Lester B. Pearson School Board

Commission scolaire Lester-B.-Pearson

2013

CHEMISTRY

Secondary 5
551-504

this was an August supplemental + therefore not checked for mistakes the way a June exam is!

Supplemental Theory Examination

Student Booklet

question 12 = buffers = not on June exam
question 14 = bad question as per Griffin + Cormier

GRICS BIM

Part A
Multiple Choice Questions

Questions 1 to 7

Answer all questions in the ***Answer Booklet***.

Each question is worth 4 marks.

Question 1

Air is a common term for the atmosphere. This layer of nitrogen, oxygen and other trace gases that surrounds our planet makes life on Earth possible.

The main gases found in air are listed below.

N_2 O_2 H_2O H_2 CO_2

Which of the following combination ranks these gases from the fastest to slowest in ability to diffuse?

A) CO_2, O_2, N_2, H_2O, H_2

B) CO_2, H_2O, O_2, N_2, CO_2

C) H_2, N_2, H_2O, O_2, CO_2

D) H_2, H_2O, N_2, O_2, CO_2

Question 2

A tire for compact size cars can be about 220 kPa.

P_T

A tire for a compact size car was filled with air to a pressure of 220kPa. Air is composed of 21% oxygen.

What is the partial pressure of oxygen gas in car tires?

A) 46.2 kPa

B) 110 kPa

C) 172 kPa

D) 220 kPa

$0.21 \times 220\ kPa = P_{O_2}$ partial pressure O_2

$= 46.2\ kPa$

Question 3

The decomposition of nitrogen dioxide , NO_2, is a reversible reaction that can occur with or without a catalyst.

The diagram below illustrates the enthalpy changes during the decomposition of nitrogen dioxide with and without a catalyst.

Enthalpy Changes for Decomposition of Nitrogen Dioxide

$2NO_{2(g)} \rightarrow N_{2(g)} + 2O_{2(g)}$

1 2 3
E_A for cat

Which of the following correctly states the activation energy for the forward catalyzed reaction, and the ΔH of the reverse uncatalyzed reaction?

ΔH rev uncat
1 2 3

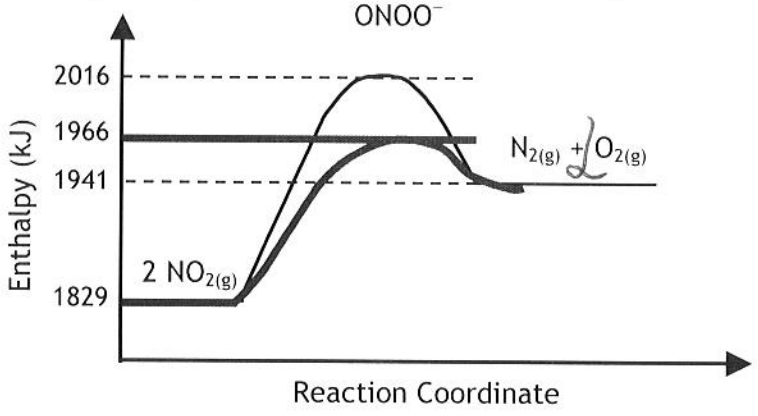
A) The activation energy for the forward catalyzed reaction is 187 kJ.
The ΔH of the reverse uncatalyzed reaction is 112 kJ.

B) The activation energy for the forward catalyzed reaction is 137 kJ.
The ΔH of the reverse uncatalyzed reaction is –112 kJ.

C) The activation energy for the forward catalyzed reaction is 137 kJ.
The ΔH of the reverse uncatalyzed reaction is –132 kJ.

D) The activation energy for the forward catalyzed reaction is 25 kJ.
The ΔH of the reverse uncatalyzed reaction is 132 kJ.

Enthalpy Changes for Decomposition of Nitrogen Dioxide



Question 4

Michael added a drain cleaner to the water in a clogged sink. He noticed that heat was released and that the accumulated grease in the pipes melted.

Sodium hydroxide (NaOH) is the main ingredient in drain cleaners.

The balanced equation for the dissolution of sodium hydroxide is shown below.

$$NaOH_{(s)} \rightarrow Na^{+}_{(aq)} + OH^{-}_{aq)} + 42.0\ kJ$$ exo!

What mass of sodium hydroxide is required to produce 1.00×10^4 J of heat?

A) 5.95×10^{-3} g

B) 1.05×10^{-1} g

C) 9.52×10^{0} g

D) 1.68×10^{2} g

$$\sim 1.00\times10^{4}\,J \times \frac{1\,mol}{42.0\,kJ} \times \frac{1\,kJ}{1000.\,J} \times \frac{40\,g\ NaOH}{1\,mol\ NaOH}$$

Question 5

Heather is performing the iodine clock reaction experiment in the laboratory.

In this reaction, the concentration of reactants determines the time it takes for the reaction to turn inky black.

The partial reaction is shown below:

$$2\ I^{-}_{(aq)} + S_2O_{8(aq)} \rightarrow I_{2(aq)} + 2\ SO_4^{2-}{}_{(aq)}$$

easy way: coef = exp

What is the rate law expression for this reaction?
Assume the reaction occurs in one step. ✱

just R not P

just g or aq not S or L

A) rate = $k\ 2\ [I^-]\ [S_2O_8]$

B) rate = $k\ [I^-]^2\ [S_2O_8]$

C) rate = $k\ [I_2]\ [SO_4^{2-}]^2$

D) rate =

rate = $k\ [I^-]^2 [S_2O_8]$

✱ but expect a hard one with trials!

Question 6

Ammonia is used to produce fertilizer. The Haber process is an important industrial reaction which produces ammonia (NH_3).

The equilibrium system for this reaction is:

$$N_{2(g)} + 3\ H_{2(g)} \rightleftharpoons 2\ NH_{3(g)} + \text{energy}$$

Which condition will **increase** the production of ammonia?

A) Increase the temperature of the system.

B) Decrease the pressure of the system.

C) Add a catalyst to the system.

D) Decrease the volume of the system.

Question 7

Kadja is preparing a chemistry experiment. He needs a weak base for the experiment. In order to choose a weak base he must consult the *Table of Ionization Constants of Bases* (K_b) shown below.

Table of Ionization Constants of Bases

Name	Formula	K_b
Ethanamine	$C_2H_5NH_2$	4.5×10^{-4}
Methanamine	CH_3NH_2	4.6×10^{-4}
Hydrazine	N_2H_2	1.3×10^{-6}
Ammonia	NH_3	1.8×10^{-5}

Which base from the table above is the **weakest**?

A) Ethanamine

B) Methanamine

C) Hydrazine

D) Ammonia

Part B
Constructed Response Questions

Questions 8 to 14

Answer all these questions in the ***Answer Booklet***.

Show all the work needed to solve the problem.

A total of 2 marks have been allocated for the consistent use of significant figures.

Question 8

Daniel Bernoulli proposed the kinetic molecular theory in 1738. He attempted to explain how gases exert pressure.

The pressure of helium gas inside a rubber balloon is an example of a gas exerting pressure.

Using the kinetic molecular theory, state four behaviours of helium gas in a balloon.

Assume that helium behaves as an ideal gas. KMT!

- He travels in straight lines
- the distance btw the particles is huge
- the volume of the particles is negligible
- the collisions are elastic
- etc etc
- it is compressible

Question 9

Two identical 20.0 L tanks are used for containers for gases. The first tank is filled with 0.1414 g of oxygen gas. same vol.

watch for diatomics

The second tank is filled with nitrogen gas, and kept at the same pressure and temperature as the tank containing oxygen gas. same T, P & V ∴ same # mol

Determine the mass of nitrogen gas in the second tank.

1) $0.1414\,g\ O_2 \times \frac{1\ mol\ O_2}{32\,g} = 4.4 \times 10^{-3}\ mol\ O_2 = 4.4 \times 10^{-3}\ mol\ N_2$

2) $4.4 \times 10^{-3}\ mol\ N_2 \times \frac{28\,g\ N_2}{1\ mol\ N_2} = 0.1232\,g\ N_2$

Question 10

Global warming is an environmental concern today.

Propane (C_3H_8) is used as an alternative to gasoline (C_8H_{18}) as it contributes less to carbon emissions.

The following equation represents the combustion reaction of propane:

$$C_3H_{8(g)} + 5\ O_{2(g)} \rightarrow 3\ CO_{2(g)} + 4\ H_2O_{(g)}$$

Given the following

$$3C_{(s)} + 4\ H_{2(g)} \rightarrow C_3H_{8(g)} \qquad \Delta H = -103.7\ \frac{kJ}{mol}$$ reverse + switch signs

$$H_{2(g)} + \frac{1}{2}\ O_{2(g)} \rightarrow H_2O_{(g)} \qquad \Delta H = -242.0\ \frac{kJ}{mol}$$

$$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)} \qquad \Delta H = -393.5\ \frac{kJ}{mol}$$

Determine the ΔH per mole of carbon dioxide produced by the combustion of propane.

per mol = per 1 mol CO_2 ← WATCH

$C_3H_8 \rightarrow 3C + 4H_2$ $\quad +103.7$

$4H_2 + 4 \times \frac{1}{2} O_2 \rightarrow 4H_2O_{(g)}$ $\quad 4(-242.0) = -968.0$

$3C + 3O_2 \rightarrow 3CO_2$ $\quad 3(-393.5) = -1180.5$

$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O \quad -2044.8\ kJ$

$\frac{-2044.8\ kJ}{1\ mol\ C_3H_8}$ or $\frac{-2044.8\ kJ}{5\ mol\ O_2}$ or $\frac{-2044.8\ kJ}{3\ mol\ CO_2}$ or $\frac{-2044.8\ kJ}{4\ mol\ H_2O}$

ANSWER: $\frac{-681.6\ kJ}{1\ mol\ CO_2}$

-2 if !!! you give it per 4 mol !

Question 11

Food will spoil over time. One of the reasons that food spoils is that the oxygen in the air can react with the fats in food, resulting in undesirable products.

Caterers follow certain procedures to reduce the rate at which the food spoils. Two of these methods are listed below:

= ↓ # coll = ↓ rate.

i) Food is stored in a sealed container. = ↓ $[O_2]$ in contact with food
ii) Meals prepared in advance are stored in the freezer. = ↓ T = ↓ speed of particl = ↓ # coll = ↓ rate

Use the collision theory and reaction rates to explain why each of the above procedures is used.

Question 12

Buffer Question = RICE table

The normal pH of blood in the arteries of the human body is 7.35 – 7.45.

The pH of the blood is controlled by a buffering system. Part of the buffering system involves the equilibrium reaction that takes place when carbonic acid (H_2CO_3) dissociates to produce bicarbonate ions (HCO_3^-) and hydrogen ions (H^+).

1 : 1

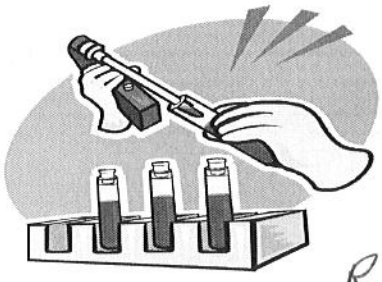
$$H_2CO_{3(aq)} \rightarrow H^+_{(aq)} + HCO_3^-{}_{(aq)} \quad K_a = 4.15 \times 10^{-7}$$

x x

A blood sample from a patient was analyzed. It was found that the concentration of H_2CO_3 was 3.50×10^{-3} mol/L and the concentration of HCO_3^- was 1.02×10^{-3} mol/L.

assuming ⇋ !

breaks up in a 1 : 1 mole ratio



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

R	H_2CO_3	⇋	H^+	+	HCO_3^-
I	3.5×10^{-3} M		Ø		1.02×10^{-3}

Does this patient have a normal blood pH?
Justify your answer.

1.26×10^{-6}

Question 13

Calcium hydroxide, $Ca(OH)_2$, has many uses. One significant use is in sewage treatment where it aids in the removal of small particles from water. Calcium hydroxide is particularly useful because of its low solubility in water.

type 2 Ksp given Ksp find solubility in $\frac{mol}{L}$

The K_{sp} of calcium hydroxide is 5.02×10^{-6} at 25°C.

Calcium hydroxide dissociates as follows:

$$Ca(OH)_{2(S)} \rightleftharpoons Ca^{2+}_{(aq)} + 2\ OH^-_{(aq)}$$

$Ksp = [Ca^{2+}][OH^-]$

What is the concentration of Ca^{2+} and OH^- ions in a saturated solution of calcium hydroxide at 25°C?

$x \quad 2x$

$= (x)(2x)^2$

$5.02 \times 10^{-6} = 4x^3$

$x = 0.0108\ M$

ANS: $[Ca^{2+}]$

Question 14

Below is a diagram of a graduated cylinder.

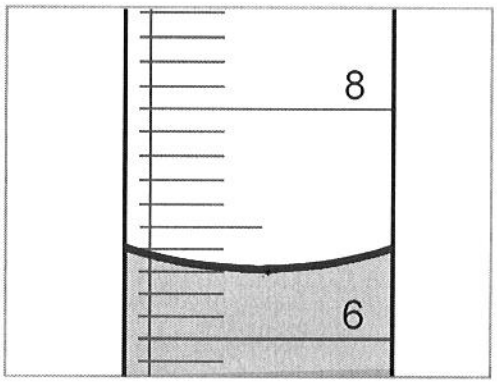
ANS: $[OH^-] = 0.0216M$

Give the volume of the liquid as measured by this graduated cylinder.

Observe the conventions regarding significant figures, and give the uncertainty of the measurement.

Below is a diagram of a graduated cylinder.

*bad question !



*wrong answer in package !

6.6 mL ± 0.1mL

1/2 the smallest = 0.2mL ∴ ± 0.1mL

Part C
Extended Constructed Response Questions

Questions 15 to 18

Answer all these questions in the ***Answer Booklet***.

Show all the work needed to solve the problem.

A total of 2 marks have been allocated for the consistent use of significant figures.

Each question is worth 6 marks.

Question 15

Carbohydrates such as glucose, $C_6H_{12}O_6$, are the body's preferred source of energy for sports like marathon running.

The carbohydrates stored in the body are easily broken down and the needed energy is released during the process of cellular respiration. This process is shown in the balanced chemical equation below.

exo / -ve ΔH

$$C_6H_{12}O_{6(aq)} + 6\ O_{2\,(g)} \rightarrow 6\ CO_{2(g)} + 6\ H_2O_{(l)} + \text{energy}$$

1) Stoich
2) $PV = nRT$

If 45.0 grams of glucose are consumed, what volume of carbon dioxide gas is produced at 38°C and 101 kPa?

1) $45.0\text{g glu} \times \frac{1\text{mol glu}}{180\text{g glu}} \times \frac{6\text{mol } CO_2}{1\text{mol glu}} = 1.5\text{ mol } CO_{2(g)}$

2) $CO_{2(g)}$ ∴ can now use $PV = nRT$

$$V = \frac{nRT}{P}$$

$38.0°C + 273 = 311\text{K}$

$$= \frac{(1.5\text{mol})(8.314)(311\text{K})}{(101\text{kPa})}$$

$V = 38.4\text{ L}$

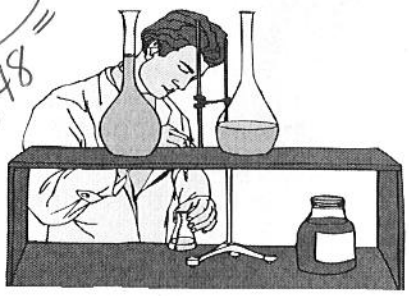
Question 16

During the nitrogen cycle, the nitrogen in the atmosphere is converted to nitrate (NO_3^-), a form that can be used by plants. The nitrate can be found as potassium nitrate (KNO_3) in soil. Potassium nitrate will dissolve in the water in soil.

A scientist is studying the temperature changes when potassium nitrate dissolves in water. The following data was collected, but the young scientist forgot to measure the final temperature of solution.

Answer: $T_f = 19.6\,^\circ C$

$39 + 14 + 16\times 3 = 48 + 101\,g/1\,mol$



* T_f lower than T_i ! ∴ water T goes down

$+\Delta H$ = endo!!

The molar heat of solution of potassium nitrate was researched and found to be **36.5 kJ/mol**.

Mass of KNO_3 dissolved	5.05 g
Volume of water used	150.0 mL
Initial temperature of water	22.5°C
Final temperature of the mixture (2) then solve for T_f	x

4 step reverse

(1) solve for ΔT

Determine the final temperature of the potassium nitrate solution.

4) + 3) $\Delta H = \frac{36.5\,kJ}{1\,mol\,KNO_3} \times 5.05\,g\,KNO_3 \times \frac{1\,mol\,KNO_3}{101\,g} = 1.83\,kJ$

$1.83\,kJ \times \frac{1000\,J}{1\,kJ} = 1830\,J$ = HE ab by KNO_3 wke dissolved in water = Q sub

2) $Q_{water} = -Q_{sub} =$

1) $Q_{water} = mc\Delta T = \frac{-1830\,J}{(150.0\,g)(4.19\,J/g\cdot C)}$

$\Delta T = -2.91\,^\circ C$

$\Delta T = T_f - T_i$

$\Delta T + T_i = T_f$

$-2.91\,^\circ C + 22.5\,^\circ C = T_f$

$T_f = 19.6\,^\circ C$

Question 17

Successful catering companies present the food they prepare in an attractive manner.

A decoration that one catering company uses is a glass container in the shape of a tree trunk that changes from a dark brown colour to a lighter colour throughout an event.

This colour change is accomplished through a chemical reaction between bromine (Br_2) reacting with phenol (C_6H_6O) and oxygen (O_2) to form bromine ion (Br^-), hydrogen ion (H^+) and carbon dioxide gas (CO_2). The balanced chemical reaction for this process is shown below:

$$2\ Br_{2(aq)} + 2\ C_6H_6O_{(aq)} + 5\ O_{2(g)} \rightarrow 4\ Br^-_{(aq)} + 12\ H^+_{(aq)} + 6\ CO_{2(g)}$$

(Brown)

At the beginning of the reaction, the presence of bromine (Br_2) gives the dark brown colour.

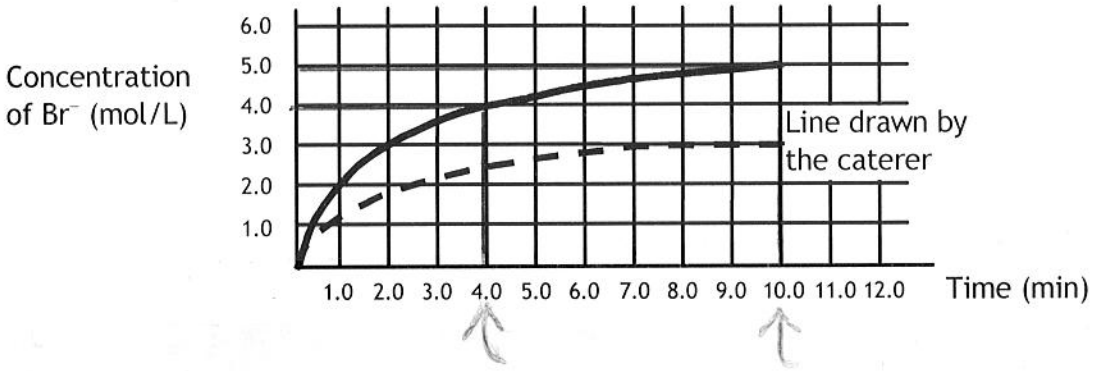
The graph below illustrates the concentration of the bromine ion ($Br^-_{(aq)}$) as a function of time.

* question is about H^+ ∴ stoic

a) What was the average rate of formation of the product $H^+_{(aq)}$, in moles per litre per minute, between 4 and 10 minutes?

Show all your work.

Graph 2 - Concentration of Br^- Versus Time



* info is for Br^-

solid line

$$\frac{5.0\ mol/L\ Br^- - 4.0\ mol/L\ Br^-}{10.0\ min - 4.0\ min} \times \frac{12\ mol\ H^+}{4\ mol\ Br^-} = 0.5\ \frac{mol\ H^+}{L\ min}$$

dashed line

$$\frac{3.0\ mol/L\ Br^- - 2.5\ mol/L\ Br^-}{10.0\ min - 4.0\ min} \times \frac{12\ mol\ H^+}{4\ mol\ Br^-} = 0.25\ \frac{mol\ H^+}{L\ min}$$

Yes H^+ appears at a lower rate of formation. OR the Br_2 disappears more slowly = Brown color

Question 17 (*Cont'd*)

The caterer would like the brown colour in the display to last longer. She looked at Graph 1. She then drew a second line on Graph 2, found below. She wants to know if this new rate would slow down the colour change, making the display last longer.

b)	Will the new rate slow down the colour change? Justify your answer.

Question 18

Graphite is a solid form of carbon. When graphite and carbon dioxide gas (CO_2) are added to a container that is under high pressure and high temperature, carbon monoxide gas (CO) is formed.

The chemical equation for this reaction is shown below:

$$C_{(s)} + CO_{2(g)} \rightleftharpoons 2\ CO_{(g)}$$

Graphite is added to a 0.50 L container containing 0.41 moles of carbon dioxide. At equilibrium, there were 0.54 mol of CO in the container.

E like! → cannot change the conc of a solid ∴ not part of K_c!

Determine the equilibrium constant, K_c, for this reaction. $K_c = 4.17$

R	$C_{(s)}$	+ CO_2	⇌ 2CO
I		0.82 M	Ø
C		−0.54M	+1.08M
E		0.28M	1.08 M

$$\text{initial } CO_2 = \frac{0.41 \text{ mol}}{0.50 \text{ L}} = 0.82 \frac{\text{mol}}{\text{L}}$$

$$* \rightleftharpoons CO = \frac{0.54 \text{ mol}}{0.50 \text{ L}} = 1.08 \frac{\text{mol}}{\text{L}}$$

$$K_c = \frac{[CO]^2 \text{ at } \rightleftharpoons}{[CO_2] \text{ at } \rightleftharpoons} = \frac{(1.08)^2}{(0.28)}$$

ANS: $K_c = 4.17$