

Chemistry Examination – 551-504

Secondary Cycle Two Year Three

June 2010

The Chemistry of Science

| | | | | | |
|---|---|---|---|---|-------------------------|
| Competency 2: Makes the most of his/her knowledge of Chemistry | | | Competency 3: Communicates ideas relating to questions involving chemistry, using the languages associated with science and technology | | |
| <i>Questions</i> 1.1 / 2.1 / 3.1 / 3.3 | <i>Questions</i> 1.2 / 3.2 / 3.3 / 4.3 / 4.4 / 5.1 | <i>Questions</i> 1.1 / 2.1 / 3.1 / 4.1 / 4.2 | <i>Questions</i> 1.1 / 3.1 / 4.1 / 4.2 | <i>Questions</i> 1.2 / 2.1 / 3.2 / 3.3 | <i>Questions</i> 5.1 |
| Cr2: _____ | Cr3: _____ | Cr4: _____ | Cr1: _____ | Cr2: _____ | Cr3: _____ |
| Overall Evaluation: | | | Overall Evaluation: | | |

Student Booklet

Name : _____

Group : _____

Time: 3 hours



The following criteria will be used to evaluate your level of competency development in the different situations presented in this booklet.

| Evaluation Criteria |
|---|
| Competency 2: Makes the most of his/her knowledge of Chemistry |
| Cr2 – Appropriate use of the concepts, laws and models of Chemistry |
| Cr3 – Relevant explanations |
| Cr4 – Suitable justification of explanations |

| Evaluation Criteria |
|---|
| Competency 3: Communicates ideas relating to questions involving chemistry, using the languages associated with science and technology |
| Cr1 – Accurate interpretation of scientific or technological messages |
| Cr2 – Appropriate production or sharing of scientific or technological messages |
| Cr3 – Use of appropriate scientific and technological terminology, rules and conventions |



Instructions

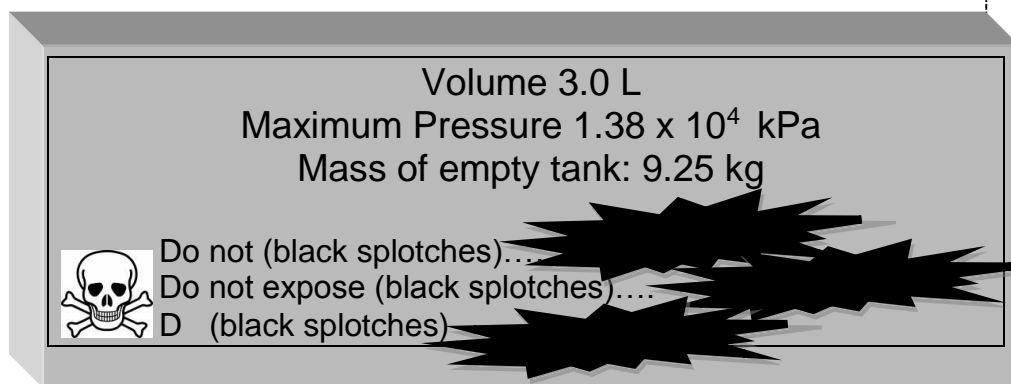
1. Write the required information on the title page of the Student Booklet.
2. This booklet contains 5 sections.
3. Answer all questions in this Student Booklet.
4. You may use drawing instruments, graph paper, and a scientific calculator with or without graphic display.
5. You may refer to the lists of formulas and quantities included in the Appendix to this Student Booklet. The use of any other reference material is **strictly** forbidden.
6. The rules of significant figures should be applied to all final statements.

Note: Figures are not necessarily drawn to scale.



Section 1 – Oxygen Daytrip

Samuel has emphysema. Emphysema is a chronic lung disease that affects many long-term smokers. One form of treatment is oxygen therapy, whereby a person receives oxygen through a tube into their nose. Of course, no one likes to be confined to their home; so many people will buy portable oxygen tanks for daytrips. They must, however, make sure not to run out of oxygen before they get home. Below is the information found on Samuel's oxygen tank:



Assume:

1. Oxygen behaves ideally for all questions.
2. Oxygen has a constant temperature of 25°C .
3. Oxygen leaves the tank at an atmospheric pressure of 101.3 kPa.

| | DAY TRIP 1: Thousand Islands Discovery Boat Tour | DAY TRIP 2: Walking Tour-Old Montreal |
|--|---|--|
| Length of the tour | 3.0 hours | 2.5 hours |
| Length of commute to the tour location | 1.75 hours each way | 0.5 hours each way |
| Oxygen-rate requirement | 1.0 L/minute | 2.0 L/minute |
| Maximum mass of luggage allowed | 10.0 kg | no restrictions |

QUESTIONS

- 1.1 Samuel and his wife are planning on going on an daytrip for his birthday. They are debating between two daytrips: the Thousand Islands Discovery Boat Tour, and the Walking tour of Old Montreal. They have two concerns:
- a) Will Samuel have enough oxygen to last through the daytrip?
 - b) Will Samuel oxygen tank be too heavy?

Based on the information given which tour should the couple choose? Please provide all relevant data for BOTH tours.

- 1.2 Samuel notices that the precautions on the label of his tank have been scratched out. In order to be safe on any daytrip, it is important to be aware of the safety precautions.

What are two pertinent precautions that should be present on any high-pressure gas tank? Explain clearly using collision theory and any relevant gas laws.



Question 1.1

Show all your work



Question 1.1

Show all your work (con't)

Circle the correct answer. Then enter which daytrip Samuel should choose.

Daytrip 1:

Samuel will / will not have enough oxygen to last through this daytrip.
His oxygen tank will / will not exceed the maximum mass limit for this daytrip.

Daytrip 2:

Samuel will / will not have enough oxygen to last through this daytrip.
His oxygen tank will / will not exceed the maximum mass limit for this daytrip.

Samuel should choose daytrip number _____.

Competency 2.2 Appropriate use of the concepts, laws and models of chemistry

Competency 2.4 Suitable justification of explanations

Competency 3.1 Accurate interpretation of scientific or technological messages

| | | | | |
|---|---|---|---|---|
| 5 | 4 | 3 | 2 | 1 |
| 5 | 4 | 3 | 2 | 1 |
| 5 | 4 | 3 | 2 | 1 |



Question 1.2

Precaution 1: _____

Precaution 2: _____



Section 2 – Brrr ... cold! Ouch ... hot!



Hot packs and cold packs are often used to treat injuries to the body. Hot packs provide instant heat when applied to the body. This promotes increased blood flow to the tissues, before physical activity which can reduce the risk of injury. Cold packs are typically used after physical activity to reduce swelling to injured areas of the body.

Both hot and cold packs operate on similar principles. Inside the pack, a soluble substance, typically a salt, is stored along with some water. The salt is physically separated from the water by a thin plastic layer. When the pack is crushed, the plastic layer inside breaks and the salt dissolves in the water. Depending on the nature of the salt, heat is either absorbed or released.

A manufacturer of these packs has asked you to analyze three substances to determine their possible usefulness in hot packs and cold packs; sodium chloride (NaCl), calcium chloride (CaCl_2), and ammonium nitrate (NH_4NO_3).

QUESTION

- 2.1 Based on your analysis, recommend the salt(s) which would be useful in the hot pack and cold pack. Your answer should include ΔH values, a sketch of the enthalpy graphs, and the type of reaction (exothermic/endothermic). Present your findings in the form of a table.

PLEASE NOTE that further information is provided on the following page.



Sodium Chloride (NaCl)

Dissolution of sodium chloride ($\text{NaCl}_{(s)}$) is described by the following reaction:



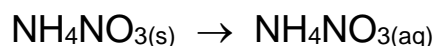
Calcium chloride (CaCl_2)

You dissolved some calcium chloride ($\text{CaCl}_{2(s)}$) in a calorimeter and measured the change in temperature. You obtained the following results:

| | |
|--|--|
| Mass of $\text{CaCl}_{2(s)}$ dissolved | 8.00 g |
| Volume of water | $5.00 \times 10^{-2} \text{ L}$ |
| Initial temperature of the water | $22.0 \text{ }^\circ\text{C}$ |
| Final temperature of the water | $50.5 \text{ }^\circ\text{C}$ |
| Specific heat of water | $\frac{4.19 \text{ J}}{\text{g}\cdot^\circ\text{C}}$ |

Ammonium nitrate (NH_4NO_3)

Dissolution of ammonium nitrate ($\text{NH}_4\text{NO}_{3(s)}$) in water is described by the following reaction:



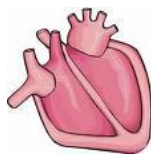
In a chemistry reference book, you find the following information:

| | ΔH (kJ/mol) |
|--|---------------------|
| $\frac{1}{2} \text{N}_{2(g)} + \frac{3}{2} \text{H}_{2(g)} \rightarrow \text{NH}_{3(aq)}$ | - 81.17 |
| $\frac{1}{2} \text{N}_{2(g)} + \frac{1}{2} \text{H}_{2(g)} + \frac{3}{2} \text{O}_{2(g)} \rightarrow \text{HNO}_{3(aq)}$ | - 206.0 |
| $\text{NH}_{3(aq)} + \text{HNO}_{3(aq)} \rightarrow \text{NH}_4\text{NO}_{3(aq)}$ | - 52.6 |
| $\text{N}_{2(g)} + 2\text{H}_{2(g)} + \frac{3}{2} \text{O}_{2(g)} \rightarrow \text{NH}_4\text{NO}_{3(s)}$ | - 365.6 |



Show all your work

A large grid of graph paper, consisting of 20 columns and 30 rows of small squares, intended for students to show their work on a problem.



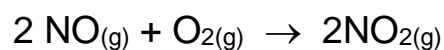
Section 3 – Healthy Heart

Nitrogen monoxide (NO) is a gas that occurs naturally in the body of many mammals, including humans. Research has shown that it can actually do more than many prescription drugs do to prevent heart attacks and strokes.

NO is essential for healthy blood circulation. It helps dilate blood vessels, prevent blood clots and regulate blood pressure. It also helps inhibit the accumulation of dangerous arterial plaque. By expanding blood vessels, NO protects the smooth muscle tissue of the blood vessels from harmful constriction. This allows for the flexibility necessary for blood to circulate with less pressure.

Arginine is an enzyme that can be taken in pill form to increase dilation of the blood vessels. It does this by acting as a catalyst in the endothermic reaction which produces NO.

NO cannot be stored in our body and therefore it combines with oxygen (O₂) to produce nitrogen dioxide (NO₂) which can then be excreted from the body.



QUESTIONS

3.1 Students obtained the following data from a laboratory experiment:

| | Initial [NO] mol/L | Initial [O ₂] mol/L | Rate of production of NO ₂ mol L ⁻¹ s ⁻¹ |
|----------------|-----------------------|------------------------------------|---|
| Trial 1 | 0.010 | 0.010 | 2.5×10^{-5} |
| Trial 2 | 0.020 | 0.010 | 1.0×10^{-4} |
| Trial 3 | 0.010 | 0.020 | 5.0×10^{-5} |

- a) Calculate the rate of reaction when the [NO] = 0.015 mol L⁻¹ and the [O₂] = 0.0050 mol L⁻¹.
- b) If NO is reacting at a rate of 1.0×10^{-4} mol L⁻¹s⁻¹, what is the rate at which O₂ is reacting and NO₂ is forming?
- 3.2 Referring to question 1, use the collision theory to explain how the rate of formation changes in the following situations:
- a) When the concentration of O₂ is decreased.
- b) When the temperature is increased.



3.3 Blood analysis was performed on two different individuals and the following data was obtained.

Individual 1

| | | | | |
|-----------------------------|----|----|----|----|
| Volume of NO collected (mL) | 10 | 20 | 30 | 40 |
| Time (s) | 1 | 2 | 3 | 4 |

Individual 2

| | | | | |
|-----------------------------|---|---|---|---|
| Volume of NO collected (mL) | 2 | 3 | 4 | 5 |
| Time (s) | 1 | 2 | 3 | 4 |

- a) Using the tables above, graph the reaction rate curves for the production of NO for the two individuals. Indicate which curve represents the individual who would have taken the arginine pill. Justify your answer.
- b) Sketch the shape of the enthalpy diagrams for the reaction in which an individual would have taken the arginine pill and in which an individual would not have taken the arginine pill. Justify your answer.



Question 3.1

Show all your work



Question 3.1

Show all your work (con't)

a) The rate of reaction is: _____

b) The rate at which O₂ is reacting is: _____

The rate at which NO₂ is forming is: _____

Competency 2.2 Appropriate use of the concepts, laws and models of chemistry

Competency 2.4 Suitable justification of explanations

Competency 3.1 Accurate interpretation of scientific or technological messages

| | | | | |
|---|---|---|---|---|
| 5 | 4 | 3 | 2 | 1 |
| 5 | 4 | 3 | 2 | 1 |
| 5 | 4 | 3 | 2 | 1 |



Question 3.2

a)

b)

Competency 2.3 Relevant explanations

Competency 3.2 Appropriate production or sharing of scientific or technological messages

| | | | | |
|---|---|---|---|---|
| 5 | 4 | 3 | 2 | 1 |
| 5 | 4 | 3 | 2 | 1 |



Section 4 – Doctor Patient Confidentiality



Medical consultation Patient X – Doctor's Notes

Digestion

Complaint 1: A patient complains of burning sensation in his chest area after eating.

Possible Cause

Epithelial stomach cells are not secreting sufficient bicarbonate-rich solution to neutralize the excess acid that is being produced. Bicarbonate is alkaline and neutralizes the acid.

Test Results

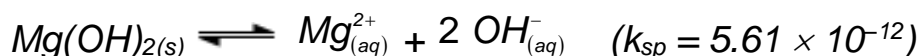
| | pH of stomach acid |
|----------------------|--------------------|
| Before eating | 4.20 |
| After eating | 2.10 |

Self Treatments

Patient has been self medicating with either Milk of Magnesia or Tums.

Did you know?

Milk of MagnesiaTM: Often used to treat acid reflux (when liquid content of the stomach moves back into the esophagus). The active ingredient is the hydroxide ion (OH^-).



TumsTM: Often used to treat acid reflux. The active ingredient is the bicarbonate ion (HCO_3^-) which can, if taken in high doses, affect blood pH.



Blood is a buffered solution. This is because small changes in blood pH can significantly affect a person's health. If the pH of blood is below 7.35, the condition is called ACIDOSIS. If the pH of the blood is higher than 7.45, the condition is called ALKALOSIS.

Respiration

Complaint 2: A patient complains of panic attacks accompanied by hyperventilation (rapid uncontrollable breathing). This results in a decrease in blood CO₂ concentration.

Self Treatment:

Breathing into a paper bag.

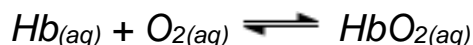
Complaint 3: A patient complains of chronic fatigue.

Possible cause

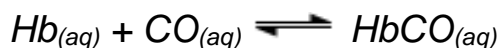
It was recently discovered that there was a small amount of carbon monoxide gas (CO_(g)) leaking into his home. Chronic fatigue can be a symptom of exposure to small amounts of CO_(g).

Did you know?

Oxygen combines with hemoglobin in the red blood cells to produce oxyhemoglobin (HbO₂). The equilibrium reaction is as follows:



Carbon monoxide (CO) is a poisonous gas which is produced in many combustion reactions. It can be lethal and produces carboxyhemoglobin (HbCO):



During respiration, CO preferentially bonds with hemoglobin. The equilibrium constant is 200 times greater for carbon monoxide.



QUESTIONS

As a first year medical student you have been asked to complete the doctor's notes by answering the following questions.

- 4.1 The hydrogen ion concentration changes in the stomach during digestion. Calculate the change in hydrogen ion concentration.
- 4.2 Milk of Magnesia relieves the symptoms of acid reflux. Calculate the pH value for the chemical equation. Explain how this relieves the patient's digestion symptoms.
- 4.3 The pH of the patient's stomach acid will be affected by the use of Tums. Explain how Tums produces this effect. (Be sure to analyze the chemical equations given and name any conditions that will result).
- 4.4 Explains using scientific principles how a small quantity of $\text{CO}_{(g)}$ can affected the patient.



Question 4.1

Show all your work

The hydrogen ion concentration _____ by a factor of _____.



Question 4.2

Show all your work

pH: _____

Explanation: _____

Competency 2.4 Suitable justification of explanations

Competency 3.1 Accurate interpretation of scientific or technological messages

| | | | | |
|---|---|---|---|---|
| 5 | 4 | 3 | 2 | 1 |
| 5 | 4 | 3 | 2 | 1 |





Section 5 – So What Do You Think?

The governing board of your school is thinking of cutting down the number of chemistry periods per cycle. As a part of the graduating chemistry class, you have been asked to determine which two units of the chemistry course can be most readily applied to real life and therefore should be kept for the following year.

Write a letter to the governing board in which you detail which two units you deem to be most relevant and why.

The units covered this year were:

1. Gas Laws
2. Thermochemistry
3. Reaction Rates
4. Chemical Equilibrium

Provide at least 3 arguments for each unit you decide to keep. Include real life examples with explanations using proper scientific terminology.



Lined writing area for student response.



Competency 2.3 Relevant explanations

Competency 3.3 Use of appropriate scientific and technological terminology,
rules and conventions

| | | | | |
|---|---|---|---|---|
| 5 | 4 | 3 | 2 | 1 |
| 5 | 4 | 3 | 2 | 1 |



FORMULAS

$$Q = mc\Delta T$$

$$PV = nRT$$

$$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

PHYSICAL CONSTANTS

| SYMBOL | NAME | VALUE |
|---------------|---------------------------------|------------------------------------|
| c_{H_2O} | Specific heat capacity of water | 4190 J/(kg•°C) or 4.19 J/(g•°C) |
| ρ_{H_2O} | Density of water | 1.00 g/mL |
| R | Molar gas constant | 8.31 kPa • L/(mol•K) |



Competency 2: Makes the most of his/her knowledge of chemistry

| Evaluation Criteria | 5 | 4 | 3 | 2 | 1 |
|---|---|--|---|---|--|
| Appropriate use of the concepts, laws and models of chemistry (Cr. 2) | <p>Applies the appropriate principles of chemistry underlying the phenomenon or application.</p> <p>When required, draws diagrams appropriately following the laws and conventions of chemistry (enthalpy diagrams, rate curves, etc.).</p> <p>Uses concepts, laws and theories of chemistry.</p> | <p>Applies the appropriate principles of chemistry underlying the phenomenon or application.</p> <p>When required, draws diagrams appropriately following the laws and conventions of chemistry (enthalpy diagrams, rate curves, etc.).</p> <p>Uses concepts, laws and theories of chemistry.</p> <p>There is a minor omission and/or mistake in the above.</p> | <p>Applies the principles of chemistry underlying the phenomenon or application.</p> <p>When required, draws diagrams following the laws and conventions of chemistry (enthalpy diagrams, rate curves, etc.).</p> <p>Uses concepts, laws and theories of chemistry</p> <p>There is a major omission and/or mistake in the above.</p> | <p>Applies the principles of chemistry underlying the phenomenon or application.</p> <p>When required, draws diagrams following the laws and conventions of chemistry (enthalpy diagrams, rate curves, etc.).</p> <p>Uses concepts, laws and theories of chemistry.</p> <p>There are major omissions and/or mistakes in the above.</p> | <p>Makes use of principles that are entirely inappropriate or does not use principles of chemistry to explain a phenomenon or application.</p> <p>When required, draws diagrams that are incorrect or does not draw diagrams when required to.</p> <p>Uses concepts, laws and theories of chemistry that are incorrect or does not use any when required to.</p> |
| Relevant explanations (Cr. 3) | <p>Produces clear and detailed explanations based on established principals of chemistry.</p> <p>Identifies the effects of a phenomenon coherently and completely.</p> | <p>Produces correct explanations based on established principles of chemistry.</p> <p>Identifies correctly most of the effects of a phenomenon.</p> | <p>Provides explanations based on established principles of chemistry.</p> <p>Identifies the effects of a phenomenon.</p> <p>There is a major omission and/or mistake in the above.</p> | <p>Provides explanations based on established principles of chemistry.</p> <p>Identifies the effects of a phenomenon.</p> <p>There are major omissions and/or mistakes in the above.</p> | <p>Does not include explanations based established principles of chemistry.</p> <p>Does not identify the effects of a phenomenon.</p> <p>Copies out information related to the phenomenon or application.</p> |
| Suitable justification of explanations (Cr. 4) | <p>Mathematical formalism: uses an appropriate procedure throughout that leads to the correct answer.</p> <p>Applies significant figures appropriately throughout.</p> | <p>Mathematical formalism: uses an appropriate procedure but has a minor error (see below):</p> <p>Applies significant figures with a minor error or has an error in calculation or transcription, if the unit of measurement is incorrect, or mission or if the student has rounded off a number incorrectly.</p> | <p>Mathematical formalism: uses a partially appropriate procedure but has a major error (see below):</p> <p>Applies significant figures with [a few errors a law, rule, or formula has been applied incorrectly].</p> | <p>Mathematical formalism: partially inappropriate procedure with major errors.</p> <p>applies significant figures with many errors.</p> | <p>Mathematical formalism: inappropriate procedure with or without correct answer.</p> <p>Does not apply significant figures or does so inappropriately.</p> |

Note: Significant figures have been included in Cr. 4 because they are most likely to accompany mathematical formalisms. This being said, significant figures are not exclusive to Cr. 4 and should be taken into account there application is relevant to other criteria.

Competency 3: Communicates ideas relating to questions involving chemistry, using the languages associated with science and technology

| Evaluation Criteria | 5 | 4 | 3 | 2 | 1 |
|---|--|--|--|--|--|
| Accurate interpretation of scientific or technological messages (Cr. 1) | <p>Selects the appropriate elements from the message (i.e. text) needed to complete the task.</p> <p>Describes the elements selected accurately.</p> <p>Uses complementary elements to enhance the quality of communication.</p> | <p>Selects the appropriate elements from the message (i.e. text) needed to complete the task.</p> <p>Describes the elements selected accurately.</p> <p>There is a minor omission and/or mistake in the above.</p> | <p>Selects the appropriate elements from the message (i.e. text) needed to complete the task.</p> <p>Describes the elements selected accurately.</p> <p>There is a major omission and/or mistake in the above.</p> | <p>Selects the elements from the message (i.e. text) needed to complete the task.</p> <p>Describes the elements selected.</p> <p>There are major omissions and/or mistakes in the above.</p> | <p>Copies out information found in the message to be interpreted (i.e. text).</p> <p>Does not describe important elements.</p> |
| Appropriate production or sharing of scientific or technological messages (Cr. 2) | <p>Selects an appropriate means of representation.</p> <p>Organizes the elements of the message correctly.</p> <p>Conveys the message clearly.</p> <p>Keeps target audience in mind.</p> <p>Uses everyday language.</p> | <p>Selects an appropriate means of representation</p> <p>Organizes the elements of the message correctly</p> <p>Conveys the message clearly</p> <p>Keeps target audience in mind</p> <p>Uses everyday language</p> <p>There is a minor omission and/or mistake in the above</p> | <p>Selects an appropriate means of representation.</p> <p>Organizes the elements of the message correctly.</p> <p>Conveys the message clearly.</p> <p>Keeps target audience in mind.</p> <p>Uses everyday language.</p> <p>There is a major omission and/or mistake in the above.</p> | <p>Selects a means of representation that is largely inappropriate.</p> <p>Conveys a message that is not adapted to a target audience and is largely unclear and disorganized.</p> | <p>Does not use an appropriate means of representation.</p> <p>Conveys a message that is unfounded, disorganized and difficult to understand.</p> |
| Use of appropriate scientific and technological terminology, rules and conventions (Cr. 3) | <p>Makes judicious and rigorous use of scientific and technological terminology, rules, and conventions.</p> <p>Presents data in tables, graphs or diagrams in clear, organized and efficient manner.</p> | <p>Uses appropriate scientific and technological terminology, rules, and conventions for all concepts.</p> <p>Uses appropriate means of presentation to display data in tables, graphs or diagrams.</p> <p>There is a minor omission and/or mistake in the above.</p> | <p>Uses appropriate scientific and technological terminology, rules, and conventions for the simplest concepts.</p> <p>Uses appropriate means of presentation to display data in tables, graphs or diagrams.</p> <p>There is a major omission and/or mistake in the above.</p> | <p>Uses basic terminology.</p> <p>Shows some concern for rules and conventions.</p> <p>Displays some data in tables, graphs or diagrams.</p> <p>There are major omissions and/or mistakes in the above.</p> | <p>Uses inappropriate terminology.</p> <p>Does not show concern for rules and conventions.</p> <p>Does not display data in tables, graphs or diagrams.</p> |