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2010 Trial Examination

STUDENT NUMBER									Letter
Figures									
Words									

CHEMISTRY

Unit 4 – Written examination 2

Reading time: 15 minutes
Writing time: 1 hour 30 minutes

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	7	7	63
			Total 83

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, VCAA data booklet and a scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied
- Question and answer book of 14 pages.

Instructions
- Print your name in the space provided on the top of this page.
- All written responses must be in English.

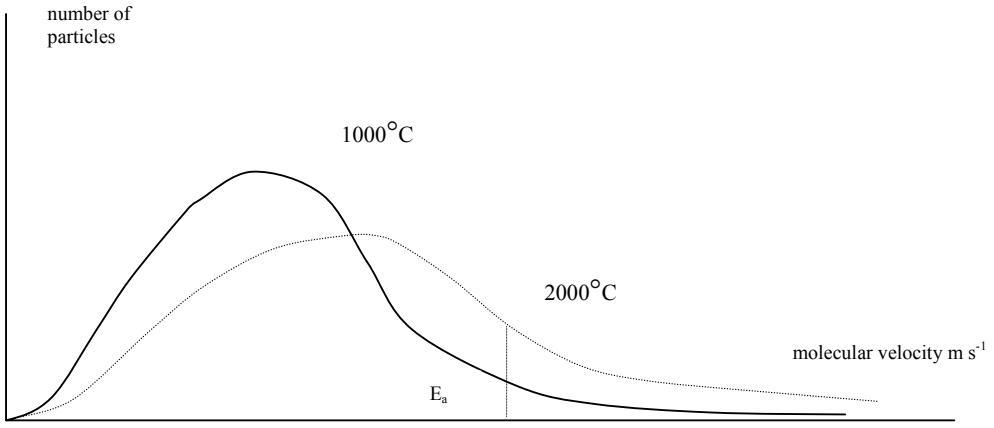
Students are NOT permitted to bring mobile phones and/or any other electronic communication devices into the examination room.

SECTION A – Multiple-choice questions

Instructions for Section A

Answer **all** questions.
Choose the response that is **correct** or **best answers** the question.
A correct answer scores 1, an incorrect answer scores 0.
No mark will be given if more than one answer is completed for any question.
Marks will **not** be deducted for incorrect answers.

Questions 1 and 2 refer to the following information



Maxwell-Boltzmann distribution curves like the ones above are often used to explain reaction rate changes. The activation energy (E_a) required for a particular reaction is shown on the graph.

Question 1
For a sample of the gases at 2000 °C,
A. all molecules have the same kinetic energy and the same velocity
B. all molecules have the same kinetic energy but their velocities vary significantly
C. the molecules have a range of kinetic energies and a range of velocities
D. the velocities of the particles increase as the kinetic energies decrease

Question 2
In comparing a gaseous mixture at 1000 °C with a mixture at 2000 °C,
A. some molecules will react at 2000 °C but none at 1000 °C will react
B. twice as many molecules will react at 2000 °C because it is twice the temperature
C. an equal number of molecules will react at either temperature
D. a greater percentage of molecules will react at 2000°C than at 1000 °C

Question 3
2 mL of phenolphthalein is added to test tube A filled with distilled water at 25 °C.
2 mL of methyl red is added to test tube B also filled with distilled water at 25 °C.
A. The pH of test tube A will be higher than that of test tube B
B. The pH of both test tubes will be the same
C. The pH of test tube B will be lower than that of test tube A
D. Both test tubes will have a pH of 7

SECTION A - continued

Question 4
Nitrogen reacts with oxygen in internal combustion reactions. The equation is

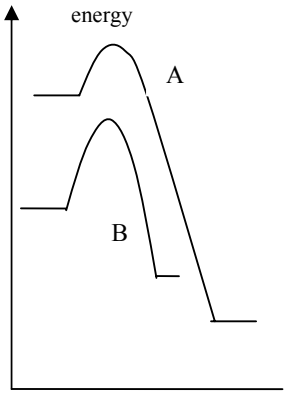
$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$

At 500 °C, the value of K is 4.6×10^{-4}

A mixture of nitrogen and oxygen gas is added to a reactor at 500 °C. When equilibrium has been reached, the

A. number of mole of NO will be less than that of N_2
B. number of mole of NO will be double that of N_2
C. number of mole of NO will be double that of O_2
D. number of mole of NO will be equal to the number of mole of N_2 added to O_2

Question 5
The change in energy during two chemical reactions is represented on the following energy profile diagram. The reactions are represented as A and B



From the energy profile diagram it is evident that

A. the activation energy of the reverse reaction of A is smaller than the activation energy of the reverse of reaction B
B. reaction A has a lower activation energy but a higher ΔH than reaction B
C. reaction A has a greater activation energy and a higher ΔH value than reaction B
D. reaction A has a lower activation energy and a lower ΔH than reaction B

Question 6
Pick the correct statement from the following

A. The activation energy of a reaction is always positive
B. The yield of a reversible reaction always decreases as temperature increases
C. The pH of pure water will always be equal to 7
D. Electrons in a galvanic cell always travel from the positive electrode to the negative

SECTION A - continued
TURN OVER

Question 7
Steam and methane can react to produce carbon monoxide and hydrogen;
$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$
0.60 mole of methane and 0.40 mole of steam are added to an empty reactor and a reaction occurs. Which alternative below lists possible equilibrium amounts of each gas?

	CH_4	H_2O	CO	H_2
A.	0.40	0.20	0.20	0.20
B.	0.20	0.20	0.20	0.60
C.	0.50	0.30	0.10	0.30
D.	0.20	0.0	0.40	1.20

Question 8
A 0.10 M solution of a weak, monoprotic acid has a $[H_3O^+]$ of 0.00114 M. The weak acid is likely to be
A. benzoic acid
B. methanoic acid
C. lactic acid
D. propanoic acid

Question 9
A particular monoprotic weak acid has a 2% ionisation level at 25 °C. A 0.1 M sample of this acid is prepared. The pH of this solution will be closest to
A. 1.0
B. 2.0
C. 2.7
D. 3.0

Question 10
The reaction between carbon monoxide and nitrogen dioxide is a reversible one;

$CO(g) + NO_2(g) \rightleftharpoons CO_2(g) + NO(g) \qquad \Delta H = -210 \text{ kJ mol}^{-1}$

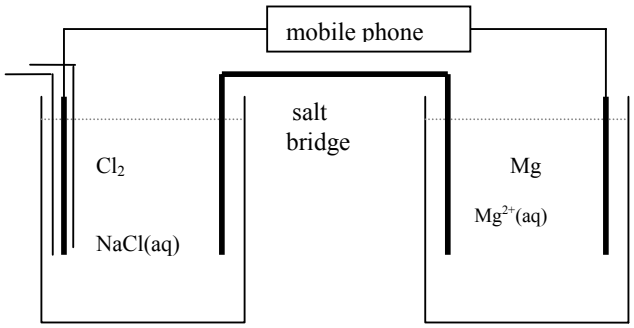
A mixture of the above gases is at equilibrium. The temperature is then doubled. The impact of the temperature change will lead to
A. a decrease in K, an increase in the amount of CO and a decrease in the amount of NO
B. a decrease in K, a decrease in the amount of CO and a decrease in the amount of NO
C. an increase in K, a decrease in the amount of CO and a decrease in the amount of NO
D. an increase in K, an increase in the amount of CO and a decrease in the amount of NO

Question 11
Which list below contains only metals that can be extracted by electrolysis of aqueous solutions?
A. lithium, aluminium, magnesium and sodium
B. lead, nickel, potassium and cobalt
C. silver, lead, copper and nickel
D. silver, cobalt, magnesium and lithium

SECTION A - continued

Question 12
A sample of distilled water is placed in a calorimeter. The water is at 18.0 °C.
0.10 g of methanol is burnt in the calorimeter and the temperature rises to 28.0 °C.
The calibration factor for the calorimeter is, in kJ $°C^{-1}$
A. 113
B. 0.227
C. 454
D. -454

Question 13
A standard galvanic cell is established to power a mobile phone, as shown below



In this cell,
A. the magnesium will be negative and its mass will decrease
B. the magnesium will be positive and its mass will increase
C. the chlorine half cell will be positive and it will be the anode
D. the chlorine half cell will be negative and it will be the cathode

Question 14
One of the first lithium batteries was the lithium – iodine cell, designed for use in pacemakers. Although it is now superseded, over one million of these batteries were implanted to power pacemakers.
The reaction in this cell is between lithium metal and iodine liquid using a conductive organic liquid as an electrolyte. Using your data book, the overall equation for this cell should be
A. $2Li\,(s) + I_2\,(l) \rightarrow 2LiI\,(l)$
B. $Li\,(s) \rightarrow Li^+\,(l) + e^-$
C. $2Li\,(s) + 2I^-\,(l) \rightarrow 2LiI\,(l)$
D. $2LiI\,(l) \rightarrow 2Li\,(s) + I_2\,(l)$

Question 15
When 0.10 g of magnesium is burnt in oxygen, 540 joule of energy is released. The closest ΔH value for the combustion of magnesium will be, in kJ mol^{-1}
A. 540
B. -130
C. -260
D. -540

SECION A – continued
TURN OVER

Questions 16 and 17 refer to the following information

Question 16

A galvanic cell is constructed from the following half cells, at 25°C

	electrode	**solution**
half cell	silver	clear solution of $AgNO_3$
half cell	nickel	green solution of $NiSO_4$

Which one of the following is likely to occur when the cell is operating?

A. The silver electrode will increase in mass and the green intensity will increase
B. The nickel electrode will increase in mass and the green intensity will increase
C. The silver electrode will increase in mass and the green intensity will decrease
D. Nothing, until a power supply is added

Question 17

When the current is flowing, the

A. electrons will flow from the silver to the nickel
B. silver electrode will be the cathode and it will be positive
C. electrons will flow through the salt bridge from the nickel to the silver
D. mass of both electrodes will increase

Questions 18 and 19 refer to the following information

An electric current is passed through a molten solution containing tin ions. The current of 2.1 amps is run for 5.0 minutes. The mass of tin produced in the cell was 0.388 g. The other product formed is chlorine gas.

Question 18

The charge on the tin ions must have been

A. -2
B. +1
C. +2
D. +4

Question 19

While the current was running, the volume of chlorine gas produced at STP was, in litres

A. 0.0021
B. 0.0730
C. 0.146
D. 0.292

Question 20

Many countries produce electricity using nuclear reactors. In the common forms of nuclear reactor

A. hydrogen atoms are fused to form helium atoms
B. chemical potential energy is converted to nuclear potential energy
C. large nuclei are split into smaller nuclei
D. the efficiency of the conversion of nuclear potential energy to electrical energy is close to 100%

END OF SECTION A

SECTION B – Short-answer questions

Instructions for Section B

Questions must be answered in the spaces provided in this book.
To obtain full marks for your responses you should

- give simplified answers with an appropriate number of significant figures to all numerical questions; simplified answers will not be given full marks.
- show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example, $H_2(g)$; NaCl(s)

Question 1

You are supplied with the following;

Item	Symbol
Power supply	
Voltmeter	
Ammeter	
Carbon electrodes	

Also beaker, Bunsen, tripod, potassium chloride powder

Task 1

a. **i**. You are asked to use the equipment listed above to design an experiment that could be used to produce 1.0 mol of potassium metal.

Sketch the experimental set up, labeling key features you would use to manufacture a sample of potassium metal.

ii. Write a balanced overall equation for the production of potassium.

_____

iii. Determine a possible combination of current and time that would lead to a theoretical production of 1.0 mol of potassium.

current _____ time _____

4 + 2 + 1 = 7 marks

Task 2

b. You are asked to produce a sample of hydrogen gas using the same equipment as in Task 1.

i. Describe the changes you would make to the experiment you have outlined in part a.

_____

_____

_____

ii. Write a half equation for the production of hydrogen.

_____

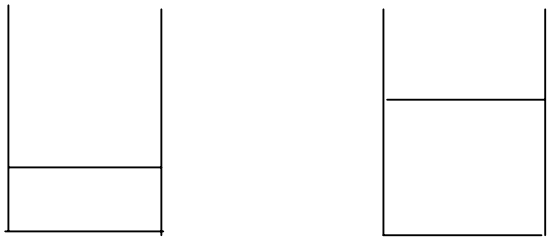
iii. What is the polarity of the electrode where hydrogen is produced? _____

2 + 1 + 1 = 4 marks

Total 11 marks

SECTION B - continued

Question 2



Beaker A	Beaker B
V = 30mL	V = 50mL
T = 18°C	T = 22°C
m = 0.20g	m= 0.40 g

0.20 g of ethanol is used to heat a sample of water in a Beaker A. 0.40 g of methanol is used to heat the water in Beaker B.

a. Use the spaces below to write a balanced equation for the combustion of each fuel. Write in also the value of ΔH for each fuel.

	Equation	ΔH
Ethanol	_____	_____
Methanol	_____	_____

4 marks

b. **i**. Calculate the amount of energy, in **J** released when the ethanol is burnt.

_____

ii. Calculate the amount of energy, in **J** released when the methanol is burnt.

_____

2 + 2 = 4 marks

Assume that 60% of the heat energy from each fuel is transferred to the water

c. **i**. Calculate the final temperature of the water in Beaker A.

_____

_____

ii. Calculate the final temperature of the water in Beaker B.

_____

_____

2 + 2 = 4 marks

Total 12 marks

SECTION B – continued

TURN OVER

Question 3

Methanol can be produced in a reversible reaction between carbon monoxide and hydrogen gas.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H < 0$$

a. Comment on the accuracy of the following statements.

i. 10 mol of carbon monoxide is introduced into a reactor containing excess hydrogen gas. After equilibrium is reached, 20 mol of hydrogen gas will have reacted.

_____

_____

ii. Carbon monoxide and hydrogen are added to an empty reactor. After equilibrium is reached, 2.44 mol of methanol has formed. This means that 1.22 mol of carbon monoxide must have reacted with 1.22 mol of hydrogen.

_____

_____

iii. A mixture of the above gases is at equilibrium. The volume of the reactor is suddenly halved. The temperature of the reactor will increase in response to the pressure change.

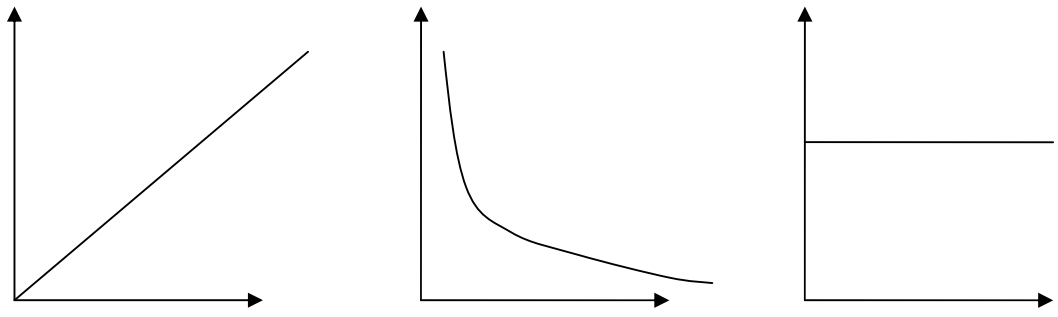
_____

_____

1 + 1 + 2 = 4 marks

b. Which graph below, A, B or C, could represent the value of the equilibrium constant, K, plotted against temperature?

_____ 1 mark



A **B** **C**

SECTION B – continued

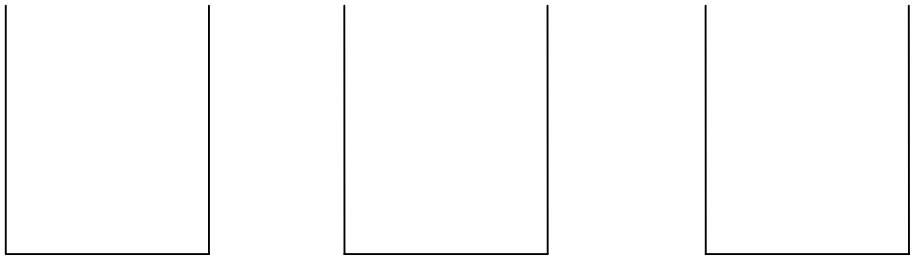
c. The K value for the above reaction is 1.0 at 152°C. Methanol is added to an empty reactor at 152°C and a reaction occurs. At equilibrium, the concentration of methanol is 0.10 M. Calculate the concentration of hydrogen gas.

_____

_____

3 marks
Total 8 marks

Question 4
Three beakers are drawn below to be set up as half cells.



A **B** **C**

a. Choose appropriate electrodes and solutions to make the following half cells;

i. Beaker A: sketch the half cell required for the reaction $2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$

ii. Beaker B: sketch the half cell required for the reaction $Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$

iii. Beaker C: sketch the half cell required for the reaction $Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$

iv. Name the strongest oxidant present in any of the three beakers _____

v. Which combination of beakers could be used to produce the highest voltage?

_____

1 + 1 + 1 + 1 + 1 = 5 marks

b. Draw a salt bridge to connect Beaker B and Beaker C to make a galvanic cell. An electrical lead is used to connect both electrodes.
This is a $Fe^{3+}(aq),Fe^{2+}(aq) \parallel Ni^{2+}(aq),Ni(s)$ cell

In this cell, the

i. positive electrode will be _____

ii. the oxidant will be _____

iii. electrons will flow from the beaker ____ to beaker _____

1 + 1 + 1 = 3 marks
Total 8 marks

SECTION B - continued
TURN OVER

Question 5

The world's energy woes have triggered massive research into battery technology. Many of the significant innovations revolve around the use of lithium. Lithium is now used in the batteries used in mobile phones and computers. The lithium cells belong to one of two categories – lithium or lithium-ion.

Lithium-ion cells combine lithium with transition metals like cobalt. The half equations for a typical lithium-ion cell are;

	Polarity	
$CoO_2 + Li^+ + e^- \rightarrow LiCoO_2$	☐	anode / cathode
$LiC_6 \rightarrow C_6 + Li^+ + e^-$	☐	anode / cathode

(phases are not shown as organic solvents are used)

a. **i**. Use the boxes provided to indicate the polarity of each half equation.

ii. Circle anode or cathode to indicate which electrode is the anode and which is the cathode.

iii. Write a balanced overall equation for the cell.

_____

iv. What is the oxidation number of the cobalt atoms before and after reaction?

Before _____ After_____

1 + 1 + 1 + 1 = 4 marks

The cell operates with a voltage of 4.6 volts.

b. How much energy is released if it operates for 5.0 minutes with a current of 1.1 amps?

_____

1 mark

c. This cell can be recharged successfully many times.

i. Write a balanced equation for the recharge of this cell.

_____

ii. Which electrode will be the positive terminal during recharge?

_____

1 + 1 = 2 marks

Total 7 marks

SECTION B - continued

Question 6

Hydrochloric acid, HCl, reacts readily with chalk, $CaCO_3$, releasing an inflammable gas.

a. Write a balanced equation for the reaction occurring between calcium carbonate and hydrochloric acid.

_____

1 mark

b. **i**. How will the pH of a reaction mixture change as the reaction proceeds?

_____

ii. Will the final pH at 25°C be 7? Explain your answer.

_____

_____

1 + 2 = 3 marks

40 mL of hydrochloric acid is added to two separate flasks, labeled as A and B. Both flasks are placed on separate balances. 5.0 g of $CaCO_3$ is then added to each flask. The mass change in each flask is shown on the graph below.

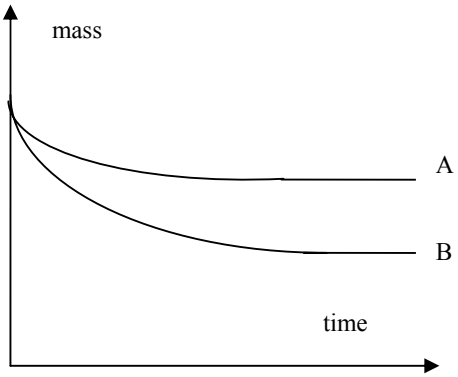
c. Suggest a reason for the difference observed between the two graphs.

_____

_____

_____

1 mark



In a second experiment, 40 mL of hydrochloric acid is added to two separate flasks. Both flasks are placed on separate balances. 5.0 g of $CaCO_3$ is then added to each flask. The mass changes are shown on the graph below.

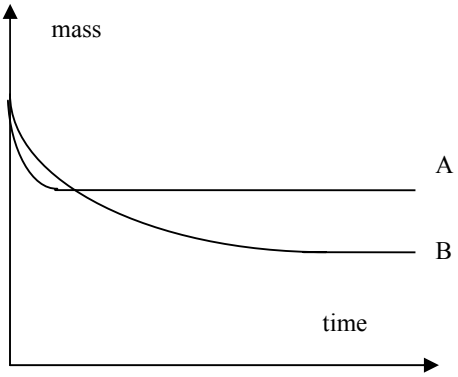
d. Suggest an explanation that is consistent with the shape of these graphs.

_____

_____

_____

2 marks



Total 7 marks

SECTION B – continued
TURN OVER

Question 7

The following chemicals are produced on an industrial scale in Australia:

ammonia ethene nitric acid sulfuric acid

Circle the chemical that you have chosen to study.

a. **i**. Write the chemical formula of the chemical you have chosen. _____

ii. List the oxidation number of each element in your chosen chemical.

_____

1 + 2 = 3 marks

b. **i**. Write a balanced equation for a reaction, in the industrial production of the chemical that you studied, that is reversible.

_____

_____

_____

ii. For the reversible reaction that you wrote, explain one way in which Le Chatelier's Principle is applied to help choose suitable conditions for the reaction.

_____

_____

_____

1 + 2 = 3 marks

c. Describe one hazard associated with the industrial process that you have chosen.

_____

1 mark

d. **i**. Name one raw material required in the industrial process that you have chosen.

_____

ii. Give an example of how that raw material can be sourced economically.

_____

_____

1 + 2 = 3 marks

Total 10 marks

END OF QUESTION AND ANSWER BOOK