THE SCHOOL FOR EXCELLENCE (TSFX)

UNIT 4 CHEMISTRY 2008

WRITTEN EXAMINATION 2

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

QUESTION AND ANSWER BOOK

Structure of Booklet

Section		*Number of Questions*	*Number of Questions to be Answered*	*Number of Marks*	*Suggested Times (min)*
A	Multiple choice questions	20	20	20	20
B	Short answer questions	8	8	62	62
				Total 82	Total 82

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SECTION A

Specific Instructions For Section A

Section A consists of 20 multiple-choice questions. Section A is worth approximately 24% of the marks available. You should spend approximately 20 minutes on this section.

Choose the response that is **correct** or **best answers the question**, and shade the square on the multiple-choice answer sheet according to the instructions on that sheet.

A correct answer is worth 1 mark, an incorrect answer is worth no marks. No mark will be given if more than one answer is shown for any question. Marks will **not** be deducted for incorrect answers. You should attempt every question.

QUESTION 1

$200\ mL$ solutions of $0.20\ molL^{-1}$ nitric acid, sulfuric acid, benzoic acid and methanoic acid are prepared and the pH of each solution is measured. Which option below best describes the order of increasing pH at $40^{o}C$?

A Sulfuric acid, Nitric acid, Methanoic acid, Benzoic acid
B Sulfuric acid, Nitric acid, Benzoic acid, Methanoic acid
C Benzoic acid, Methanoic acid, Nitric acid, Sulfuric acid
D Methanoic acid, Benzoic acid, Sulfuric acid, Nitric acid

QUESTION 2

What would be the pH of the solution resulting from the complete reaction between $200\ mL$ of $0.20\ M\ H_2SO_4$ and $100\ mL$ of $0.10\ M\ Ca(OH)_2$?

A 0.7
B 1.0
C 2.0
D 7.0

QUESTION 3

A ranger out on a three day hike at 10°C and 1.5atm carries a 4.0 L canister of butane gas to boil water for his evening meals. The butane gas needs to supply enough energy to raise the temperature of the water from 10°C to boiling. How much water can the ranger boil on each of the two evenings?

A 682 mL
B 986 mL
C 1364 mL
D 1970 mL

QUESTION 4
Consider the reaction: $2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)} \quad \Delta H = -114kJ/mol$

The amount of energy released during the complete reaction of 1.00 L of nitrogen monoxide at 0^oC and $101.3\,kPa$ is

A 114 kJ
B -114 kJ
C 2.54 kJ
D -2.54 kJ

QUESTION 5
Consider the following equations:

$$Na_{(s)} + H_2O_{(l)} \rightarrow NaOH_{(s)} + \frac{1}{2}H_{2(g)} \qquad \Delta H = -146\,kJ$$
$$Na_2SO_{4(s)} + H_2O_{(l)} \rightarrow 2NaOH_{(s)} + SO_{3(g)} \qquad \Delta H = +418\,kJ$$

The enthalpy change for the reaction $Na_2SO_{4(s)} + H_{2(g)} \rightarrow 2Na_{(s)} + H_2O_{(l)} + SO_{3(g)}$ is

A $-126\,kJ$
B $+408\,kJ$
C $+564\,kJ$
D $+710\,kJ$

QUESTION 6
An alternative energy source that is non-renewable is nuclear energy. Which of the following reactions given below does **not** represent a nuclear fission process?

A $4\,{}^1_1H \rightarrow {}^4_2He + 2\,{}^0_1e + energy$
B ${}^{235}_{92}U + {}^1_0n \rightarrow {}^{140}_{56}Ba + {}^{93}_{36}Ba + 3\,{}^1_0n + energy$
C ${}^{56}_{26}Fe + energy \rightarrow 13\,{}^4_2He + 4\,{}^1_0n$
D ${}^{230}_{90}Th \rightarrow {}^{226}_{88}Ra + {}^4_2He + energy$

QUESTION 7
Which of the following methods of waste disposal would be the least desirable according to the principles of green chemistry?

A Vitrification (sealing in molten slag)
B Dumping into the ocean
C High temperature incineration
D Landfill

QUESTION 8
Under certain conditions, cyclohexane can react to form benzene and hydrogen according to the equation $C_6H_{12(g)} \rightleftharpoons C_6H_{6(g)} + 3H_{2(g)} \quad \Delta H = +206\ kJ/mol$

Which two changes could be used to increase the rate of reaction?

A Add a catalyst and reduce the temperature.
B Add a catalyst and decrease the pressure.
C Increase the temperature and the external pressure.
D Add a catalyst and decrease the concentration of benzene.

QUESTION 9
Solid silver chloride is in equilibrium with its aqueous solution at 25^oC.

$$AgCl_{(s)} \rightleftharpoons Ag^+_{(aq)} + Cl^-_{(aq)} \qquad K = 2.0\times10^{-10}\,M^2$$

When a solution containing $NH_{3(aq)}$ is added, the solid silver chloride rapidly dissolves.

$$Ag^+_{(aq)} + 2NH_{3(aq)} \rightleftharpoons Ag(NH_3)^+_{2(aq)} \qquad K = 1.6\times10^{7}\,M^{-2}$$

The equilibrium expression for the dissolution of the precipitate is

A $\dfrac{\left[Ag^+\right]\left[Cl^-\right]}{\left[AgCl\right]}$

B $\dfrac{\left[Ag(NH_3)^+_2\right]}{\left[NH_3\right]^2}$

C $\dfrac{\left[Ag(NH_3)^+_2\right]\left[Cl^-\right]}{\left[NH_3\right]^2}$

D $\dfrac{\left[Ag(NH_3)^+_2\right]\left[Cl^-\right]}{\left[AgCl\right]\left[NH_3\right]^2}$

QUESTION 10
Which of the following actions would result in an **increase** in the amount of undissolved $AgCl_{(s)}$?

A Dilution with water.
B The addition of more ammonia.
C The addition of HCl.
D An increase in the atmospheric pressure.

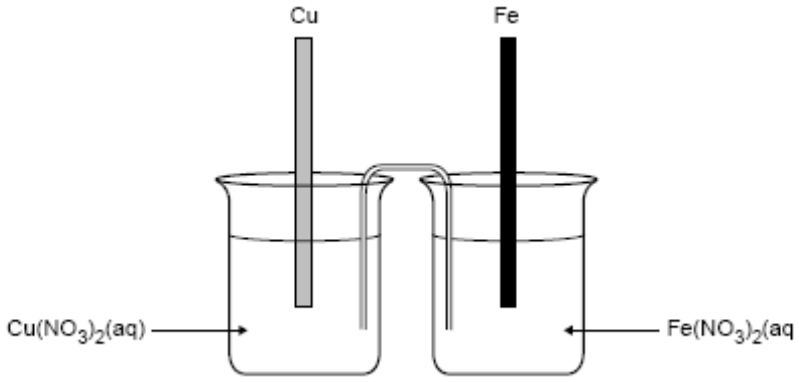
QUESTION 11
Nitryl chloride forms a gaseous equilibrium with nitrogen dioxide and chlorine gas.
This equilibrium may be represented by the following equation:

$$2NO_2Cl(g) \rightleftharpoons NO_2(g) + Cl_2(g) \; ; \; K = 0.558$$

What would be the equilibrium amount (in mol) of NO_2 if the 4.0 L container was found to contain 0.00424 mol of NO_2Cl and 0.02152 mol of Cl_2 at equilibrium?

A 1.17×10^{-4}
B 1.17×10^{-2}
C 4.68×10^{-4}
D 4.68×10^{-2}

QUESTION 12
A student sets up a galvanic cell using two standard half cells as illustrated below.



The solutions are connected to each other with a salt bridge consisting of an inverted U-tube containing an appropriate electrolyte.

Which species below could be used as the electrolyte for the salt bridge in the illustrated cell?

A CH_3OH
B $NH_4(NO_3)$
C $AgNO_3$
D KOH

QUESTION 13
The most common secondary cell is the lead-acid accumulator, which is used as a car battery. The overall equation representing the discharge reaction in this cell is

$Pb(s) + PbO_2(s) + 2SO_4^{2-}(aq) + 4H^+(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$

In the recharging process:

A Pb(s) is produced at the negatively charged anode.
B Pb(s) is produced at the negatively charged cathode.
C $PbO_2(s)$ is produced at the negatively charged anode.
D $PbO_2(s)$ is produced at the negatively charged cathode.

QUESTION 14
When metal X is placed in a solution of Y^{2+} ions, Y and X^{2+} are formed. When both metals are placed in an acidified solution, no reaction occurs. The order in which the species X^{2+}, Y^{2+} and H^+ decrease in oxidising strength is

A $Y^{2+} > X^{2+} > H^+$
B $X^{2+} > Y^{2+} > H^+$
C $H^+ > Y^{2+} > X^{2+}$
D $X^{2+} > H^+ > Y^{2+}$

QUESTION 15
When manganese dioxide, MnO_2, was used as an oxidising agent in a galvanic cell, the cell produced 2220 Coulomb of electricity for each gram of MnO_2 consumed. The final oxidation number of manganese is

A 2
B 3
C 4
D 5

QUESTION 16
In which of the following cells is oxygen gas likely to be produced at the anode?

A The electrolysis of molten potassium iodide using platinum electrodes.
B The electrolysis of aqueous potassium iodide using platinum electrodes.
C The electrolysis of molten sodium chloride using platinum electrodes.
D The electrolysis of aqueous sodium chloride using platinum electrodes.

QUESTION 17
Platinum electrodes were suspended into $500\ mL$ of a solution containing the following ions: $Ag^{+}, Cu^{2+}, Al^{3+}, Ni^{2+}$. If a current is passed through the cell at a constant voltage of $1.40\ V$, the last metal to be deposited onto the cathode would be:

A Ag
B Cu
C Al
D Ni

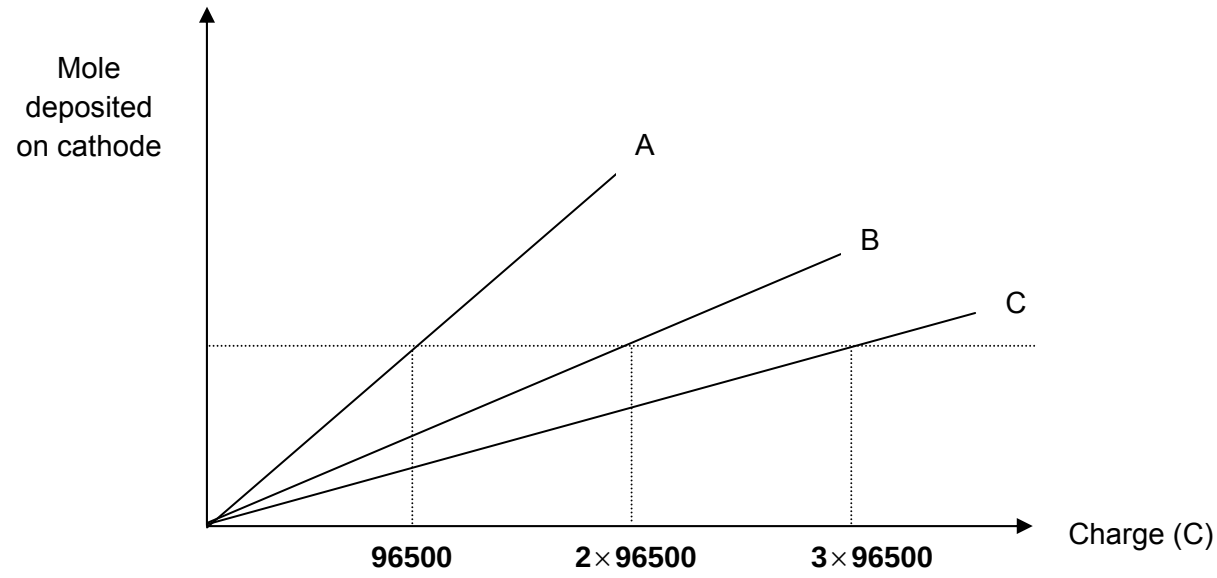
QUESTION 18
A non-rechargeable alkaline cell has a zinc anode with a mass of 1.2 g. How long will the battery last if it delivers a current of 50 mA?

A 1.5 hrs
B 10 hrs
C 20 hrs
D 24 hrs

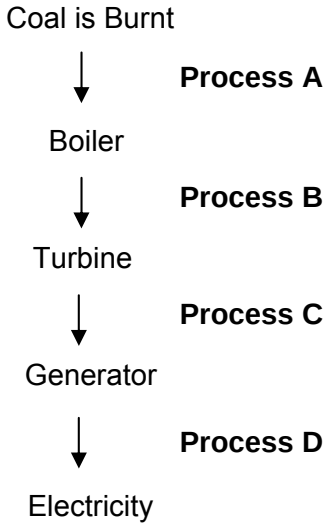
QUESTION 19
The relationship between the charge passed through an electrolytic cell and the mass of metal deposited at the cathode for three different solutions, A, B and C is given below.

The species whose ion has the highest valency is

A Metal A
B Metal B
C Metal C
D Cannot be determined from the given information



QUESTION 20
Most of Australia's electrical energy is obtained from the combustion of coal. A diagram of the processes involved in the production of electricity in a coal fired power station is given below.



Which of the following best describes the energy transformation that occurs in Process C?

	Reactants		**Products**
A	Chemical potential energy	is converted to	Kinetic energy
B	Chemical potential energy	is converted to	Chemical potential energy
C	Kinetic energy	is converted to	Chemical potential energy
D	Kinetic energy	is converted to	Kinetic energy

SECTION B

Specific Instructions For Section B

Section B consists of 8 short-answer questions numbered 1 to 8; you must answer all of these questions. This section is worth 62 marks which is approximately 76 per cent of the total available marks You should spend approximately 70 minutes on this section.

The marks allotted to each question are shown at the end of each question.

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 for all numerical questions; unsimplified 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 that all 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
The following equations represent important reactions in the industrial production of certain chemicals.

A $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

B $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$

C $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

D $C_3H_8(g) \rightleftharpoons C_2H_4(g) + CH_4(g)$

Select one of the above equations and answer the following questions.

a. (i) Name the significant chemical manufactured by the process to which the reaction belongs.

_____

(ii) State **two uses** of the significant chemical produced from your chosen reaction.

_____

_____

1+1 = 2 marks

b. (i) What conditions of temperature and pressure favour a high yield of product from your chosen reaction?

_____

_____

(ii) Are these conditions employed on an industrial scale? Give reasons for your answer.

_____

_____

_____

_____

1+2 = 3 marks

c. State 2 different waste management measures that are employed by industries involved in the production of your selected chemical.

_____

_____

_____

_____

2 marks

d. (i) Explain, in terms of the collision theory, why most reaction rates increase with increasing temperature.

_____

_____

_____

_____

(ii) Explain how an increase in temperature of just 5% can result in the doubling of a reaction rate.

_____

_____

_____

_____

1+1 = 2 marks

Total 9 marks

QUESTION 2

The heat of combustion of diesel fuel was determined using a bomb calorimeter. The calorimeter was first calibrated by combusting 0.7663 g of pure ethanol. A temperature rise from 20.62 to 24.64°C was observed.

a. (i) Calculate the Calibration Factor for the calorimeter in $kJ°C^{-1}$.

_____

_____

_____

(ii) If the bomb was emptied of water and replaced with a solution with specific heat capacity $1.2\ J/g/^oC$, what effect would this change have on the calibration constant?

_____

_____

_____

2+1 = 3 marks

A 1.0 ml sample of diesel was then combusted in the bomb and a temperature rise of 6.44°C was recorded.

b. (i) Determine the heat of combustion of diesel in MJL^{-1}.

_____

_____

_____

_____

2 marks

(ii) Calculate the efficiency of the bomb if the energy density of diesel is $44.8\ kJg^{-1}$ and its density is $0.85\ kgL^{-1}$.

_____

_____

_____

_____

2 marks

c. Diesel is obtained from fractional distillation of petroleum. An alternative not derived from petroleum is biodiesel.

(i) State two natural sources of biodiesel fuel.

_____

_____

(ii) Biodiesel is classified as a renewable source of energy. State one other renewable source of energy and give one advantage of using this source to produce energy.

_____

_____

_____

1+1 = 2 marks

Total 9 marks

QUESTION 3

Liquid bromine, when added to water, forms hypobromous acid ($HOBr$) and hydrobromic acid (HBr). Hypobromous acid is a weak acid used as a disinfectant due to its ability to destroy bacteria and algae.

a. Write an equation representing the ionisation of hypobromous acid in water.

_____

1 mark

b. Calculate the pH of a 1.0 M solution of hypobromous acid at $25^{o}C$.

_____

_____

_____

_____

_____

_____

2 marks

c. Two drops of methyl red indicator was added to 2.0 ml of the hypobromous solution which then became red in colour. The 2.0 mL was then diluted to a volume of 20 L at constant temperature.

(i) State the colour of the diluted solution.

_____

_____

_____

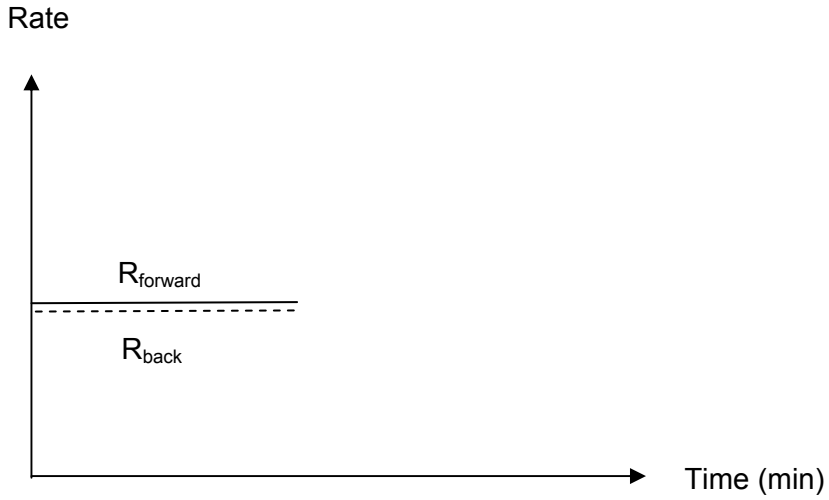
1 mark

(ii) Indicate, by placing a tick in the correct cell, what changes would be expected once the hypobromus system had re-established equilibrium following the dilution.

	Increase	**Decrease**	**No Change**
Amount, in mole, of the bromous ion (OBr^{-})			
Concentration of bromous ion (OBr^{-})			
K_a value			

1+1+1 = 3 marks

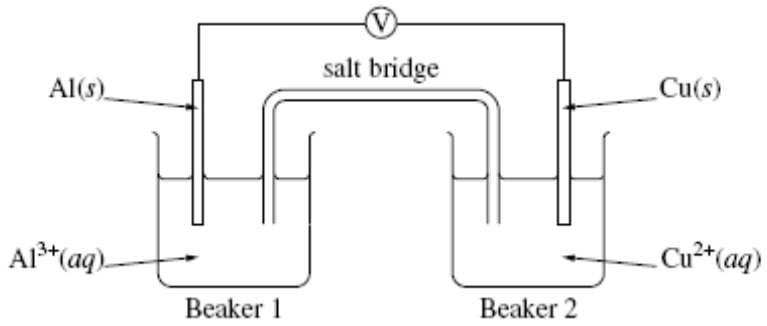
(iii) Sketch the corresponding changes in reaction rates as the hypobromous solution is diluted on the graph below.



2 marks

Total 9 marks

QUESTION 4
An electrochemical cell is set up as shown in the diagram below.



a. On the given diagram , label the anode and the direction of electron flow.

1 mark

b. Circle the response that best describes the effect on the voltmeter reading after an extended period in time if:

A represents an increase in the voltmeter reading
B represents a decrease in the voltmeter reading
C represents no change in the voltmeter reading
D represents a zero voltmeter reading

(i) The salt bridge is removed.

A B C D

(ii) The copper electrode is replaced with tin.

A B C D

(iii) The aluminium electrode is replaced with zinc.

A B C D

(vi) The two half cells were combined to form one cell.

A B C D

4 marks

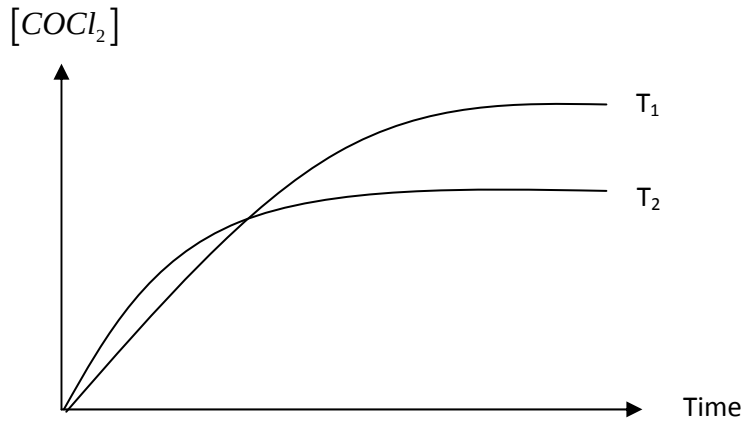
Total 5 marks

QUESTION 5

Carbon monoxide reacts with chlorine to form phosgene, $COCl_2$.

$$CO_{(g)} + Cl_{2(g)} \rightleftharpoons COCl_{2(g)}$$

1.0 mol of Cl_2 was mixed with 1.0 mol of CO in two separate $1.0\,L$ containers at two different temperatures - T_1 and T_2, and the concentration of $COCl_2$ was measured. The results of this experiment is given below.



a. (i) Which of the temperatures, T_1 or T_2 is the higher? Give a reason to support your answer.

_____

_____

_____

(ii) Is the formation of $COCl_2$ and exothermic or endothermic process. Give a reason for your answer.

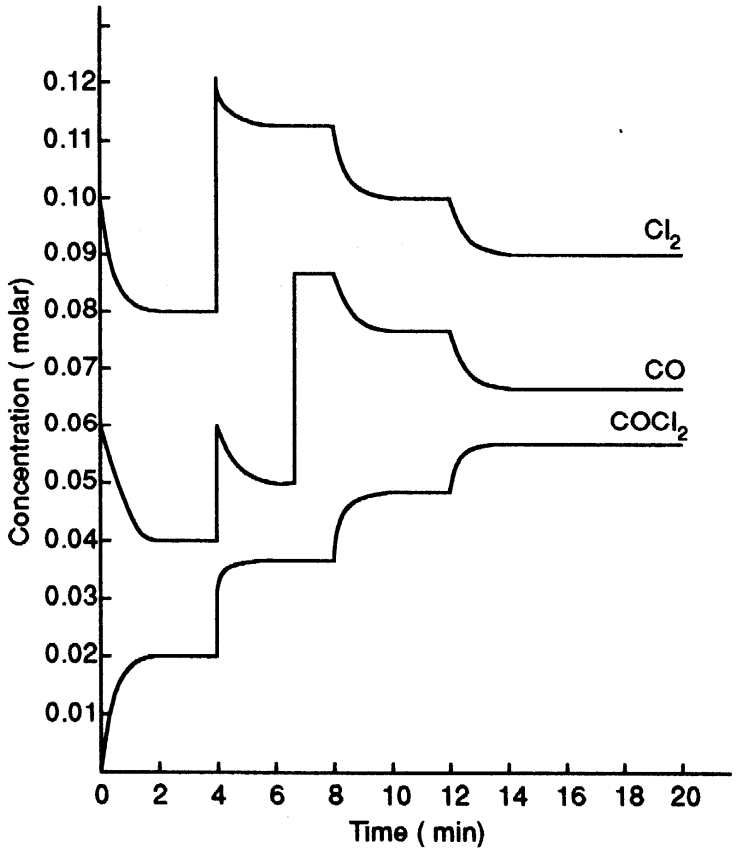
_____

_____

_____

1+1 = 2 marks

The concentration of CO , Cl_2 and $COCl_2$ for another experiment was plotted against time to produce the graph below.



b. (i) How many times did this system reach equilibrium?

_____

_____

(ii) Calculate the equilibrium constant at the time that the system first reaches equilibrium.

_____

_____

1+1 = 2 marks

c. (i) What change occurred at the 4 minute mark?

_____

_____

(ii) What change occurred at the 8 minute mark?

_____

_____

1+1 = 2 marks

d. 5.0 mole of CO and 4.0 mole of Cl_2 were added to a 2.0 L vessel and allowed to reach equilibrium. When equilibrium was reached, 3.0 mole of $COCl_2$ were present. Calculate the equilibrium constant for this reaction system.

_____

_____

_____

_____

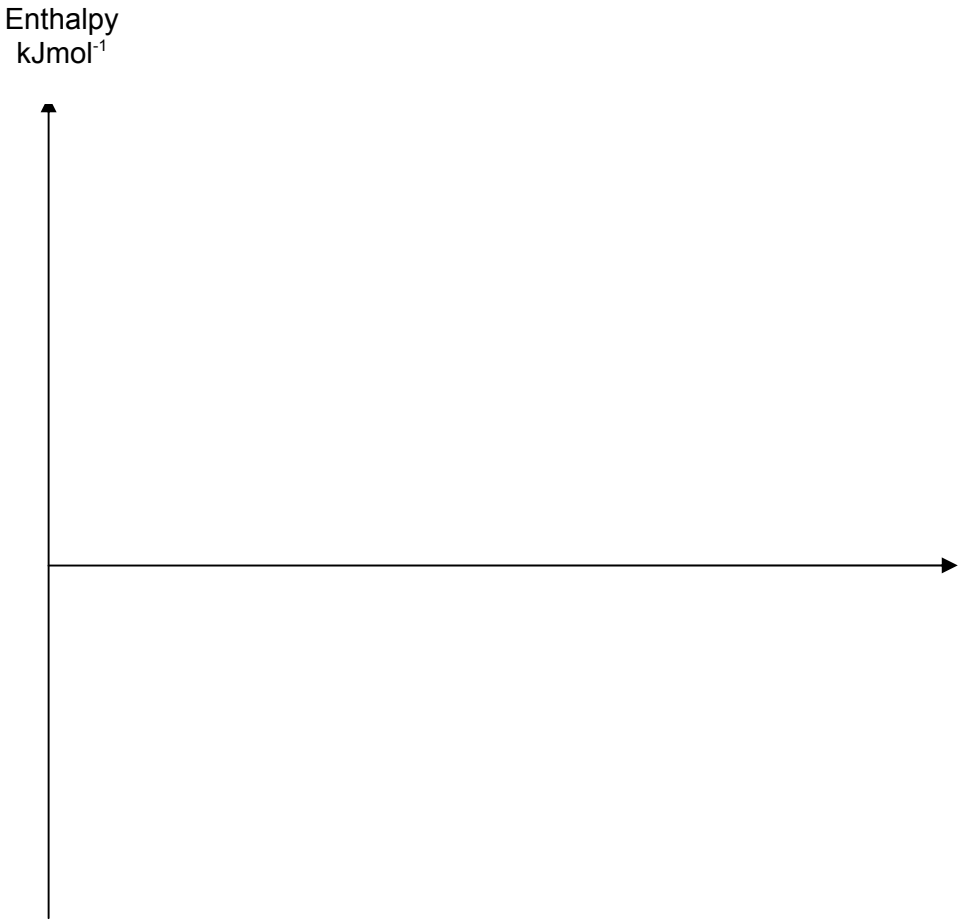
_____

_____

3 marks

e. The activation energy requirement for the reaction $CO_{(g)} + Cl_{2(g)} \rightleftharpoons COCl_{2(g)}$ is $135\,kJ/mol$ and the enthalpy of $COCl_2$ is $60\,kJ/mol$.

Given that the energy **change** for the reaction is $108\,kJ/mol$, draw a potential energy diagram for this reaction.



2 marks

Total 11 marks

QUESTION 6
The principle storage form of energy in plants is starch; which is a large branched polymer of glucose. Large quantities of glucose are also found in cellulose; the structural support material in plants.

One way in which it may be possible to utilise the energy stored in plants is by converting cellulose and starch to glucose and then using the glucose produced as a fuel in a fuel cell.

a. (i) Using the equation below, write the overall reaction that occurs in this cell.

$$6CO_{2(g)} + 24H^{+}_{(aq)} + 24e^{-} \rightarrow C_6H_{12}O_{6(aq)} + 6H_2O_{(l)} \qquad E^o = 0.01V$$

(ii) Calculate the EMF of this fuel cell under standard conditions.

_____

_____

2+1 = 3 marks

b. (i) If the efficiency of this cell is 95%, calculate the amount of energy that could be theoretically derived from the reaction of 1 mole of glucose in such a fuel cell. State you answer to the nearest whole number.

_____

_____

_____

(ii) State a reason why the efficiency of fuels cells so high?

_____

_____

_____

1+1 = 2 marks

c. Hydrogen is the fuel that is most commonly used in fuel cells. Give one advantage and one disadvantage of using hydrogen gas in the fuel cell, in comparison to the burning of fossil fuels such as coal.

_____

_____

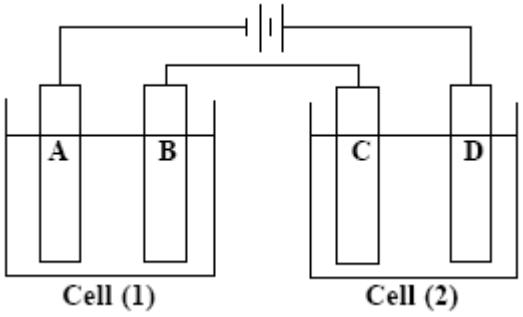
_____

2 marks

Total 7 marks

QUESTION 7

The diagram below shows 2 electrolytic cells connected in series to a DC power supply. Cell (1) consists of a $Cu(NO_3)_{2(aq)}$ solution and $Cu_{(s)}$ electrode. Cell (2) consists of an unknown metal nitrate solution, $MNO_{3(aq)}$ and electrodes made of the same unknown metal.



In 31.0 minutes, 0.0949 g of $Cu_{(s)}$ is deposited on electrode (A). In the same time, 0.322 g of the unknown metal is deposited on electrode (C) in Cell (2).

a. (i) Calculate the number of Faradays of charge transferred while copper is being deposited in Cell 1.

_____

_____

_____

(ii) Determine the identify the unknown metal, M .

_____

_____

_____

1+2 = 3 marks

b. An old iron pot is to be plated with a layer of chromium. The pot is connected to the negative terminal of a battery and an inert electrode is connected to the positive terminal. A solution of 2.0 M chromium chloride, $CrCl_3$ is used as the electrolyte.

(i) What would be the expected product at the anode?

_____

_____

_____

(ii) If the pot requires 15.0g of chromium to be plated, how long would the cell need to operate at a current of 30Amps if the process is 75% efficient?

_____

_____

_____

_____

_____

_____

1+4 = 5 marks

Total 8 marks

QUESTION 8

a. (i) A aqueous solution of $FeCl_2$ was acidified and oxygen was then bubbled through the system. Write the overall equation to describe the reaction occurring.

_____

_____

_____

(iii) A solution of 1 M NaOH was then added to form a precipitate. Write the equation that describes the precipitation process.

_____

_____

2+1 = 3 marks

b. A positive EMF does not guarantee that a redox reaction will take place - it only indicates that the reaction has the potential to occur spontaneously. Give a reason as to why no observable reaction may occur even though the EMF of a cell may be positive.

_____

_____

_____

1 mark

Total 4 Marks

End of Paper