Lester B. Pearson School Board
Commission scolaire Lester-B.-Pearson

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CHEMISTRY

Secondary 5

551-504

Theory Examination

Administration and Marking Guide

Administration and Marking Guide

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1. Presentation of the Examination

This document provides all the necessary information concerning the *Chemistry* Examination for Competency 2 for the end of Secondary Cycle 2, Year 3. This examination was developed by a group of teachers and coordinated by MaST and edited by GRICS.

The examination provides teachers with information that can help them evaluate the extent to which students have developed essential knowledge and subject-specific Competency 2 in the *Chemistry* program.

Examples of appropriate responses and marking scales are provided for each question to help teachers assess a student's level of Knowledge aquisition and Competency development.

2. Description of the Examination

2.1 General description

This examination requires students to analyze chemical phenomena and applications. Students will have to solve different problems on their own by using their knowledge of gases, energy changes in reactions, reaction rates and chemical equilibrium, which are general concepts in the *Chemistry* program.

This examination, which is worth 60 marks, includes 13 extended answer questions pertaining to four different themes.

2.2 Time allotted

- 180 minutes (3 hours)

2.3 Chemistry competencies evaluated

The examination consists of questions related to evaluation criteria associated with Competency 2. The three criteria to be considered in this examination are as follows:

- Appropriate use of concepts, laws and models of chemistry
- Relevant explanations
- Suitable justification of explanations

Note that the first criterion associated with Competency 2, *Formulation of appropriate questions*, will not be considered.

2.4 Compulsory concepts

General Concept	Compulsory Concept
Gases	Physical properties of gases • Kinetic theory of gases • General Gas law • Ideal Gas law • Dalton's Law • Avogadro's Hypothesis • Molar Volume of a Gas
Energy Changes in Reactions	Energy Diagram Activation Energy Enthalpy Change Molar Heat of reaction
Reaction rate	Factors that influence reaction rate Rate Law
Chemical Equilibrium	Factors that influence the state of equilibrium Le Chatelier's Principle Equilibrium Constant • Acidity and Alkalinity constants • Solubility-product constant Relationship between pH and the molar concentration of hydronium and hydroxide ions

2.5 Other knowledge evaluated

- Significant figures and uncertainty of measurements

  A total of 2 marks have been allocated to the consistent use of significant figures throughout the examination. A marking scale to assess the use of significant figures has been provided at the end of the marking guide in this document.

2.6 Examination documents

- Question Booklet
- Answer Booklet
- Administration and Marking Guide

2.7 Permitted materials

Only the following materials are permitted during the examination:

- Writing instruments
- Rulers
- Scientific calculator with or without graphic display

3. Procedure for Administering the Examination

3.1 Initial preparation

No initial preparation is required. You may choose to review the evaluation criteria with the students prior to examination.

3.2 Carrying out the tasks

1. Distribute the *Question Booklets* and *Answer Booklets*.
2. Review the evaluation criteria with the students and make sure they understand them.
3. Tell students they are to answer all questions individually in their *Answer Booklet*.
4. Collect all booklets at the end of the evaluation session.

4. Evaluation

4.1 Determination of final mark

The examination mark is out of 60 and can be converted to a score out of 100. The marks awarded for each question are not percentage values.

4.2 Evaluation tools

The questions that comprise this exam are scored using answer keys and marking scales, which are adapted to each question and related to three of the evaluation criteria associated with the competency. The sample answers correspond to the work expected of students if they are to earn the maximum number of marks. Parenthetical information indicated within each sample answer is not regarded as an essential part of the expected answer, but rather as a clarification or as additional information.

4.3 Marking guide

GUIDELINES FOR CORRECTING QUESTIONS

The marking scale for correcting the answers to the questions of the examination is presented below, along with explanations of the terms used in the scale.

It is **IMPORTANT** that the teacher read this information carefully before correcting the examination.

Questions usually consist of two parts: the **procedure** used to solve the problem and the **answer**. Thus, a question should be corrected in two steps.

Step 1

Analyze the work to understand the procedure used by the student, and then decide if the procedure is appropriate or not.

A **procedure** is **appropriate** if the steps presented could lead to the correct answer.

A **procedure** is **partially appropriate** if the steps presented do not lead to the correct answer, but include at least one step that is relevant and correct.

A **procedure** is **inappropriate** if none of the steps presented is relevant or if the student has not shown any work.

Step 2

If the procedure is deemed appropriate, then evaluate the answer. If the answer is incorrect, identify the type of error made.

The **error** is considered **minor** if it is an error in calculation or transcription, if the unit of measurement is incorrect or missing, or if the student has rounded off a number incorrectly.

The **error** is considered **major** if a law, rule, or formula has been applied incorrectly.

No marks are allotted for a correct answer when the procedure used is inappropriate.

4.4 Appropriate responses and marking scale

Part A: Chemistry of Aquarium Gases

Question 1

Example of appropriate responses

- The oxygen and ammonia gas molecules travel in a straight-line motion.

- The gas volumes of oxygen and ammonia are negligible.

- Collisions between oxygen and ammonia gas molecules are perfectly elastic (that is, no energy is gained or lost during the collision), and there are no attractive or repulsive forces between the oxygen and ammonia gas molecules.

- The average kinetic energy of the oxygen and ammonia gas particles depends only on the temperature of the system.

***Note**: Accept any other appropriate answer.*

Marking Scale

4 marks	All four points are stated and are correct.
3 marks	Only three points are stated and are correct.
2 marks	Only two points are stated and are correct.
1 mark	Only one point is stated and is correct.
0 marks	No correct points or no answer given.

Question 2

Example of an appropriate response

$$\text{molar mass oxygen} = 32.0\ \text{g/mol}$$
$$\text{molar mass water vapour} = 18.0\ \text{g/mol}$$
$$\text{molar mass nitrogen} = 28.0\ \text{g/mol}$$
$$\text{molar mass ammonia} = 17.0\ \text{g/mol}$$

Answer: The gases in increasing order of rates of diffusion are: O_2, N_2, H_2O, NH_3

Justification: The lower the molar mass, the higher the rate of diffusion

Marking Scale

3 marks	Justification and order is correct.
2 marks	Justification is correct but minor error in calculation of a molar mass.
1 mark	Correct order and no justification.
0 marks	Incorrect justification or no answer given.

Question 3

Example of appropriate responses

a) Partial pressure of ammonia

$$P_t = P_{O_2} + P_{H_2O} + P_{N_2} + P_{NH_3}$$
$$101.3\text{ kPa} = 36.1\text{ kPa} + 0.600\text{ kPa} + 63.3\text{ kPa} + x\text{ kPa}$$
$$P_{NH_3} = \mathbf{1.3\text{ kPa}}$$

Answer: The partial pressure of ammonia gas is 1.3 kPa.

Marking Scale	
2 marks	Appropriate procedure and correct answer.
1 mark	Appropriate procedure, but incorrect answer because of minor mistakes such as a calculation or transcription error, or an incorrect or missing unit of measure.
0 marks	Inappropriate procedure or did not show the procedure, regardless of the answer.

b) Moles of dissolved gases

Step 1: Moles of dissolved oxygen

$$PV = nRT$$
$$(36.1\text{ kPa})(0.303\text{ L}) = n\,(8.31\text{ kPa L/mol K})(298\text{ K})$$
$$n = 4.42 \times 10^{-3}\text{ mol}$$

Step 2: Moles of dissolved NH_3

$$PV = nRT$$
$$(1.3\text{ kPa})(0.303\text{ L}) = n\,(8.31\text{ kPa L/mol K})(298\text{ K})$$
$$n = 1.6 \times 10^{-4}\text{ mol}$$

Answer: There are 4.42 x 10^{-3} moles of O_2 gas and 1.6 x 10^{-4} moles of NH_3 gas.

Marking Scale	
4 marks	Appropriate procedure and correct answer.
3 marks	Appropriate procedure, but incorrect answer because of minor mistakes such as a calculation or transcription error, or an incorrect or missing unit of measure.
2 marks	Appropriate procedure but incorrect answer because of major mistakes.
1 mark	Partially appropriate procedure, regardless of the answer.
0 marks	Inappropriate procedure or did not show the procedure, regardless of the answer.

Question 4

Example of an appropriate procedure

Step 1: Moles of NH_3

$$n = c \times V$$

$$= 5.88 \times 10^{-5} \text{ mol/L} \times 40.0 \text{ L}$$

$$= 2.35 \times 10^{-3} \text{ mol NH}_3$$

Step 2: Moles of O_2

$$\frac{7 \text{ mols O}_2}{4 \text{ mols NH}_3} \times 2.35 \times 10^{-3} \text{ mol NH}_3$$

$$= 4.11 \times 10^{-3} \text{ mol O}_2$$

Step 3: Volume of O_2 (May also be solved using *PV=nRT.)*

$$1 \text{ mol SATP} = 24.5 \text{ L}$$

$$\frac{24.5 \text{ L}}{\text{mol}} \text{ at SATP} \times 4.11 \times 10^{-3} \text{ mol O}_2$$

$$= \mathbf{1.01 \times 10^{-1} \text{ L O}_2}$$

Answer: The volume of oxygen gas required is 1.01×10^{-1} L .

Marking Scale

4 marks	Appropriate procedure and correct answer.
3 marks	Appropriate procedure, but incorrect answer because of minor mistakes such as a calculation or transcription error, or an incorrect or missing unit of measure.
2 marks	Appropriate procedure but incorrect answer because of major mistakes.
1 mark	Partially appropriate procedure, regardless of the answer.
0 marks	Inappropriate procedure or did not show the procedure, regardless of the answer.

Part B: Natural Gas and Energy

Question 5

Example of an appropriate procedure

Step 1: Find *n* of butane

$$n = \text{mass} / \text{molar mass}$$
$$n = 5.8\text{ g} / 58\text{ g/mol}$$
$$n = 0.10\text{ moles of butane}$$

Step 2: Set up ratio between energy and *n* of butane

$$\frac{1\text{ mol butane}}{-2657.4\text{ kJ}} = \frac{0.10\text{ mol of butane}}{x\text{ kJ}}$$
$$x = -265.74\text{ kJ of energy released for 0.10 moles of butane}$$

Step 3

$$Q_{\text{water}} = -Q_{\text{butane}}$$
$$Q_w = +265.74\text{ kJ} = 265\,740\text{ J}$$
$$Q_w = m \times c \times \Delta T$$
$$\Delta T = Q_w / (m \times c)$$
$$\Delta T = 265\,740\text{ J} / (1000\text{ g} \times 4.19\text{ J/g°C})$$
$$\Delta T = 63.4\text{°C}$$
$$T_f = \Delta T + T_i$$
$$T_f = (63.4 + 20.0)\text{°C}$$
$$T_f = \mathbf{83°C}$$

Answer: The final temperature of the water is 83 °C.

Marking Scale

4 marks	Appropriate procedure and correct answer.
3 marks	Appropriate procedure, but incorrect answer because of minor mistakes such as a calculation or transcription error, or an incorrect or missing unit of measure.
2 marks	Appropriate procedure but incorrect answer because of major mistakes (ex. Student solved for ΔT and did not solve for T_f or students did not convert L to g and kJ to J)
1 mark	Partially appropriate procedure, regardless of the answer.
0 marks	Inappropriate procedure or did not show the procedure, regardless of the answer.

Question 6

Example of an appropriate response

Reverse Eq. #1:	CH_4 (g)	$\rightarrow$	C (s) + $2H_2$ (g)	ΔH = +74.6 kJ
Use Eq. #2:	C (s) + O_2 (g)	$\rightarrow$	CO_2 (g)	ΔH = –393.5 kJ
Double Eq. # 3:	$2H_2$ (g) + O_2(g)	$\rightarrow$	$2H_2O$ (g)	ΔH = –484 kJ
Sum:	CH_4 (g) + 2 O_2 (g)	$\rightarrow$	CO_2(g) + $2H_2O$ (g)	ΔH = –803 kJ

Answer: The molar heat of combustion of methane is **−803 kJ/mol**.

Marking Scale

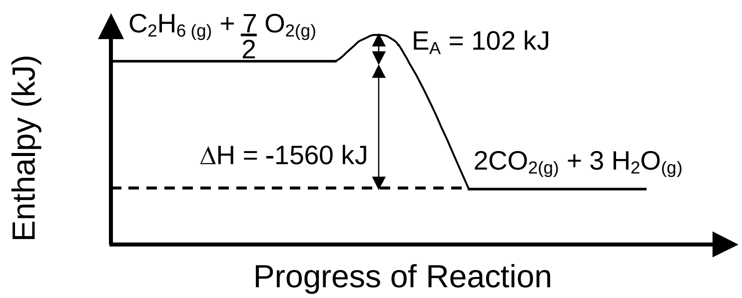
4 marks	Appropriate procedure and correct answer.
3 marks	Appropriate procedure, but incorrect answer because of minor mistakes such as a calculation or transcription error, or an incorrect or missing unit of measure.
2 marks	Appropriate procedure but incorrect answer because of major mistakes (ex. incorrect sign on the ΔH value(s).
1 mark	Partially appropriate procedure regardless of the answer.
0 marks	Inappropriate procedure or did not show the procedure, regardless of the answer.

Question 7

Example of appropriate responses

a)

Enthalpy vs. Progress of Reaction



Marking Scale	
4 marks	Appropriate and correct diagram, includes title, correctly labelled plateaus, axes and E_a, ΔH values.
3 marks	Partially appropriate diagram, omitted one out of the five components of the diagram.
2 marks	Partially appropriate diagram, but made major omissions such as forgetting two of the five components of the diagram.
1 mark	Partially appropriate diagram, provided only one or two components.
0 marks	Inappropriate diagram or did not draw a diagram.

b) ΔH = +1560 kJ

E_a = +1662 kJ

Marking Scale	
2 marks	Two correct answers.
1 mark	One correct answer.
0 marks	No correct answers or no answer given.

Part C: Reaction Rates and the Human Body

Question 8

Example of appropriate responses

a) 75 kg man:

$$\text{moles } O_2 = \frac{\text{mass } O_2}{\text{molar mass } O_2}$$

$$\text{moles } O_2 = \frac{3.5 \text{ g}}{32 \text{ g/mol}}$$

$$\text{moles } O_2 = 0.109 \text{ moles}$$

moles of glucose :

$$\text{glucose} : O_2 = 1 : 6$$

$$\text{moles glucose} = \frac{\text{moles } O_2}{6} = \frac{0.109 \text{ moles}}{6} = 0.018 \text{ moles}$$

100 kg man:

$$\text{moles } O_2 = \frac{\text{mass } O_2}{\text{molar mass } O_2}$$

$$\text{moles } O_2 = \frac{4.2 \text{ g}}{32 \text{ g/mol}}$$

$$\text{moles } O_2 = 0.131 \text{ moles}$$

moles of glucose :

$$\text{glucose} : O_2 = 1 : 6$$

$$\text{moles glucose} = \frac{\text{moles } O_2}{6} = \frac{0.131 \text{ moles}}{6} = 0.022 \text{ moles}$$

Answer: **The 75 kg man uses 0.018 moles of glucose in 10 minutes.**
The 100 kg man uses 0.022 moles of glucose in 10 minutes.

Note: *There are two different thoughts on the ambiguous zero (significant figures). Please correct your students work based on your teachings.*

Marking Scale	
4 marks	Appropriate procedure and correct answer.
3 marks	Appropriate procedure but incorrect answer because of minor mistakes such as a calculation or transcription error, or an incorrect or missing unit of measure.
2 marks	Appropriate procedure but incorrect answer because of major mistakes.
1 mark	Partially appropriate procedure and incorrect answer.
0 marks	Inappropriate procedure and incorrect answer.

b) Rate law expression is **Rate = k[$C_6H_{12}O_6$] [O_2]^6.**

Marking Scale	
2 marks	Correctly states the rate law expression.
1 mark	Does not apply.
0 marks	Incorrectly states rate law expression.

c) **There are no differences in the rate law expression because both are derived from the cellular respiration equation.**

Marking Scale	
2 marks	Correct answer and justification.
1 mark	Correct answer without any justification.
0 marks	Incorrectly compares rate law expressions.

Question 9

Example of an appropriate response

- Use powdered marble chips (calcium carbonate).
  Increasing the surface area increases the probability of effective collisions.

- Increase the concentration of HCl.
  Increasing the concentration of HCl increases the probability of effective collisions.

- Heat HCl solution.
  Increasing the temperature of the reactants increases the kinetic energy of the reactants and therefore increases the probability of effective collisions and the probability that the collisions will have sufficient energy for a transformation to take place.

- Add a catalyst.
  The catalyst reduces the activation energy barrier for the reaction and therefore increases the probability of effective collisions.

Marking Scale

3 marks	Three correct methods with appropriate use of collision theory are provided.
2 marks	Two correct methods with appropriate use of collision theory are provided.
1 mark	One correct method with appropriate use of collision theory is provided OR three correct methods, but did not use collision theory.
0 marks	Answers are incorrect.

Part D: Chemical Equilibrium in the Blood

Question 10

Example of appropriate responses

a) At high altitudes, there is less oxygen in the air. The stress of a reduced oxygen concentration results in a shift in equilibrium to the reactant side, which lowers the concentration of oxyhemoglobin, HbO_2.

Marking Scale	
1 mark	Correct answer.
0 marks	Incorrect answer or no answer given.

b) Put the athlete in an environment with an increased concentration of oxygen, which will alleviate the stress, and re-establish a new equilibrium.

Marking Scale	
1 mark	Correct answer.
0 marks	Incorrect answer or no answer given.

Question 11

a) **Example of an appropriate response**

$H_2CO_{3(aq)} \rightleftharpoons H^+_{(aq)} + HCO^-_{3(aq)}$

$$K_a = \frac{[H^+][HCO_3^-]}{H_2CO_3}$$

$$7.94 \times 10^{-7} = \frac{[H^+](2.77 \times 10^{-2})}{1.10 \times 10^{-3}}$$

$$[H^+] = 3.15 \times 10^{-8} \text{ mol/L}$$

$$pH = 7.50$$

Answer: The athlete is suffering from alkalosis.

Note: *As this is the second part of a two part equilibrium reaction, the bicarbonate ion concentration at equilibirum is not equal to the hydrogen ion concentration at equilibrium.*

Marking Scale	
4 marks	Appropriate procedure and correct answer.
3 marks	Appropriate procedure but incorrect answer because of minor mistakes such as a calculation or transcription error, or an incorrect or missing unit of measure.
2 marks	Appropriate procedure but incorrect answer because of major mistakes.
1 mark	Partially appropriate procedure and incorrect answer.
0 marks	Inappropriate procedure and incorrect answer.

b) **Example of an appropriate response**

Decrease the bicarbonate ion (HCO_3^-) concentration in the blood. Decreasing the blood's concentration of HCO_3^- shifts the equilibrium reaction toward the right to compensate for the loss in HCO_3^-. When the equilibrium shifts to the right, more H^+ ions are generated together with HCO_3^- ions. As a result, the pH decreases.

Marking Scale	
2 marks	Correct answer.
1 mark	Partially correct answer (ex. does not explain how removal of bicarbonate ion affects blood).
0 marks	Incorrect answer or no answer given.

Question 12

Example of an appropriate procedure

Calculation of fluoride ion concentration in the water

$$K_{sp} = [Ca^{2+}][F^-]^2$$
$$3.9 \times 10^{-11} = (x)(2x)^2$$
$$x = \frac{\sqrt[3]{(3.9 \times 10^{-11})}}{4}$$
$$x = 2.1 \times 10^{-4} \text{ mol/L } (Ca^{2+})$$
$$[F^-] = 2 \times 2.1 \times 10^{-4} \text{ mol/L}$$
$$[F^-] = 4.2 \times 10^{-4} \text{ mol/L}$$

Answer: The fluoride ion concentration is 4.2×10^{-4} mol/L.

Marking Scale

4 marks	Appropriate procedure with correct answer.
3 marks	Appropriate procedure but incorrect answer because of minor mistakes such as a calculation or transcription error, or an incorrect or missing unit of measure.
2 marks	Appropriate procedure and incorrect answer because of major mistakes.
1 mark	Partially appropriate procedure but incorrect answer.
0 marks	Inappropriate procedure and incorrect answer.

Question 13

Example of appropriate responses

The volume and uncertainty of measurement of gas in the syringe A is **15 mL ± 5 mL**.

The volume and uncertainty of measurement of gas in the syringe B is **15.0 mL ± 0.5 mL**.

Marking Scale

4 marks	Volume of both gases correct with correct significant figures and correct uncertainty.
3 marks	One error involving significant figures or uncertainty.
2 marks	Two errors involving significant figures or uncertainty.
1 mark	Three errors involving significant figures or uncertainty.
0 marks	Incorrect answer or no answer given.

Marking Guide for Significant Figures (for consistent use during the entire exam)

Use this marking scale to assess the use of significant figures throughout the first 12 questions of the examination. Do not take into account work from question 13 for this mark.

Marking Scale

2 marks	Appropriate and consistent use of significant figures.
1 mark	Partially appropriate use of significant figures and/or inconsistent use of significant figures.
0 marks	Inappropriate use of significant figures or does not take into account significant figures.

Feedback Questionnaire

Chemistry Examination – Secondary Cycle 2 Year 3
Theory Examination – June 2011

Please comment on the following:

1. Time allotted for theory examination:

2. Students' level of interest:

3. Level of difficulty:

4. Administration and Marking Guide (quality and clarity):

5. Other comments:

6. Please list any errors or omissions:

Please return questionnaire to your school board Science and Technology consultant.
Thank You.