Information Bulletin
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Chemistry 30

Diploma Examinations Program

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This document was written primarily for:

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Teachers	✓ of Chemistry 30
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General Audience	
Others	

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Contents

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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*. The specific statements of standards are written primarily to inform Chemistry 30 teachers as to what extent 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.

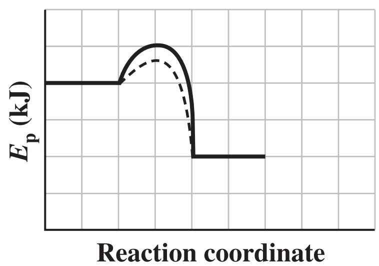
Examples of Acceptable-Standard Questions

Use the following information to answer the next question.

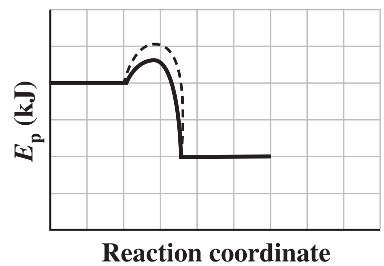
Dr. Richard Trotter has developed what could be the first cost-effective process for limiting methane emissions from underground coal mines. In this process, methane and oxygen are reacted at 800 °C in the presence of a catalyst. The products of this process are carbon dioxide gas and liquid water.

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

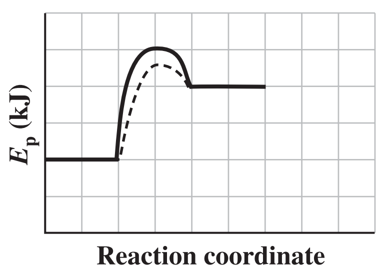
A.



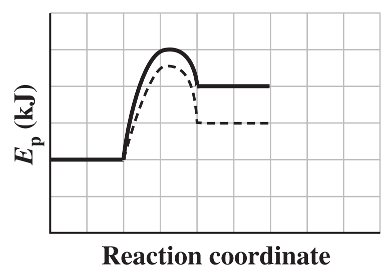
B.



C.



D.



------- Catalyzed ——— Uncatalyzed

Use the following information to answer the next question.

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. $2\,MnO_4^-(aq) + 16\,H^+(aq) + 5\,Sn^{2+}(aq) \rightarrow 2\,Mn^{2+}(aq) + 8\,H_2O(l) + 5\,Sn^{4+}(aq)$

B. $2\,MnO_4^-(aq) + 16\,H^+(aq) + 5\,Sn^{2+}(aq) \rightarrow 2\,Mn^{2+}(aq) + 8\,H_2O(l) + 5\,Sn(s)$

C. $MnO_4^-(aq) + 8\,H^+(aq) + Sn^{2+}(aq) \rightarrow Mn^{2+}(aq) + 4\,H_2O(l) + Sn^{4+}(aq)$

D. $MnO_4^-(aq) + 8\,H^+(aq) + Sn^{2+}(aq) \rightarrow Mn^{2+}(aq) + 4\,H_2O(l) + Sn(s)$

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 the next question.

Four Reaction Equations	Key			
$In(s) + La^{3+}(aq) \rightarrow$ no reaction	**1**	In(s)	**5**	$In^{3+}(aq)$
$Np(s) + La^{3+}(aq) \rightarrow Np^{3+}(aq) + La(s)$	**2**	Np(s)	**6**	$Np^{3+}(aq)$
$Np(s) + Nd^{3+}(aq) \rightarrow Np^{3+}(aq) + Nd(s)$	**3**	Nd(s)	**7**	$Nd^{3+}(aq)$
$La(s) + Nd^{3+}(aq) \rightarrow$ no reaction	**4**	La(s)	**8**	$La^{3+}(aq)$

Numerical Response

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

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

Use the following information to answer the next question.

$$CO_2(g) + H_2(g) \rightleftharpoons CO(g) + H_2O(g) \qquad K_c = 0.137$$

2. 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

Use the following information to answer the next question.

Sulfur dioxide gas reacts with oxygen to form sulfur trioxide gas, as represented by the following equilibrium equation.

$$2\,SO_2(g) + O_2(g) \rightleftharpoons 2\,SO_3(g)$$

Numerical Response

3. In order to obtain the equilibrium system above, 2.60 mol of $SO_2(g)$ and 2.30 mol of $O_2(g)$ are injected into a 1.00 L container. When the system reaches equilibrium, the concentration of the remaining $SO_2(g)$ is 1.32 mol/L. The concentration of $O_2(g)$ at equilibrium is __________ .

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

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

The content of the Chemistry 30 Diploma Examinations is emphasized as follows.

General Outcomes (GOs)

Unit A (GO 1 and 2)	Thermochemical Changes
Unit B (GO 1 and 2)	Electrochemical Changes
Unit C (GO 1 and 2)	Chemical Changes of Organic Compounds
Unit D (GO 1 and 2)	Chemical Equilibrium Focusing on Acid-Base Systems

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

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

Examination Specifications

Question Format	*Number of Questions*	*Percentage Emphasis*
Multiple Choice	44	73%
Numerical Response	16	27%

Emphasis

The approximate emphasis of each unit in the examination is given below.

Machine-Scored Content	*Range of Percentage Emphasis*
Thermochemical Changes	20%–22%
Electrochemical Changes	32%–34%
Chemical Changes of Organic Compounds	12%–16%
Chemical Equilibrium Focusing on Acid-Base Systems	30%–32%

Assessment of Skills and STS Connections

Chemistry 30 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 items, from the writing stage until they appear on an examination, may take a number of years.

Assessment of Communication Skills

The following section describes the scoring process used for written-response questions that appeared on the Chemistry 30 Diploma Examinations prior to 2010. Teachers will find scoring guides shown in this document, the *Chemistry 30 Bulletin*, and the *Chemistry 30 Classroom Assessment Materials and Examples* documents consistent with these descriptions of scoring standards.

Chemistry is a discipline in which there is a stringent set of rules for proper scientific communication. Communication skills are most evident and can be directly assessed on the written-response questions. The closed-response (analytic) written-response questions will be marked out of 6, with 5 marks for chemistry content and 1 mark for communication. The communication mark is partially determined by the extent to which the question has been attempted. Communication is marked based on organization, clarity, use of correct scientific conventions, and use of proper language conventions.

Proper scientific conventions include

- labelling of graphs and diagrams
- mathematical formulas and equations
- significant digits, units of measurement, and unit conversion
- states of matter
- abbreviations

The open-ended response (holistic) written-response question will be marked using the holistic scoring rubrics, which integrate the assessment of communication skills into the marking matrix that is used to assess the overall response.

Therefore, on the analytic questions, communication skills are assessed more independently; whereas on the holistic question, communication is assessed as part of the total response.

The intent of evaluating communication is to reward students for creating responses that are on topic, clear, concise, and well written using the conventions of scientific language.

Communication Guidelines for Classroom Assessment

The following list is a set of guidelines that were used during the marking of the communication scale for any of the written-response questions.

- Do not score work that the student has indicated should not be scored—this includes partially erased or clearly crossed-out work.
- If a student's response contains contradictory information, then score the work as either ambiguous or incorrect.
- Do not score any irrelevant and extra information that is not incorrect but that does not contribute to the correct response.
- The omission of leading zeros is not a scientific error and therefore will not be scored as such.
- States, units, significant digits, and ion charges must be included within the response. The student must be consistent with their use. (The exception to this is equilibrium expressions, which do not require units.) Units used should respect the conventions of the International System of Units (SI).
- Significant digits in the final recorded answer must be correct. It is not necessary to carry extra significant digits in intermediate steps, but it is a preferred practice to carry at least one extra digit throughout intermediate steps. If the number of significant digits in intermediate steps has been truncated (is less than the required number), then this will be considered an error.
- If spelling and grammar errors limit the understanding of the response and cause ambiguity, then this will be considered a communication error.
- Graphs should include an appropriate title, labelled axes with units, and an appropriate scale. The manipulated variable should always be on the *x*-axis.
- When the student is asked to draw a diagram of a cell, the diagram should include labels for the anode, cathode (or the specific substances), reagent solutions (electrolytes), a salt bridge or porous cup, voltmeter or power source, and a connecting wire to the electrodes. Students are not required, unless specifically asked, to label the migration of ions, the solution in the salt bridge (although the diagram or procedure should indicate there is a solution present), and the electron flow. If a student chooses to include these labels, then they will also be marked as part of the response.
- The *y*-axis on an energy diagram can be labelled E_p, H, or ΔH with appropriate units. However, on diploma examinations and field tests the *y*-axis will be labelled E_p (kJ).
- Portions of a response not assessed for chemistry marks will not be assessed for communication.

Analytic Communication Scoring Guide

Communication Scoring Guide for Closed-Response (Analytic) Questions

Score	Criteria
1	The teacher does not have to interpret any part of the response, and no reference to the question is needed to understand the response. The response is clear, concise, and presented in a logical manner. Scientific conventions have been followed. The response may contain a minor error.
0 Ambiguous or >1 scientific error	The teacher has to interpret the response (ambiguous) or the response is so poorly organized that the marker has to refer to the question in order to understand the response. The response may be ambiguous, incomprehensible, and/or disorganized, and/or contains errors (more than one) in scientific conventions.
0	**50% or less** of the question has been attempted. There is not much of a response present and not enough to score for communication.
NR	No response given.

Scientific conventions to be followed:

- Correct, appropriate units are used throughout the response.
- States are given throughout the response except in calculation labels and when a formula replaces a word in a sentence.
- Significant digits are used throughout the response.
- Branch names in organic molecules are in alphabetical order, using lowest possible numbers to indicate the position of branches.

***Note: Content and communication are scored on separate scales for the analytic question.**

Explanation of the Holistic Scoring Guide

Holistic questions are designed so that students can demonstrate their understanding of science from more than one valid approach or perspective and are assessed in a holistic fashion. The holistic question will be scored on two rubrics with a 5-point scale.

Teachers must read the student response in its entirety in order to decide if it contains the key component(s) for the particular question. The teacher then looks for the necessary support details. These two aspects are used to assess the quality of students' responses. Communication skills and scientific conventions are considered in the determination of the overall quality of the key component(s) and support.

Holistic Scoring Rubrics

Score	Key–no Key Criteria
1 **Key** **(weight of 2)**	The student has addressed the key component(s) of the question asked. The key component(s) of the question can be found in the stem of the question.
0 **No Key**	The student has not addressed the key component(s) of the question asked.

Score	Support
3 **Very Good to Excellent**	The student has provided good support for **all** of the bullets. The support may include a minor error/weakness in **one** of the support bullets.
2 **Satisfactory to Good**	The student has provided support for the majority of the bullets but not necessarily all of the bullets. The support provided may contain minor errors/weaknesses. There is **more correct than incorrect** support.
1 **Minimal**	The student has provided minimal support for one or more of the bullets, but there are many errors throughout. There is **more incorrect than correct** support.
0 **Limited to No support**	The student has not provided enough support to demonstrate more than a limited understanding. The support is either off topic or contains major errors throughout all of the bullets.

Sample Written-Response Questions and Responses for Classroom Assessment

Use the following information to answer the first question.

Sour gas contains a significant amount of hydrogen sulfide gas mixed with methane gas. Hydrogen sulfide gas is a colourless, toxic gas that smells like rotten eggs. Hydrogen sulfide gas can be converted to sulfur dioxide gas in a process called flaring, as represented by the equation below.

$$2\,H_2S(g) + 3\,O_2(g) \rightarrow 2\,SO_2(g) + 2\,H_2O(g)$$

1. **a.** **Determine** the enthalpy change for the flaring process represented by the equation above. **(3 marks)**

b. **Sketch** and label a potential energy diagram that represents the enthalpy change for the flaring process. **(2 marks)**

Use the following information to answer the next question.

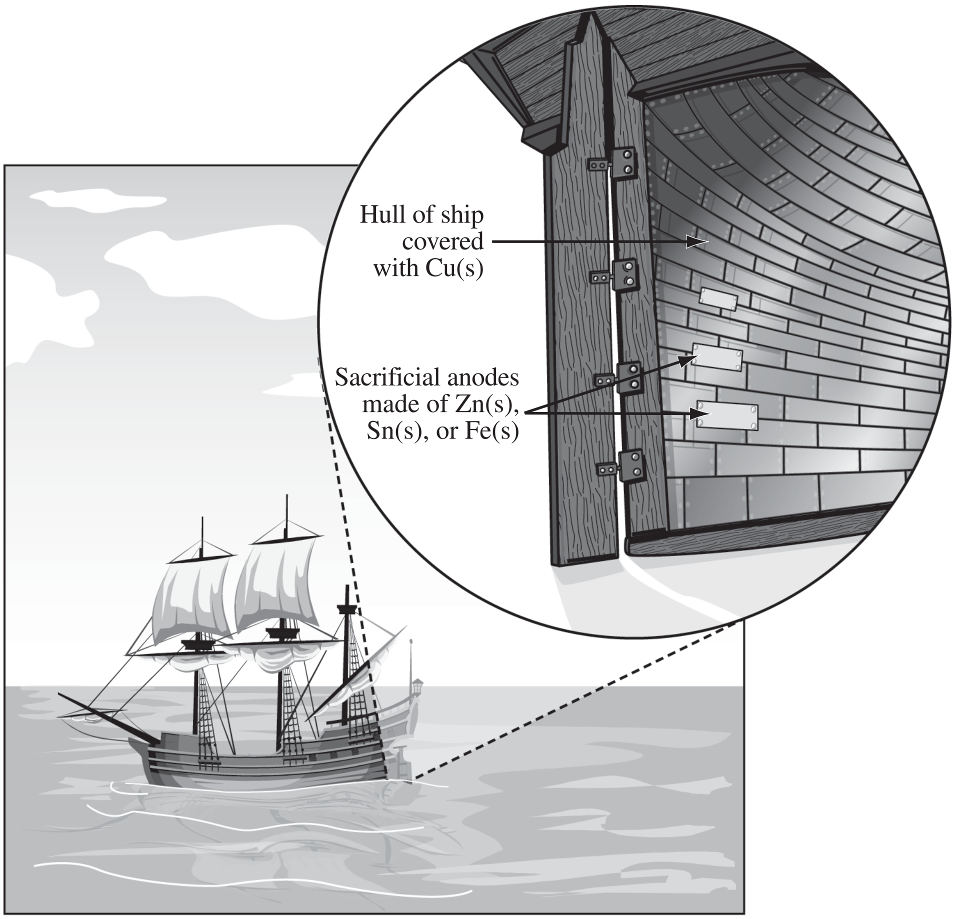
Large amounts of ammonia for the production of fertilizers and other consumer goods are made by the Haber process. During the Haber process, hydrogen gas combines with nitrogen gas to produce ammonia gas. This process is carried out in the presence of a catalyst.

2. **a.** Write a balanced equilibrium equation for the Haber process. Include the enthalpy change as an energy term in the balanced equation. **(3 marks)**

b. **Describe** what happens to the equilibrium position and the value of the equilibrium constant when the temperature of the system is increased from 200 °C to 500 °C. **(2 marks)**

Use the following information to answer the next question.

The copper covering on the hull of a ship, which is the main body of the ship that is in contact with water, corrodes when it is exposed to water and oxygen. To protect against such corrosion on British naval ships, Sir Humphry Davy was the first to use blocks of either zinc, tin, or iron as sacrificial anodes, which were attached to the ship's hull.

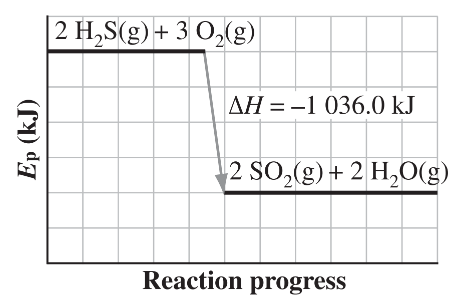


3. **Explain** how a block of zinc, tin, or iron would prevent the corrosion of the copper on a ship's hull.

Your response should include

- an explanation of the corrosion of copper
- an explanation of how a block of zinc, tin, or iron protects the copper from corrosion
- relevant balanced equations and $E°_{cell}$ calculations to support each of your explanations

Analytic-Style Written-Response Question Sample Response

Question	Marks	Sample Response	Comments
1.a.	3	$2\,H_2S(g) + 3\,O_2(g) \rightarrow 2\,SO_2(g) + 2\,H_2O(g)$ $\Delta H° = \sum n\Delta_f H°_{(products)} - \sum n\Delta_f H°_{(reactants)}$ $= [(2\text{ mol})(-296.8\text{ kJ/mol}) + (2\text{ mol})(-241.8\text{ kJ/mol})] - [(2\text{ mol})(-20.6\text{ kJ/mol}) + (3\text{ mol})(0\text{ kJ/mol})]$ $= (-1\,077.2\text{ kJ}) - (-41.2\text{ kJ})$ $= -1\,036.0\text{ kJ}$	• 1 mark for correct method • 1 mark for substitution consistent with method • 1 mark for correct answer
1.b.	2	**Combustion of $H_2S(g)$**  **Note:** Can also be labelled reactants and products.	• 1 mark for correct labels • 1 mark for shape of graph consistent with calculation
	1	Communication—See Guide	Use Analytic Scoring Guide
		Total possible marks = 6	

Analytic-Style Written-Response Question Sample Response

Question	Marks	Sample Response	Comments
2.a.	3	$3\,H_2(g) + N_2(g) \rightleftharpoons 2\,NH_3(g) + 91.8\text{ kJ}$	• 1 mark for balanced equation • 1 mark for the correct heat value • 1 mark for the inclusion of the heat term on the correct side
2.b.	2	The equilibrium position would shift toward the reactants because the forward reaction is exothermic, and the K_c value would decrease.	• 1 mark for correct shift in equilibrium consistent with heat term • 1 mark for a change in K_c consistent with the shift
	1	Communication—See Guide	Use Analytic Scoring Guide
		Total possible marks = 6	

Holistic-Style Written-Response Question Sample Response

Question	Marks	Sample Response	Comments
3.		**Corrosion Explanation** The corrosion of copper is the spontaneous oxidation reaction that occurs when copper reacts with water and oxygen. Solid copper is oxidized to $Cu^{2+}(aq)$. $O_2(g) + 2\,H_2O(l) + 4\,e^- \rightarrow 4\,OH^-(aq)$ $E°_{reduction} = +0.40$ V $Cu(s) \rightarrow Cu^{2+}(aq) + 2\,e^-$ $E°_{reduction} = +0.34$ V $O_2(g) + 2\,H_2O(l) + 2\,Cu(s) \rightarrow 4\,OH^-(aq) + 2\,Cu^{2+}(aq)$ $\Delta E°_{cell} = +0.06$ V OR $\rightarrow 2\,Cu(OH)_2(s)$ **Sacrificial Anode Explanation** The metal found in the sacrificial anode prevents the corrosion of copper because it (Zn, Sn, or Fe) is a stronger reducing agent than copper and the metal undergoes oxidation before the copper. If both iron and copper are present with water and oxygen, the reaction that occurs is the following. $O_2(g) + 2\,H_2O(l) + 2\,Fe(s) \rightarrow 4\,OH^-(aq) + 2\,Fe^{2+}(aq)$ $\Delta E° = +0.85$ V OR $\rightarrow 2\,Fe(OH)_2(s)$	*Key Component* • explanation that Fe(s), Sn(s) or Zn(s) reacts spontaneously with the oxidizing agent before Cu(s) *Support* • explanation of the corrosion of copper • explanation of the sacrificial anode • relevant equations and $E°_{cell}$ calculation

Sample Student Responses and Rationales

A number of sample responses to written-response questions are given on the following pages. For each, the score awarded and a rationale for that score are also provided.

Written-Response Questions—Student Response 1

Use the following information to answer the first question.

> Sour gas contains a significant amount of hydrogen sulfide gas mixed with methane gas. Hydrogen sulfide gas is a colourless, toxic gas that smells like rotten eggs. Hydrogen sulfide gas can be converted to sulfur dioxide gas in a process called flaring, as represented by the equation below.
>
> $$2\,H_2S(g) + 3\,O_2(g) \rightarrow 2\,SO_2(g) + 2\,H_2O(g)$$

Written Response—10%

1. **a.** **Determine** the enthalpy change for the flaring process represented by the equation above. **(3 marks)**

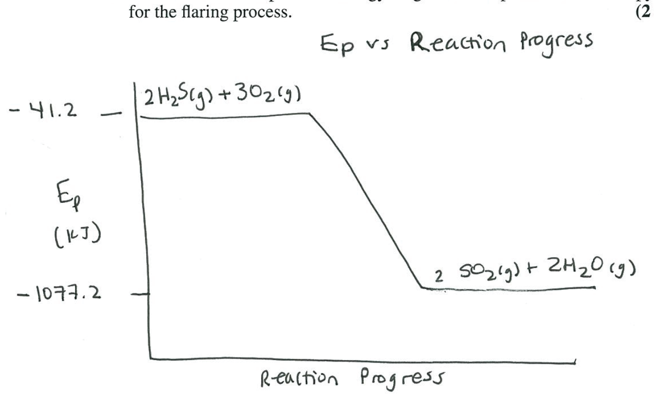
$$\Delta H = \Sigma_p - \Sigma_r$$

$$= \left(2\,mol\left(-296.8\,\frac{kJ}{mol}\right)\right) + \left(2\,mol\left(-241.8\,\frac{kJ}{mol}\right)\right) - \left[2\,mol\left(-20.6\,\frac{kJ}{mol}\right)\right]$$

$$= -593.6\,kJ + (-453.6\,kJ) - (-41.2\,kJ)$$

$$= -1036\,kJ$$

b. **Sketch** and label a potential energy diagram that represents the enthalpy change for the flaring process. **(2 marks)**



Score—6 out of 6
(5 for content and 1 for communication)

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

Rationale
The correct method for determining ΔH is used, but the final answer does not have the correct number of significant digits. The energy diagram has the correct shape and is labelled.

The response received 1 mark for communication because the only error in communication was in part **a** with the significant digits in the final answer.

Written-Response Questions—Student Response 2

Use the following information to answer the first question.

Sour gas contains a significant amount of hydrogen sulfide gas mixed with methane gas. Hydrogen sulfide gas is a colourless, toxic gas that smells like rotten eggs. Hydrogen sulfide gas can be converted to sulfur dioxide gas in a process called flaring, as represented by the equation below.

$$2\,H_2S(g) + 3\,O_2(g) \rightarrow 2\,SO_2(g) + 2\,H_2O(g)$$

Written Response—10%

1. **a.** **Determine** the enthalpy change for the flaring process represented by the equation above. **(3 marks)**

$2\,H_2S(g) + 3O_2(g) \rightarrow 2\,SO_2(g) + 2H_2O(g)$

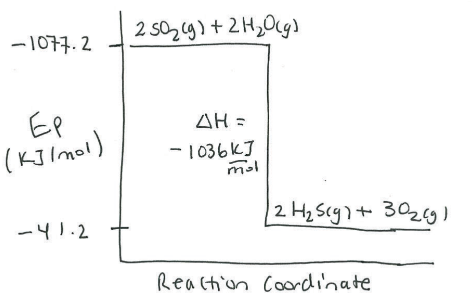
$\Delta H = \Sigma\,\text{products} - \Sigma\,\text{reactants}$

$\Delta H = \begin{bmatrix} 2\text{ mol } SO_2(g)\,(-296.8\text{ kJ/mol}) \\ + 2\text{ mol } H_2O(g)\,(-241.8\text{ kJ/mol}) \end{bmatrix} - \begin{bmatrix} 2\text{ mol } H_2S(g)\,(-20.6\text{ kJ/mol}) \\ + 3\text{ mol } O_2(g)\,(0\text{ kJ/mol}) \end{bmatrix}$

$(-1077.2\text{ kJ/mol}) - (-41.2\text{ kJ/mol})$

$\Delta H = -1036\text{ kJ/mol}$

b. **Sketch** and label a potential energy diagram that represents the enthalpy change for the flaring process. **(2 marks)**



Score—4 out of 6
(4 for content and 0 for communication)

Rationale

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

The correct method for determining ΔH is used, but the units included are incorrect, as are the significant digits.
The shape of the energy diagram is correct but the diagram is missing a title.

The response received 0 marks for communication because of the significant-digits and unit errors.

Use the following information to answer the next question.

Large amounts of ammonia for the production of fertilizers and other consumer goods are made by the Haber process. During the Haber process, hydrogen gas combines with nitrogen gas to produce ammonia gas. This process is carried out in the presence of a catalyst.

Written Response—10%

2. **a.** Write a balanced equilibrium equation for the Haber process. Include the enthalpy change as an energy term in the balanced equation. **(3 marks)**

$183.6\,KJ + 3H_2(g) + N_2(g) \overset{\text{catalyst}}{\rightleftharpoons} 2NH_3(g)$

$\Delta H = \Delta_f H^\circ products - \Delta H_f^\circ reactants$

$\Delta H = (2NH_3(g)) - (3H_2(g) + N_2(g))$

$\Delta H = (2(^-45.9 KJ/mol)) - (3(0KJ/mol) + (0KJ/mol))$

$\Delta H = (-91.8 KJ/mol) - (0KJ/mol + 0KJ/mol)$

$\Delta H = -91.8\ KJ/mol$

$2mol(91.8KJ/mol) = 183.6\,KJ$

b. **Describe** what happens to the equilibrium position and the value of the equilibrium constant when the temperature of the system is increased from 200 °C to 500 °C. **(2 marks)**

As the temperature of the system is increased from 200°C to 500°C products will be more favored than reactants. The value of the equilibrium constant will increase.

Score—3 out of 6
(3 for content and 0 for communication)

Rationale
This example meets the minimum requirements of the *acceptable standard*.

The equation was correctly balanced with an equilibrium arrow. The calculation appears to have been done correctly, but an incorrect value was substituted into the equation, and was on the wrong side of the equation. The shift and the change in the K_c were consistent with the student's equation.

The response received 0 for communication, as units were incorrect more than once.

Written-Response Questions—Student Response 4

Use the following information to answer the next question.

Large amounts of ammonia for the production of fertilizers and other consumer goods are made by the Haber process. During the Haber process, hydrogen gas combines with nitrogen gas to produce ammonia gas. This process is carried out in the presence of a catalyst.

Written Response—10%

2. **a.** Write a balanced equilibrium equation for the Haber process. Include the enthalpy change as an energy term in the balanced equation. **(3 marks)**

$-91.8 \text{ kJ} + 3\ H_2(g) + N_2(g) \xrightarrow{\text{catalyst}} NH_3(g)$

b. **Describe** what happens to the equilibrium position and the value of the equilibrium constant when the temperature of the system is increased from 200 °C to 500 °C. **(2 marks)**

There would be no change in the value of the equilibrium constant.

Score—2 out of 6
(1 for content and 1 for communication)

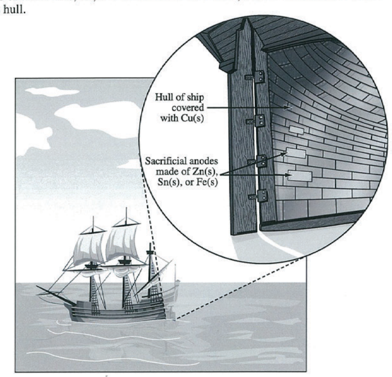
Rationale
This example does not meet the requirements of the *acceptable standard.*

The equation was not correctly balanced and did not have an equilibrium arrow. The value for the enthalpy change was correct. The enthalpy change was on the wrong side of the equation. The change in the value of the equilibrium constant was incorrect and no shift was indicated.

The response received 1 mark for communication, as states and units were correct.

Use the following information to answer the next question.

The copper covering on the hull of a ship, which is the main body of the ship that is in contact with water, corrodes when it is exposed to water and oxygen. To protect against such corrosion on British naval ships, Sir Humphry Davy was the first to use blocks of either zinc, tin, or iron as sacrificial anodes, which were attached to the ship's hull.



Written Response—15%

3. **Explain** how a block of zinc, tin, or iron would prevent the corrosion of the copper on a ship's hull.

Your response should include

- an explanation of the corrosion of copper
- an explanation of how a block of zinc, tin, or iron protects the copper from corrosion
- relevant balanced equations and $E°_{cell}$ calculations to support each of your explanations

The corrosion of Cu(s) is when Cu(s) spontaneously reacts with $O_2(g)$ and $H_2O(l)$ to form $Cu^{2+}(aq)$ and $OH^-(aq)$. Cu(s) is the reducing agent and the O atom is the oxidizing agent.

½ reduction $O_2(g) + 2H_2O(l) + 4e^- \rightleftharpoons 4OH^-(aq)$

½ oxidation $(Cu(s) \rightleftharpoons Cu^{2+}(aq) + 2e^-)\,2$

$$O_2(g) + 2H_2O(l) + 2Cu(s) \rightarrow 2Cu^{2+}(aq) + 4OH^-(aq)$$

$$E° = +0.40\text{ V} - +0.34\text{ V} = 0.06\text{ V}$$

A block of Zn(s), Sn(s) or Fe(s) could act as a sacrificial anode protecting the Cu(s) by being a stronger reducing agent. This would mean that instead of Cu(s) donating electrons to become $Cu^{2+}(aq)$, Zn(s) or Sn(s) or Fe(s) would donate electrons and become a cation.

Zn(s) as an example

$$2\,Zn(s) + O_2(g) + 2H_2O(l) \rightarrow 2\,Zn^{2+}(aq) + 4OH^-(aq)$$

$$E° = +0.40\text{ V} - -0.76\text{ V} = +1.16\text{ V}$$

Since the electrical potential of this reaction is higher than the corrosion of Cu(s), the Zn(s) is more likely to be oxidized instead of Cu(s).

Score—5 out of 5
(Holistically Scored)

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

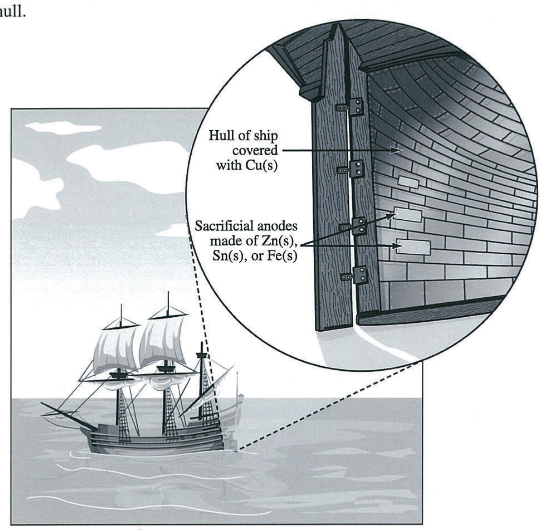
The response addresses the question asked by making reference to the sacrificial anode reacting instead of copper (key component). The response explains why the sacrificial anode reacts instead of copper and it is supported with correct equations and $E°_{cell}$ calculations. Scientific conventions are followed and the information is clearly communicated.

A total score of 5 was awarded (2 for key component and 3 for support).

Written-Response Questions—Student Response 6

Use the following information to answer the next question.

The copper covering on the hull of a ship, which is the main body of the ship that is in contact with water, corrodes when it is exposed to water and oxygen. To protect against such corrosion on British naval ships, Sir Humphry Davy was the first to use blocks of either zinc, tin, or iron as sacrificial anodes, which were attached to the ship's hull.



Written Response—15%

3. **Explain** how a block of zinc, tin, or iron would prevent the corrosion of the copper on a ship's hull.

Your response should include

- an explanation of the corrosion of copper
- an explanation of how a block of zinc, tin, or iron protects the copper from corrosion
- relevant balanced equations and E°_{cell} calculations to support each of your explanations

The corrosion of copper takes place when copper is exposed to water and oxygen because the water and oxygen react with the copper to form Copper (I) or Copper (II) oxides.

Other metals such as zinc, tin or iron can protect copper from corrosion because they are more likely to react with the oxygen and water, therefore they corrode instead of copper.

$$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$$
$$Fe(s) \rightleftharpoons Fe^{2+}(aq) + 2e^-$$
$$Cu^{2+}(aq) + Fe(s) \rightleftharpoons Cu(s) + Fe^{2+}(aq)$$
$$E^\circ_{cell} = +0.34 - -0.45$$
$$= +0.79$$ ✓

Score—3 out of 5
(Holistically Scored)

Rationale
This example just meets the minimum requirements of the *acceptable standard*.

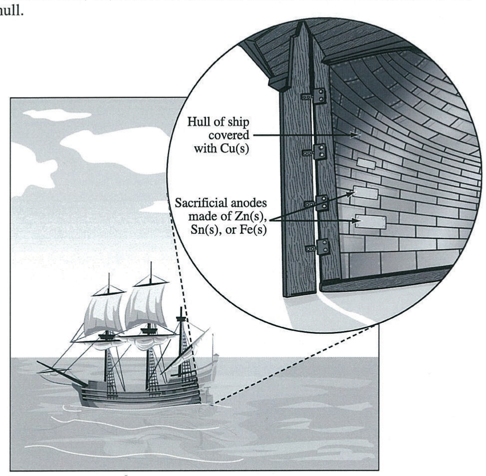
The student has addressed the question by making reference to the sacrificial anode in a comparison to copper in a minimal way (key component). The student does not provide correct equations, or an explanation of why the sacrificial anode reacts instead of copper. The student does provide an E°_{cell} calculation for the equation the student provided. The student has provided minimal support for one of the bullets, but there is more incorrect than correct support.

A total score of 3 was awarded (2 for key component and 1 for support).

Written-Response Questions—Student Response 7

Use the following information to answer the next question.

The copper covering on the hull of a ship, which is the main body of the ship that is in contact with water, corrodes when it is exposed to water and oxygen. To protect against such corrosion on British naval ships, Sir Humphry Davy was the first to use blocks of either zinc, tin, or iron as sacrificial anodes, which were attached to the ship's hull.



Written Response—15%

3. **Explain** how a block of zinc, tin, or iron would prevent the corrosion of the copper on a ship's hull.

Your response should include

- an explanation of the corrosion of copper
- an explanation of how a block of zinc, tin, or iron protects the copper from corrosion
- relevant balanced equations and $E°_{cell}$ calculations to support each of your explanations

$Zn^{2+} + Cu_{(s)} \rightleftharpoons Cu^{2+} + Zn_{(s)}$

$Cu^{2+} + 2e^- \rightleftharpoons$

The copper is reduced as the $H_2O_{(l)} + O_{2(g)}$ acts as oxidizing agents the copper looses e^- and is Corroded by the $H_2O_{(l)}$ & $O_{2(g)}$

The zinc however is a stronger oxidizing agent then the $H_2O_{(l)}$ & $O_{2(g)}$ so it acts as a sacrificial anode that gains the e^- saving the $Cu_{(s)}$ from corrosion.

$Cu_{(s)} \rightleftharpoons Cu^{2+} + 2e^- = +0.34$

$Cu^{2+} + 2e^- \rightleftharpoons Cu_{(s)} = 0.76$

$Zn_{(s)} \rightleftharpoons Zn^{2+} + 2e^-$

$Cu^{2+} + Zn_{(s)} \rightleftharpoons Zn^{2+} + Cu_{(s)}$

1.10 V

Score—1 out of 5
(Holistically Scored)

Rationale
This example does not meet the requirements of the *acceptable standard*.

The student has not addressed the question as the student has not made a correct reference to Zn as a sacrificial anode in comparison to copper. The student does not provide correct equations or an explanation of why zinc reacts instead of copper. The student does provide an $E°_{cell}$ calculation for the equation they provided. The student has provided an explanation of the corrosion of copper, but there is more incorrect than correct support.

A total score of 1 was awarded (0 for key component and 1 for support).

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.

***Exemplars* Document**

Examples of questions are also posted on the website next to the *Information Bulletin* in the *Exemplars* document. There are examples for each type of question format used in diploma examinations. This document outlines some of the general principles of question construction used by examination developers at the Assessment Sector, contains the *Chemistry 30 Program of Studies* outcome statements, and provides examples of questions that can be used to assess these outcome statements.

Constructing the Diploma Examination

Classroom teachers work on item-development committees to develop questions that meet the program of studies and technical standards incorporated in 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, in addition to the statistics, are reviewed before the question is deemed acceptable for a diploma examination. Before an item appears on an examination, it is reviewed and edited internally, and then reviewed externally by a committee of teachers and professionals working in the chemistry field.

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

Diploma Examination Instructions Pages

January 2012

Chemistry 30

Grade 12 Diploma Examination

Description

Time: 2 hours. This closed-book examination was developed to be completed in 2 h; however, you may take an additional 0.5 h to complete the examination.

- 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 turn this page and 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

● Ⓑ Ⓒ Ⓓ

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

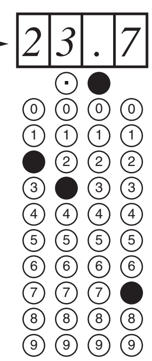
Calculation Question and Solution

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 ⟶



Correct-Order Question and Solution

Four Subjects

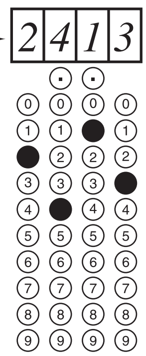
1 Physics
2 Biology
3 Science
4 Chemistry

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

Five Elements

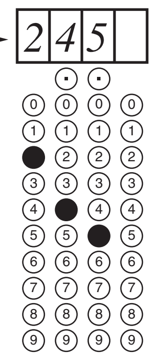
1 Carbon
2 Iron
3 Nitrogen
4 Potassium
5 Tin

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

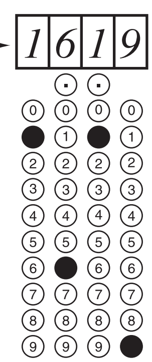
$X(g) + Y(g) \rightarrow XY(g) \qquad \Delta H^\circ = +1.61 \times 10^9$ kJ

The energy transferred when 1.00 mol of X(g) is consumed during the reaction represented by the equation above is $\boldsymbol{a.bc} \times 10^{\boldsymbol{d}}$ 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: 1.61×10^9 kJ

Record 1619 on the answer sheet ⟶



Examination Security

All Chemistry 30 Diploma Examinations are secured.

More information can be found in the *General Information Bulletin* on the Alberta Education website at education.alberta.ca by following the pathway:

Teachers > (Additional Programs and Services) Diploma Exams > Diploma General Information Bulletin > 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 will be conducting extensive standard-setting exercises with a view to re-introducing examination equating in all examinations from January 2012 onward. Details of the equating process will be published in the *2011–2012 Information Bulletin*.

A baseline examination will be established, and equating will be reestablished once the introduction of the new *Chemistry 30 Program of Studies, 2007* has been completed.

More information can be found in the *General Information Bulletin* on the Alberta Education website at education.alberta.ca by following the pathway:

Teachers > (Additional Programs and Services) Diploma Exams > Diploma General Information Bulletin > Marks, Results, & Appeals

Significant Digits

The examples below illustrate the proper use of significant digits for the Chemistry 30 Diploma Examination in a response.

Example 1

A 10.0 mL sample of a $Fe^{2+}(aq)$ solution of unknown concentration is titrated with a standardized 0.120 mol/L $KMnO_4(aq)$ solution. The following data are recorded.

2 decimal places (10.10–1.00) according to the addition/subtraction rules leaves 3 significant digits

Trial	**I**	**II**	**III**
Final burette reading (mL)	10.10	19.22	28.33
Initial burette reading (mL)	1.00	10.10	19.22
Titrant added (mL)	**9.10***	9.12	9.11

The concentration of the $Fe^{2+}(aq)$ is ___________.

Reaction Equation

$$MnO_4^-(aq) + 8\,H^+(aq) + 5\,Fe^{2+}(aq) \rightarrow Mn^{2+}(aq) + 4\,H_2O(l) + 5\,Fe^{3+}(aq)$$

Exact number, therefore does **not** change the final number of significant digits

Average volume of titrant added is 9.11 mL

$$[Fe^{2+}(aq)] = 9.11\text{ mL } MnO_4^-(aq) \times 0.120\text{ mol/L } MnO_4^-(aq) \times \frac{5\text{ mol } Fe^{2+}(aq)}{1\text{ mol } MnO_4^-(aq)} \times \frac{1}{10.0\text{ mL } Fe^{2+}(aq)}$$

$[Fe^{2+}(aq)] =$ **0.547** mol/L

* Final answer has 3 significant digits (least number present according to the multiplication/division rule)

Example 2

K_a value has 2 significant digits

The pH of a 0.100 mol/L solution of ethanoic acid is ___________.

$$K_a = \mathbf{1.8 \times 10^{-5}} = \frac{x^2}{(0.100\text{ mol/L} - x)}$$

The value of x can be ignored when compared to 0.100 mol/L in the case of such a weak acid.

K_a is approximately $\dfrac{x^2}{0.100\text{ mol/L}}$

$x = [H_3O^+(aq)] =$ **0.001342**

Additional digits carried through on an interim basis

pH = −log(0.001342 mol/L)
= **2.87**

Final answer has 2 significant digits

Example 3

A student conducts a calorimetry experiment to determine the energy transferred when Solution A is mixed with Solution B. The data collected are shown below. Assume the specific heat capacity for each solution is the same as that of water.

Mass of Solution A (g)	100.0
Mass of Solution B (g)	100.0
Mass of final solution mixture (g)	200.0
Initial temperature of solutions A and B (°C)	20.0
Final temperature of the solution mixture (°C)	23.0

The original data is limited to 3 significant digits.

$\Delta H = mc\Delta t$

$\Delta H = (200.0 \text{ g})(4.19 \text{ J/g}\cdot°\text{C})(\mathbf{3.0}\ °\text{C})$

The resulting temperature has 2 significant digits.

$\Delta H = \mathbf{2.5} \text{ kJ}$

The final answer should be rounded to the same number of significant digits contained in the input data for the calculation that has the fewest number of significant digits.

The final answer has 2 significant digits because the input data for the $\Delta H = mc\Delta t$ calculation is limited by the temperature difference of 3.0 °C, which has 2 significant digits.

Changes to the Chemistry 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.

Rationale

- To address feedback received from the field regarding the Chemistry 30 Data Booklet, specifically regarding the solubility table
- To better align the Chemistry 30 Data Booklet with the *Chemistry 30 Program of Studies, 2007*
- To reflect current values

- With the inclusion of relevant chemistry constants or formulas, we do not want to add values and formulas to the Chemistry 30 Data Booklet that will increase the difficulty of the examination and expand the examination to assessing outcomes not in the *Chemistry 30 Program of Studies, 2007*. We want to include only those values and formulas that will be of assistance.
- We received an overwhelming response from the field in our online survey recommending that we not include Chemistry 20 and Chemistry 30 formulas in the data booklet.

Updated Values

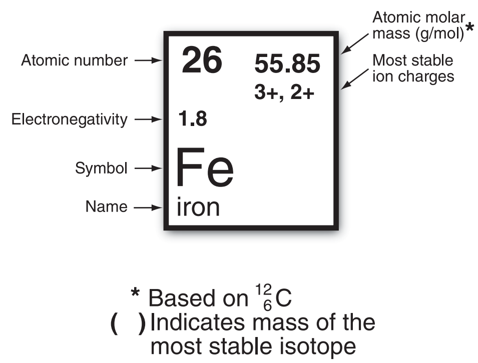
- Specific heat capacity for iron, 0.449 J/(g·°C)
- Zn has a molar mass of 65.41 g/mol.
- Pb has a molar mass of 207.2 g/mol.
- $\Delta_f H°$ for sodium hydroxide is -425.8 kJ/mol.
- Flame colours of calcium (yellowish red), strontium (scarlet red), and barium (yellowish green) are adjusted to reflect the 86th edition of the *CRC Handbook*.
- K_a for nitrous acid is 5.6×10^{-4}.
- Errors in the solubility chart were corrected to be consistent with the K_{sp} values.
- K_a of methyl violet ~ 2×10^{-1}
  cresol red ~ 3×10^{-1}
  orange IV ~ 1×10^{-2}

Changes in Charts and Symbols

- Using K_c instead of K_{eq}, as indicated in the program of studies.
- Including the IUPAC names for the acids and bases in addition to the common names.
- Adding additional organic acids (butanoic, lactic, propanoic) and remove concentration of water from the Relative Strengths of Acids and Bases Table.
- Removing boiling and melting points on the periodic table because they were viewed as not useful.
- Removing the Thermodynamic Properties tables (ΔH_{fusion}, $\Delta H_{vaporization}$) because phase changes are no longer in the *Chemistry 30 Program of Studies*.
- Removing the Molar Enthalpies of Combustion of Selected Organic Compounds.
- Adding specific heat capacity of Al, Cu, Sn, and $H_2O(l)$ to the miscellaneous chart, to be used with calorimetry data.
- Changing the colour scheme of the periodic table to reflect states (solids, liquids, and gases) at 101.325 kPa and 298.15 K because electron configurations are not part of the program of studies.
- Replacing $\Delta H°_f$ with $\Delta_f H°$ to be consistent with IUPAC and the *CRC Handbook*.

Periodic Table Rationale

- Using the term *common ion charge* leads to some misconceptions. First, not all the elements listed on the periodic table commonly form ions; usually non-metals have a wide range of oxidation states. For example, nitrogen rarely forms an ionic compound, and it would be a misconception to think that the 3– ion is the most common charge for nitrogen. Second, the term *common* is ambiguous—does it refer to stability, existence, or classroom use? We feel the term *most stable* would be more appropriate and correct to use here.
- Include the most stable ions (or commonly used stable ions) on the periodic table, but only for elements that generally form ions, so that we do not cause any misconceptions.



Changes to the Reporting Categories

Rationale

- To make a direct reference to the program of studies in the reports
- To add more value to the reporting categories

Classification of Items

1. Instead of general learner expectations (GLEs), we will use General Outcomes (GOs) to be consistent with the new Chemistry 30 Program of Studies.

GO 1 and 2 A: Thermochemical Changes
GO 1 and 2 B: Electrochemical Changes
GO 1 and 2 C: Chemical Changes of Organic Compounds
GO 1 and 2 D: Chemical Equilibrium Focusing on Acid–Base Systems

2. Use the program of studies codes on the school reports to tag the specific Knowledge, SPC, and STS outcome that the item relates to. More than one tag may be included in the classification. For example:

Use the following information to answer the next question.

The decomposition of hydrogen iodide can be represented by the following equilibrium equation.

$$2\,HI(g) + 53.0\text{ kJ} \rightleftharpoons H_2(g) + I_2(g)$$

1. Which of the following rows identifies the equilibrium law expression for the reaction above, and the direction of the shift in equilibrium that would occur if the temperature of the system is increased?

Row	Expression	Shift
A.	$K_c = \frac{[H_2(g)][I_2(g)]}{[HI(g)]^2}$	to the right
B.	$K_c = \frac{[H_2(g)][I_2(g)]}{[HI(g)]^2}$	to the left
C.	$K_c = \frac{[H_2(g)][I_2(g)]}{[HI(g)]}$	to the right
D.	$K_c = \frac{[H_2(g)][I_2(g)]}{[HI(g)]}$	to the left

Table 7.2-4
Chemistry 30
Part B – Results, Blueprint Classifications, and Item Descriptions, by Item

Item #	% Correct Prov.	% Correct Auth.	Knowledge Outcome	Skill Outcome	STS Outcome	Item Description
9	67.9	**68.2**	**30-D1.3k**	**30-D1.3s**		Select the equilibrium law expression and direction of shift in equilibrium that would occur for a system when the temperature of the system is increased.

The specific program of studies tags that relate to the item.

3. Remove the set emphasis relating to Skills and STS (Science, Technology, and Society Connection) so that we can assign a tag if the classification is relevant to the item, rather than trying to classify items to obtain a set criteria.

Reminders and Explanations (2010-2011)

Chemistry Data Booklet

The English and French Chemistry 30 data booklets are available in PDF format on the Alberta Education website at education.alberta.ca. Printed booklets are available at a nominal cost from the Learning Resources Centre (LRC) at 12360-142 Street, Edmonton, AB T5L 4X9.

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 items, and length of time for field tests available for the 2010–2011 school year. Teachers may wish to consider this table when requesting a field test placement.

	Paper	**Digital (Online)**
Number of items (MC and NR)	20	20
Test time (min)	65	65
Administration time (min)	10	15
Total time (min)	75	80

Teachers wishing to arrange for a field test must provide an appropriate length of time for the writing and administration of the exam, according to the total times listed above.

As in past years, both unit and semester-end examinations will be available.

Type of Field Test	**Semester 1**	**Semester 2**
Unit Test (20 items)	Unit A Unit D	Unit A Unit B Unit C Unit D
End of Semester (20 items)	All units	All units

The unit field test will be administered by an examination administrator from Alberta Education on the date specified by the teacher.

Unit A: Thermochemical Changes

The following information is included to help with the implementation of the 2007 Chemistry 30 program of studies.

Calorimeter

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.

Heat of Combustion: $H_2O(l)$ or $H_2O(g)$

There appears to be some confusion as to whether a heat of combustion should form $H_2O(l)$ or $H_2O(g)$. When most substances undergo combustion, sufficient heat is released to convert any water produced from the reaction into water vapour. When heats of combustion are determined empirically, they are determined in a bomb calorimeter, and because of the low temperature change, the water produced is in liquid form. Often, a diploma examination question refers to a heat of combustion for a fuel such as propane in a barbecue or butane in a lighter. These examples represent reactions that are performed in an open environment, and students should use water vapour as a product to determine acceptable values for the heat 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 heat 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.

Phase Changes and Calorimetry

Students are **not** required to perform calorimetry calculations involving a phase change but, rather, only those involving chemical reactions. For example, we would not expect students to determine the energy released during a chemical reaction in which liquid water also undergoes a phase change. Students are also **not** required to sketch an energy diagram of a phase change.

Nuclear Reaction Types

Students are **not** required to have existing knowledge or exposure to nuclear reactions.

Enthalpy Diagrams

On the diploma examination, enthalpy diagrams will be similar to the two figures shown on this page. 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 heats 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

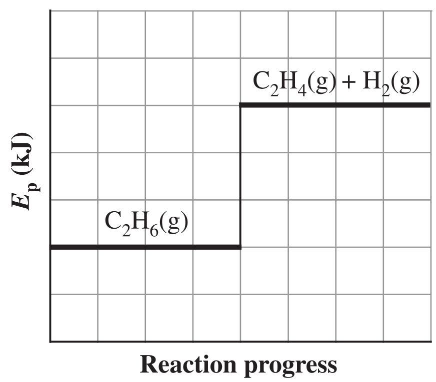
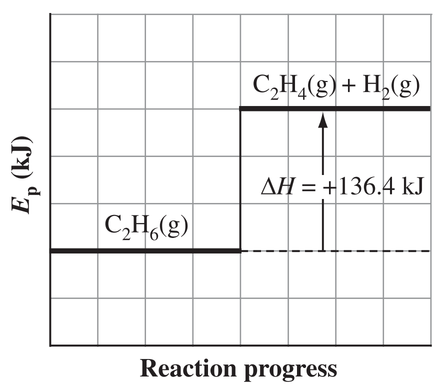


Figure 2



Unit B: Electrochemical Changes

Oxidation Number

Students should be able to determine the oxidation numbers for elements in compounds, including oxygen in peroxides and hydrogen in metal hydrides. In molecular compounds, students should be able to determine the oxidation number for binary molecular compounds and for simple organic molecules and carbohydrates such as sucrose and glucose. Students are **not** expected to be able to assign different oxidation numbers to two atoms of the same element within a compound. For example, each of the carbons in $CH_3COOH(aq)$ would be assigned an oxidation number of 0. Students are **not** expected to assign oxidation numbers to elements in molecular compounds containing a number of different elements, such as urea ($CO(NH_2)_2(s)$) or nitromethane ($CH_3NO_2(s)$). Students are expected to be able to assign oxidation numbers for simple ionic compounds, complex ions, binary acids, and oxoacids. The term *oxidation number* will be the only term used.

Balancing Electrochemical Equations

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.

Auto-oxidation versus Disproportionation

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.

Chloride Anomaly

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 values must be used cautiously when one is predicting the actual order of oxidation or reduction of species in an electrolytic cell.

Classifications

Electrochemical cells will be defined as either voltaic cells or electrolytic cells. The term *galvanic* will **not** be used on the diploma examinations.

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.

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.* 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 dies.

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

$$Fe(s) \mid Fe^{2+}(aq) \parallel MnO_4^-(aq), H^+(aq) \mid Pt(s)$$

Unit C: Chemical Changes of Organic Compounds

Use of organic compounds in question sets:

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

Use of the terms *hydrocarbon* and *hydrocarbon derivative*:

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

Use of the term *elimination reaction:*

For the diploma examination, elimination is considered a type of chemical reaction in which atoms are removed from adjacent carbons in a single reactant. This definition distinguishes this reaction type from a condensation reaction in which two molecules react and the result of their interaction produces a water molecule.

Polymerization reactions:

Knowledge of both types of polymerization reaction—addition and condensation—will be tested.

IUPAC Organic Nomenclature Update

The purpose of this section is to provide teachers of programs containing organic chemistry with updated information regarding organic nomenclature.

The International Union of Pure and Applied Chemistry (IUPAC) incorporated the following 1993 modifications into the organic naming system. The changes that were introduced affect the naming of alcohols and unsaturated hydrocarbons.

Naming of Alcohols, Alkenes, and Alkynes

The number describing the location of a multiple bond within an unsaturated hydrocarbon and the number describing the location of a functional group should be placed immediately before the part of the name to which they relate.

<u>Examples</u>

refers to the number of carbon atoms in the parent chain

i. **but-2-ene** (formerly 2-butene)

refers to the location of the multiple bond

ii. **but-1-yne** (formerly 1-butyne)

iii. **propan-2-ol** (formerly 2-propanol)

refers to the location of the hydroxyl functional group

iv. **1,2-dichloropropane** (the format for naming halogenated compounds has not changed)

v. **2-ethylbutan-1-ol** (formerly 2-ethyl-1-butanol)

The letter "e" is omitted because the first letter of the suffix is a vowel.

vi. **butane-1,4-diol** (formerly 1,4-butanediol)

vii. **4-ethyl-3-methylheptan-2-ol** (branches are named in alphabetical order; functional groups are not considered to be a branch)

Resource books may not have adopted the use of the 1993 modifications, so students are likely to be exposed to both names. The IUPAC website is available at www.iupac.org/index_to.html.

Note: To facilitate both formative and summative assessment within classrooms, teachers may accept either naming system. However, in the diploma examination, we will use the 1993 modified organic naming system shown above when referring to organic compounds in both question stems and distracters.

Saturated and Unsaturated Compounds

When determining whether a compound is saturated or unsaturated, double bonds in a functional group are not considered. For example, propanoic acid is a saturated compound because all of its carbon atoms are joined to each other by single bonds.

Aromatic Compounds

An aromatic molecule is a molecule containing one or more benzene rings.

Esters

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.

R–

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

Unit D: Chemical Equilibrium

Buffering regions on a titration curve

On a titration curve representing the titration of a weak acid with a strong base (or a strong acid with a weak base), a buffer region or 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). In terms of scoring student responses, we consider buffer regions to be only those regions on the titration curve where a buffer is present.

Equilibrium units

When writing equilibrium law expressions or calculating equilibrium constants, students are **not** required to include units. However, if students choose to include units, they must be correct and consistent. When determining the concentration of a substance from an equilibrium law expression, students are not required to use units within the expression but are required to use units in the final answer.

Example 1

$$K_c = \frac{[NO_2(g)]^2}{[NO(g)]^2 [O_2(g)]}$$

$$K_c = \frac{(0.20)^2}{(1.0)^2 (0.10)} \quad \textbf{or} \quad K_c = \frac{(0.20 \text{ mol/L})^2}{(1.0 \text{ mol/L})^2 (0.10 \text{ mol/L})}$$

$$K_c = 0.40 \qquad\qquad K_c = 0.40$$

*__Note:__ This is a case in which units do not cancel, but because we do not require units with the K_c value, students are not required to include them. Both of these responses are acceptable, and no marks for communication will be deducted.

Example 2

Given that the value of the equilibrium constant is shown as $K_c = 0.40$, the equilibrium concentration of $NO_2(g)$ is 0.20 mol/L, and the equilibrium concentration of NO(g) is 1.0 mol/L, calculate the equilibrium concentration of $O_2(g)$.

$$0.40 = \frac{(0.20)^2}{(1.0)^2 (x)}$$

$$x = [O_2(g)] = 0.10 \text{ mol/L}$$

*__Note:__ Because units are not required in the equilibrium expression, students do not need to include units until they record their final answer. However, if students choose to include units, they must be correct and consistent.

K_c and Pressure Changes

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.

If the total volume available to an equilibrium system is adjusted, the value of the equilibrium constant for that system will not change, providing there is not a corresponding 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.

Magnitude of K_c

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 one means that the products are favoured and a K_c less than one 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.

Pressure Changes and Le Châtelier's Principle

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.

Buffer Systems

Students are required to recognize that a buffer system is composed of relatively equal amounts of a conjugate acid and its base pair 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.

Amphiprotic/Amphoteric Substances

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

Amphiprotic species are species that have an ability to act as either an acid or a base: for example, $H_2PO_4^-(aq)$ or $HCO_3^-(aq)$. 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.

Weak Acid pH and Weak Base pH

Students will **not** be expected to solve questions by using the quadratic equation. However, it is expected that students set up the relationship correctly, and only when the mathematical operation is to take place is a statement about approximation to be made and used. However, this is not meant to discourage the teaching of this concept. Furthermore, students are expected to use a quadratic equation in responding to open-ended written-response questions if they select an acid for which an approximation cannot be made. No student will be penalized on any portion of the examination for using the quadratic equation to solve the problem.

The use of the approximation to solve acid–base equilibrium expressions is acceptable only when solving the 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.

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

Students are expected to know that $K_a \times K_b = K_w$.

pH Curves, Equivalence Point, and Endpoint

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.

Equilibrium Constant Expressions

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,

$$\mathrm{CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)}$$

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

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 the concentration (density) cannot be varied. For example,

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

$$K_c = \frac{[\mathrm{CH_3COO^-(aq)}][\mathrm{H_3O^+(aq)}]}{[\mathrm{CH_3COOH^-(aq)}]}$$

Mixtures of liquids must be included since the concentration can be varied by changing the relative amounts of the mixed liquids. For example,

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

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

Equilibrium and Temperature

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.

$$A(g) + B(g) \rightleftharpoons C(g) + \text{heat}$$

If the temperature of the equilibrium system above is increased, the equilibrium constant value will decrease.

Sulfuric Acid

Sulfuric acid is unique in that it is a strong acid and it is diprotic. It is important to remember it is a strong acid in its first dissociation step but a weak acid in its second dissociation step. When determining the pH of an $H_2SO_4(aq)$ sample, the second dissociation step does not significantly contribute to the hydronium ion concentration. For example, a 1.0 mol/L sample of $H_2SO_4(aq)$ cannot be used in a titration and assumed to undergo the reaction represented by the half-reaction equation

$$SO_4^{2-}(aq) + 4\,H^+(aq) + 2\,e^- \rightarrow H_2SO_4(aq) + H_2O(l) \text{ at } 0.17\text{ V}$$

because a 1.0 mol/L sample of $H_2SO_4(aq)$ would not produce 1.0 mol/L of $SO_4^{2-}(aq)$. An acidified sample of $SO_4^{2-}(aq)$ would be required for this titration.

Example Organic Questions

The example questions included are taken from the organic chemistry unit field tests that were administered to those in the field who were piloting the *Chemistry 30 Program of Studies, 2007.*

Use the following information to answer the next question.

The IUPAC names for two organic molecules are hept-2-ene and but-2-ene.

Descriptions

1	Saturated
2	Unsaturated
3	Cyclic
4	Aliphatic
5	Aromatic
6	Alkanes
7	Alkenes
8	Contains only single bonds
9	Contains single and double bonds

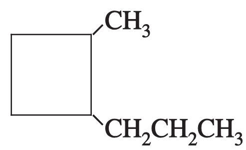
Numerical Response

1. The descriptions above that apply to both hept-2-ene and but-2-ene are numbered ______, ______, ______, and ______.

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

Use the following information to answer the next two questions.

A student drew the structural diagram shown below.

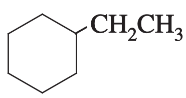


Eight-Carbon Structures

1 octane

2 oct-3-ene

3 2,3-dimethylhex-2-ene

4 

5 2-ethyl-2-methylpentane

6 1,2-dimethyl-3-propylcyclopropane

7 

1. The structural diagram that the student drew can be described as an

A. aromatic containing a four-carbon ring structure

B. aliphatic alkene containing a three-carbon parent chain

C. alkane containing a double-bonded four-carbon ring structure

D. alkane containing a four-carbon parent with only single bonds

Numerical Response

2. The eight-carbon structures above that are isomers of the structural diagram that the student drew are numbered ______, ______, ______, and ______.

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

Use the following information to answer the next question.

Compounds Containing Carbon

1	$CH_3COOH(l)$	**5**	$CH_3OH(l)$
2	$CH_3CH_3(g)$	**6**	$CaCO_3(s)$
3	$CH_2CH_2(g)$	**7**	$SiC(s)$
4	$NaCN(s)$		

Numerical Response

3. The compounds above that can be classified as organic compounds are numbered ______, ______, ______, and ______.

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

Use the following information to answer the next question.

Organic Compounds

1	3-methylcyclohexene	**4**	5-ethylhept-3-yne
2	1,2-dibromopentane	**5**	cyclopropane
3	2,2-dimethylbutane	**6**	butan-1-ol

2. The organic compounds that contain branches off the parent chain are

A. 1, 3, and 4 only

B. 1, 2, 3, and 4

C. 5 only

D. 5 and 6

3. Which of the following processes are physical processes that can be used to separate an organic compound from a natural mixture?

A. Crystallization and titration

B. Precipitation and neutralization

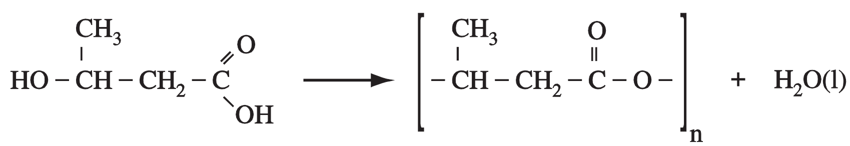
C. Hydrocarbon boiling and combustion

D. Fractional distillation and solvent extraction

Use the following information to answer the next question.

Polyhydroxybutyrate (PHB) is a biodegradable plastic. It results from the fermentation of renewable raw materials such as glucose or food scraps. Bacteria, which are added to the fermentation mixture, store energy as fat. When extracted, this bacterial fat solidifies into PHB, which is similar to traditional plastics. The preparation of PHB is represented by the equation below.

Preparation of PHB



PHB

4. *PHB is a ____**i**____, and the reactant molecule used to form PHB contains ____**ii**____ functional group.*

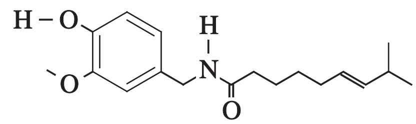
The statement above is completed by the information in row

Row	*i*	*ii*
A.	monomer	a carboxylic acid
B.	monomer	an ester
C.	polymer	a carboxylic acid
D.	polymer	an ester

Use the following information to answer the next question.

Drinking milk relieves the burning sensation that can be caused by eating chili peppers much better than drinking water. The substance responsible for the burning sensation is capsaicin. The structural diagram of capsaicin is shown below.

Capsaicin



5. The molecular formula of capsaicin is

A. $C_{18}H_{32}NO_3$

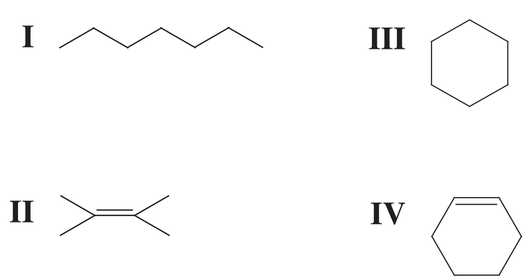
B. $C_{18}H_{29}NO_3$

C. $C_{18}H_{27}NO_3$

D. $C_{17}H_{29}NO_3$

Use the following information to answer the next question.

Line Diagrams for Some Organic Compounds



6. Which line diagrams above represent organic compounds that are structural isomers?

A. I and II only

B. I, II, III, and IV

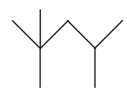
C. II and III only

D. III and IV only

Use the following information to answer the next question.

Petroleum refineries use catalytic reforming to make large molecules from smaller ones. The organic compound 2,2,4-trimethylpentane is produced using catalytic reforming and is added to gasoline to increase combustion efficiency.

2,2,4-trimethylpentane



7. Two molecules that could be used to make 2,2,4-trimethylpentane are

A. methane and hexane

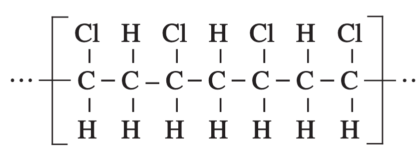
B. ethane and pentane

C. propane and 2,2-dimethylpropane

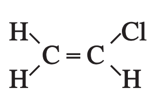
D. methylpropane and 2,2-dimethylpropane

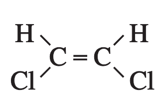
Use the following information to answer the next question.

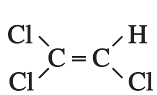
Polyvinyl chloride (PVC) is a plastic used in the manufacture of pipes, simulated leather fabrics, and structural plastics. A portion of the polymer is illustrated below.

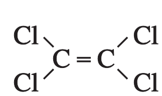


8. Which of the following structural diagrams represents the monomer used in the manufacture of PVC?

A. 

B. 

C. 

D. 

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 at education.alberta.ca by following this pathway:
For Teachers > (Additional Programs and Services) Diploma Exams > Diploma General Information Bulletin > Using Calculators & Computers.