Student Name: _____

CHEMISTRY

Unit 4 – Written examination 2

2008 Trial Examination

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*	*Suggested times (minutes)*
A	20	20	20	25
B	6	6	53	65
			Total 73	90

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, 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

Hydrochloric acid can react with sodium thiosulfate solution to form a sulfur precipitate. The equation is:

$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2S(s) + SO_2(g) + 2NaCl(aq) + H_2O(l)$

Question 1
Which list below contains only changes that will decrease the rate of this reaction?

A. Increase the temperature, increase the hydrochloric acid concentration and add a catalyst
B. Decrease the temperature and add a catalyst
C. Decrease in temperature, decrease in concentration of the hydrochloric acid, addition of water to the sodium thiosulfate
D. Decrease the concentration of the sodium thiosulfate solution and increase the temperature

Question 2
In a second experiment, an extra 50 mL of water is added to the hydrochloric acid. As a result of this change, the

A. rate of evolution of the sulfur dioxide decreases
B. precipitate will form more quickly
C. more fruitful collisions will occur
D. reaction will not be affected because water is not a reactant

Question 3
There are many factors for the chemical industry to consider when planning a new chemical manufacturing process. Select the correct alternative from the options below.

A. If there are several possible manufacturing pathways, scientists will always choose the one with the fastest reaction rate.
B. The process that produces the least waste is always the best process to use.
C. A catalyst must be found before a process will be viable.
D. Increasing the reaction rate might not improve the yield.

SECTION A- continued

Question 4
Beaker A contains 400 mL of a solution of pH 3. Beaker B contains 800 mL of a solution of pH 4.

A. Beaker A contains less H_3O^+ ions
B. The concentration of H_3O^+ in Beaker A will equal that of Beaker B
C. The concentration of H_3O^+ in Beaker B is ten times that of Beaker A
D. The concentration of H_3O^+ in Beaker A is ten times that of Beaker B

Question 5
For the reaction:

$$A(g) + 2B(g) \Leftrightarrow C(g) + D(g) \quad \Delta H = +220 \text{ kJ mol}$$

The yield would be maximized through the use of
A. low pressure, high temperature and a catalyst
B. high pressure, high temperature and excess of reagent B
C. low pressure, addition of a catalyst and excess of reagent A
D. high pressure, low temperature and the use of a catalyst

Question 6
The value of the equilibrium constant, K for a reaction is found to have the same value as K for its reverse reaction. If this is the case, it means that
A. the numerical value of K must be 1.
B. the reaction is not actually reversible.
C. the rate of the forward reaction and back reaction is always equal
D. the number of mole of products must equal the number of mole of reactants.

Question 7
The formation of nitrogen oxide is a reversible reaction:

$$N_2(g) + O_2(g) \Leftrightarrow 2NO(g) \qquad \Delta H = \text{negative}$$

The temperature is increased in a particular equilibrium mixture and the amount of N_2 changes by 0.01 mol. The changes occurring would be

	N_2	O_2	NO
A.	increased by 0.01	increased by 0.01	decreased by 0.02
B.	increased by 0.01	decreased by 0.01	decreased by 0.02
C.	decreased by 0.01	increased by 0.01	increased by 0.02
D.	decreased by 0.01	decreased by 0.01	decreased by 0.01

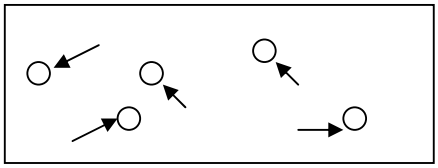
Question 8
In solution, the OCl^- hydrolyses according to the equation:

$$OCl^-(aq) + H_2O(l) \Leftrightarrow HOCl(aq) + OH^-(aq)$$

5 mL of 0.1 M sodium hydroxide is added to a 50 mL solution of 0.1M NaOCl. When equilibrium is reached again, the

A. pH is higher and the concentration of OH^- is higher
B. pH is lower and the concentration of the OH^- is higher
C. concentration of OH^- is lower as the reverse reaction has been favoured
D. relative concentrations are unchanged because the temperature has not changed

Question 9



The circles in the box represent particles of nitrogen gas in a reactor at $25^\circ C$.
In describing the motion of these particles,

A. each particle will be moving at the same velocity
B. the heavier particles will move more slowly
C. each particle will have the same kinetic energy
D. the particles will be moving at a range of velocities

Question 10
The range of methods available for producing electricity is increasing as many countries investigate ways of meeting their energy demands in the future. Choose the correct option from the list below

A. The efficiency of a solar cell is greater than the efficiency of a steam turbine used in the manufacture of electricity from coal.
B. Nuclear power involves harnessing the energy released from the fusion of uranium atoms
C. Natural gas is a mainly methane together with smaller amounts of alkanes such as ethane and propane.
D. All fuel cells convert the energy released from the reaction of hydrogen and oxygen gases to electrical energy

Question 11

A	B	C	D
thermal energy → mechanical energy	mechanical energy → electrical energy	chemical energy → thermal energy	thermal energy coal → thermal energy steam

The boxes above refer to different steps involved in the process of producing electrical energy from coal. The correct sequence for the production of electrical energy is

A. C, D, A, B
B. C, A, B, D
C. C, D, B, A
D. D, C, A, B

Question 12

0.60 g of ethanol is burnt in a bomb calorimeter. The temperature of the calorimeter contents rises from $12.8^{\circ}C$ to $24.5^{\circ}C$. $\triangle$H for the reaction is -1364 kJ/mol.
The calibration factor of the calorimeter is, in J $^{o}C^{-1}$,

A. 550
B. 760
C. 1520
D. 3040

Question 13

The equation for the combustion of hydrogen is:

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g) \quad \Delta H = -484 \text{ kJ mol}^{-1}$

The energy released when 2.40 g of hydrogen reacts is

A. 145 J
B. 290 J
C. 145 kJ
D. 290 kJ

Question 14

The following two half cells are connected to form a galvanic cell.

$Fe^{3+}(aq), Fe^{2+}(aq)$ and $I_2(aq), I^-(aq)$

When the cell is closed,

A. no reaction will occur
B. the iodine will react to form iodide ions
C. the iodine half cell will form the positive electrode
D. the electrons will flow from the iodine half cell to the iron ions

Question 15
In a galvanic cell, the strongest oxidant is
A. oxidised at the cathode
B. reduced at the cathode
C. oxidized at the anode
D. donating electrons to the strongest reductant

Question 16
The number of mole of electrons passing through a cell is 0.9 mol. For this cell,
A. the voltage must have been 10 volts and the time 145 mins.
B. 0.15 mole of metal will be obtained
C. 1.8 mole of metal will be obtained
D. the current was 10 amps and the cell was in operation for 145 mins.

Question 17
In an electrolytic cell,
A. electrons move to the negative cathode, where reduction occurs
B. electrons move to the positive cathode, where reduction occurs
C. oxidation occurs at the negative cathode
D. oxidation occurs at the positive cathode

Question 18
Beaker A contains a molten solution of copper iodide, CuI_2. Beaker B contains a dilute aqueous solution of CuI_2. If both solutions are subjected to electrolysis
A. copper and iodine will form in Beaker A, while copper and hydrogen will form in Beaker B
B. the products will be the same in both cells
C. copper and iodine will form in Beaker A, but hydrogen and oxygen will form in Beaker B
D. copper will form at the anode in both cells

Questions 19 and 20 refer to the following information.

The overall equation for the methane – oxygen fuel cell, operating in acid conditions, is

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

Question 19
The half equation for the reaction occurring at the cathode will be
A. $CH_4(g) + 2H_2O(l) + 8e \rightarrow CO_2(g) + 8H^+(aq)$
B. $CO_2(g) + 2H_2O(l) \rightarrow CH_4(g) + 2O_2(g)$
C. $O_2(g) + 4H^+(aq) + 4e \rightarrow 2H_2O(l)$
D. $CH_4(g) + 2H_2O(l) \rightarrow CO_2(g) + 8H^+ + 8e$

Question 20

This cell will require

A. porous electrodes and potassium hydroxide as the electrolyte
B. hydrogen gas at one electrode and oxygen at the other
C. porous electrodes and a continuous supply of reactants
D. non reactive and non porous electrodes

END OF SECTION A
TURN OVER

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
Give concise explanations for each of the following.

a. The same amount of charge flowing through different molten ionic solutions does **not** always lead to the same number of mole of metal being extracted.

_____

_____

2 marks

b. When the temperature is increased in most industrial processes, the products form more quickly. The amount of product formed in any given time, however, is not always greater.

_____

_____

2 marks

c. The calibration factor for a calorimeter can be determined without any measurement of voltage or current.

_____

_____

2 marks

d. The chemical potential energy of 1 mole of diesel is many times greater than that of 1 mole of ethanol. The efficiency of ethanol as a fuel, however, is only marginally less than that of diesel.

_____

_____

2 marks
Total 8 marks

SECTION B - continued

Question 2

Ethyne, C_2H_2, is a gas used in industry to produce a high temperature flame. The flame is used to cut through metal. Ethyne can be produced from ethane in a reversible reaction.

$C_2H_6(g) \Leftrightarrow C_2H_2(g) + 2H_2(g) \quad \Delta H = +355$ kJ mol

a. Draw a structural formula for ethyne.

1 mark

b. At mild conditions of temperature and pressure, the yield of ethyne is low. Chemical engineers change the conditions to improve the yield. Complete the table below to predict the impact on this process of each change listed.

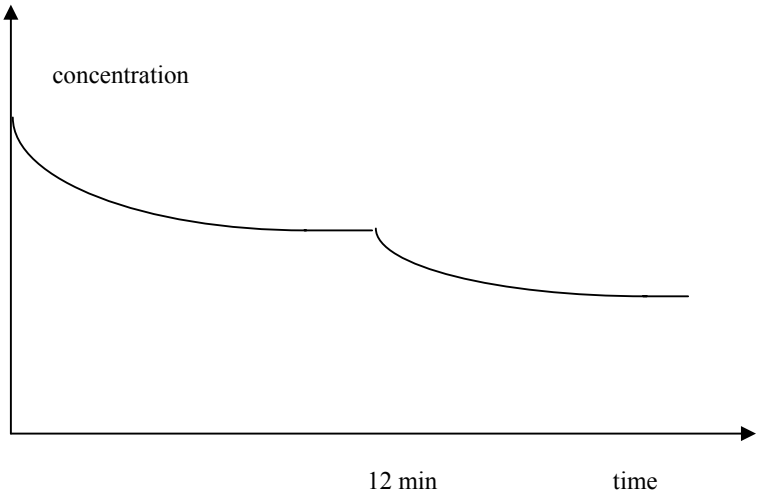
For each space in the table, choose from **decrease**, **unchanged** or **increase**

change	**value of K**	**equilibrium yield of ethyne**	**rate of reaction**
decrease in temperature			
increase in pressure			
addition of a catalyst			

3 marks

SECTION B – Question 2 – continued
TURN OVER

c. A sample of ethane is added to an empty reactor at 800 ^{0} C. The graph shown is of the concentration of ethane in the reactor. At the 12 minute mark, the temperature of the system is changed.



i. Use the graph provided to draw the concentration of ethyne up to the 12 minute mark.

ii. Add to the graph, the concentration of the hydrogen. Label each gas carefully.

iii. Was the temperature change an increase or a decrease? Explain your answer.

_____

_____

1 + 1 + 1 = 3 marks

d. From a green chemistry point of view, it is important to be able to use all products of a reaction. Give a possible use of the hydrogen gas produced in this process.

_____

1 mark

e. The torch used to cut metal uses a mixture of ethyne and oxygen. Write a balanced equation for the reaction of ethyne and oxygen.

_____

1 mark

Total 9 marks

SECTION B - continued

Question 3

a. Answer True or False (T or F) for each of the following statements

All neutral solutions have a pH of 7. _____

Neutral solutions contain neither acid nor base. _____

The product, $[H_3O^+][OH^-]$, is always 10^{-14} _____

In pure water, $[H_3O^+]$ will always equal $[OH^-]$ _____

20.0 mL of 0.1 M ethanoic acid can neutralize the same volume of 0.2 M NaOH as 20.0 mL of 0.1 M hydrochloric acid _____

5 marks

b. Complete the table below for samples of pure water held at different temperatures

Temp ^{0}C	**$[H_3O^+]$**	**$[OH^-]$**	**K_w**
0	**$10^{-7.5}$**		
25			**10^{-14}**
50		**$10^{-6.6}$**	

3 marks

c. The expression for K_a for carbolic acid is

$$K_a = \frac{[H_3O^+][C_6H_5O^-]}{[C_6H_5OH]}$$

Write a balanced equation for the reaction of carbolic acid and water.

_____

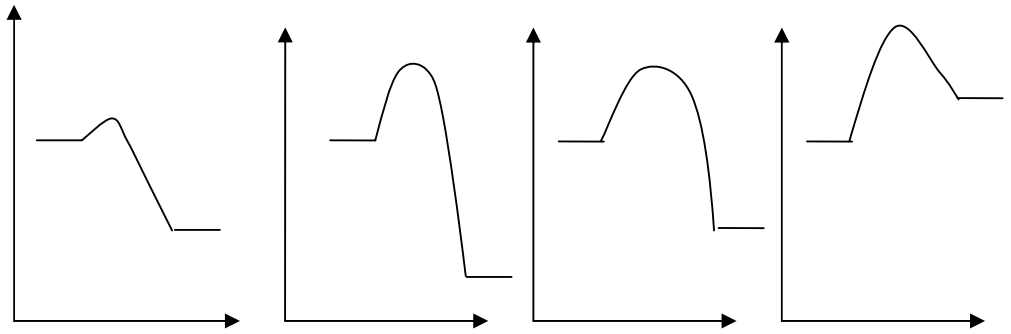
1 mark

Total 9 marks

SECTION B - continued
TURN OVER

Question 4

The diagram below contains four energy profile diagrams labelled A to D.



A **B** **C** **D**

a.

i. Pick two graphs that represent the same reaction, with and without a catalyst.

_____

ii. Explain the difference between the two graphs that you chose.

_____

_____

1 + 1 = 2 marks

b.

i. Which graphs represent reactions with positive activation energy?

_____

1 mark

ii. Which graph represents the reaction with the greatest activation energy?

_____

1 mark

c. Respiration is a highly exothermic reaction occurring in body cells.

$C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(g) \quad \Delta H = -2803 \text{ kJ mol}^{-1}$

Calculate the amount of energy released from the combustion of 4.80 g of oxygen.

_____

_____

_____

3 marks

Total 7 marks

SECTION B - continued

Question 5

The vanadium redox cell is a newly developed cell that uses oxides of vanadium at both electrodes. The cell is an example of a redox flow battery; it is a rechargeable fuel cell.
The half equations for the cell during discharge, are:

polarity

$2VO(aq) + H_2O(l) \rightarrow V_2O_3(aq) + 2H^+(aq) + 2e^-$ _____

$V_2O_5(aq) + 2H^+(aq) + 2e^- \rightarrow 2VO_2(aq) + H_2O(l)$ _____

a. Use the spaces provided to label the polarity of each electrode.

1 mark

b. Write an overall equation for the reaction occurring in this cell.

_____

1 mark

c. For ach of the vanadium compounds below, indicate the oxidation number of the vanadium.

VO ____ V_2O_3 _____ V_2O_5 _____ VO_2 _____

2 marks

d. The operating voltage of the cell is 1.40 volts.

i. How much energy is produced by this cell if it runs for 8.0 hours with a current of 3.50 amps?

_____

_____

ii. What mass of VO would react in this time?

_____

_____

2 + 2 = 4 marks
Total 8 marks

SECTION B - continued
TURN OVER

Question 6

English scientist, Sir Humphry Davy, first isolated potassium in 1807 by electrolysis of molten potassium hydroxide.

a.

i. Write balanced half equations for the reactions that will occur at the anode and the cathode in this cell.

anode _____

cathode _____

ii. What is the polarity of each electrode?

anode _____ cathode _____

2 + 2 = 4 marks

b. Give two reasons why this reaction was a very dangerous one.

_____

_____

2 marks

c. A current of 6.20 amps flows for 4.00 minutes. Calculate the mass of potassium that will be produced.

_____

_____

2 marks

d. This potassium hydroxide electrolysis cell is operated for about 15 minutes. The power supply is then removed and replaced with an ammeter. The ammeter indicates that a current is flowing.

i. Explain why a current is flowing even though the power supply has been removed.

_____

_____

ii. Give the half equation of the reaction occurring at the anode.

_____

iii. What is the polarity of the anode? _____

2 + 1 + 1 = 4 marks

Total 12 marks

END OF QUESTION AND ANSWER BOOK

