachers and chemistry professionals.

To participate in our question development, examination review, or French translation working groups, teachers need to be nominated by their schools and their names submitted to Alberta Education.

Examination Security

All Chemistry 30 Diploma Examinations are secured.

More information can be found in the General Information Bulletin on the Alberta Education website under Security & Examination Rules.

Maintaining Consistent Standards over Time on Diploma Examinations

The process of examination equating was suspended for the 2008–2009 school year, as it was the year of the introduction of the new program of studies in Chemistry 30. The suspension was continued for the 2009–2010 school year, as there was a major change in format to the diploma examinations, with the removal of the written-response questions.

In the 2010–2011 school year, Alberta Education conducted extensive standard-setting exercises, and examination equating has now been reintroduced.

A goal of Alberta Education is to make scores achieved on examinations within the same subject directly comparable from session to session, thereby enhancing fairness to students across administrations.

In order to achieve this goal, a number of questions called anchor items remain the same from one examination to another. 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 differences in examination form difficulty. Examination marks may be adjusted 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, Chemistry 30 diploma examinations will be fully secured and will not be released at the time of writing. For more information about equating, please refer to the Alberta Education website under *Maintaining Consistent Standards Through Equating*.

More information can be found in the *General Information Bulletin* on the Alberta Education website under *Marks, Results, & Appeals*.

**Data Booklet**

The most current version of the *Chemistry 30 Data Booklet* has a publication date of 2010 and a red cover. This version replaces previous versions, which have an earlier publication date and blue covers.

**Assessment Standards**

The *Chemistry 30 Student Based Performance Standards* document that describes standards of achievement appropriate to the Chemistry 30 Program of Studies can be found on the Alberta Education website. The assessment standards document was developed by teachers from across Alberta in cooperation with the Provincial Assessment Sector, Alberta Education. It is a document intended to help teachers identity behaviors that may be exhibited by students at the acceptable standard and at the standard of excellence. It is not intended to replace the Chemistry 30 program of studies.

**Assessment Exemplars**

The *Chemistry 30 Exemplars* document has been developed to assist teachers with the interpretation of outcomes in the Chemistry 30 program of studies. The assessment exemplars can be found on the Alberta Education website.

*NEW* **Released Materials**

A new *Released Materials* documents for 2017, containing sample items that have been used previously on Chemistry 30 diploma exams, is available on the Alberta Education website.
**Field Tests**

The chemistry program is thankful to the many teachers and students who have volunteered for field test placements. The table below shows the format, number of questions, and length of time for field tests available for the 2017-2018 school year. Teachers may wish to consider this table when requesting a field test placement.

<table>
<thead>
<tr>
<th></th>
<th>Unit Test (Online)</th>
<th>Semester-end Test (Online)</th>
<th>Semester-end Test (Hybrid)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of questions (MC and NR)</strong></td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td><strong>Test time (min)</strong></td>
<td>65*</td>
<td>65*</td>
<td>65*</td>
</tr>
</tbody>
</table>

*The field tests are designed to be completed in 65 minutes; however, an additional 15 minutes may be used if available. These new time instructions appear on the field test instructions page.

<table>
<thead>
<tr>
<th>Type of Field Test</th>
<th>Semester 1</th>
<th>Semester 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Test (20 questions)</td>
<td>Unit A</td>
<td>Unit A</td>
</tr>
<tr>
<td></td>
<td>Unit B</td>
<td>Unit B</td>
</tr>
<tr>
<td></td>
<td>Unit C</td>
<td>Unit C</td>
</tr>
<tr>
<td></td>
<td>Unit D</td>
<td>Unit D</td>
</tr>
<tr>
<td>End of Semester Digital (20 questions)</td>
<td>All units</td>
<td>All units</td>
</tr>
<tr>
<td>End of Semester Hybrid (20 questions)</td>
<td>All units</td>
<td>All units</td>
</tr>
</tbody>
</table>

Students are expected to use paper copies of the data booklet when writing field tests, and teachers should ensure that their class has sufficient unmarked data booklets available for the testing session.

For field-test availability dates, teachers should go to the field test section of the General Information Bulletin.
# Publications and Support Documents

<table>
<thead>
<tr>
<th>Publication/Resource (Chemistry 30 Program of Studies)</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Information Bulletin</td>
<td></td>
</tr>
<tr>
<td>Chemistry 30 Information Bulletin</td>
<td></td>
</tr>
<tr>
<td>Chemistry 30 Information Bulletin Archived</td>
<td></td>
</tr>
<tr>
<td>Chemistry 30 Exemplars</td>
<td></td>
</tr>
<tr>
<td>Chemistry 30 Student Based Performance Standards</td>
<td></td>
</tr>
<tr>
<td>Mathematics and Science Directing Words</td>
<td></td>
</tr>
<tr>
<td>Science Process Words</td>
<td></td>
</tr>
<tr>
<td>Data Booklet</td>
<td></td>
</tr>
<tr>
<td>Chemistry 20–30 Program of Studies</td>
<td></td>
</tr>
<tr>
<td>Released Items</td>
<td></td>
</tr>
<tr>
<td>Diploma Examination Detailed Reports</td>
<td></td>
</tr>
<tr>
<td>A Guide for Students</td>
<td></td>
</tr>
<tr>
<td>Quest A+</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Semester-end self-scoring practice tests can be found here, as can four previous diploma examinations (January and June 2009, August and November 2012). All four diploma examinations in Quest A+ now include buttons which provide students with feedback on each of the alternatives for the multiple-choice questions, and hints for the numerical-response questions. For the correct response, the feedback will include the rationale for that answer and, if appropriate, supporting calculations. For incorrect responses, the feedback will highlight the common misconceptions and allow students to review their response more carefully. This feature is available for both English and French versions of these examinations.

<table>
<thead>
<tr>
<th>ATA Science Council</th>
<th>sc.teachers.ab.ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberta Regional Professional Development Consortia</td>
<td>arpd.ab.ca</td>
</tr>
</tbody>
</table>
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Inquiries about special cases, achievement test accommodations, and special-format materials can be sent by email to special.cases@gov.ab.ca

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

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