Neap:

Trial Examination 2012

VCE Chemistry Unit 4

Written Examination

Question and Answer Booklet

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

Student's Name: _____

Teacher's Name: _____

Structure of Booklet

Section	Number of questions	Number of questions to be answered	Marks
A Multiple-choice	20	20	20
B Short-answer	5	5	55
			Total 75

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners and one 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 booklet of 18 pages.
Data booklet of 11 pages.
Answer sheet for multiple-choice questions.

Instructions

Please ensure that you write **your name** and your **teacher's name** in the space provided on this booklet and in the space provided on the answer sheet for multiple-choice questions.
All written responses must be in English.

At the end of the examination

Place the answer sheet for multiple-choice questions inside the front cover of this booklet and hand them in.

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

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2012 VCE Chemistry Unit 4 Written Examination.

SECTION A: MULTIPLE-CHOICE QUESTIONS

Instructions for Section A

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

Question 1

Waste management is a fundamental role of chemical industries. One method of dealing with any organic wastes that cannot be prevented, recycled or treated is to burn them at 1100°C in a high temperature incinerator. When organic wastes are not properly incinerated, extremely toxic chemicals called dioxins can be released into the atmosphere.

Consider the following variables:

I operating temperature of the furnace

II duration of the incineration

III proportions of wastes and oxygen used

Which of the above variables would influence the nature of the products formed by incineration of organic wastes?

A. I only
B. I and II only
C. II and III only
D. I, II and III

The following information relates to Questions 2 and 3.

Acrylic acid ($CH_2CHCOOH$) is a weak acid that ionises in water in an exothermic reaction.

Question 2

A 0.10 M solution of acrylic acid has a pH of 2.62.

The percentage ionisation of the acid is closest to

A. 1.0
B. 2.0
C. 3.0
D. 4.0

Question 3

If a solution of acrylic acid is heated, the pH of the solution would be expected to

A. increase.
B. decrease.
C. remain unchanged.
D. initially decrease, then return to the original value as equilibrium is re-established.

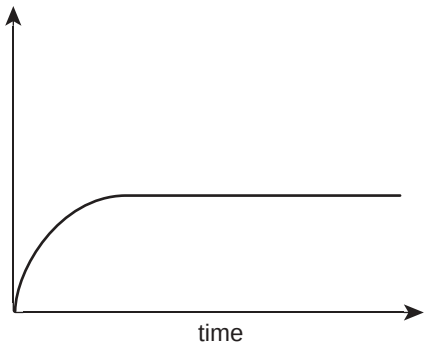
The following information relates to Questions 4 to 6.

The decomposition of phosphorus pentachloride (PCl_5) can be represented by the following equation:

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

Question 4

A quantity of PCl_5 is placed in an evacuated vessel and allowed to reach equilibrium. The results obtained during one experiment are shown in the graph below.



The range of variables which may have been measured during the experiment and represented on the vertical axis of the results graph are:

I rate of the forward reaction

II concentration of PCl_3

III total gas pressure in the vessel

IV gas pressure of Cl_2

Which of the variables listed would be consistent with the results shown in the graph above?

A. I and II only
B. I, II and III only
C. II, III and IV only
D. II and IV only

Question 5

Which of the following will affect both the yield of PCl_3 and the rate of its formation?

A. decreasing the volume of the vessel containing the equilibrium mixture
B. increasing the gas pressure by adding nitrogen gas to the equilibrium mixture
C. removing chlorine gas from the equilibrium mixture at regular intervals
D. using a catalyst

Question 6

In one experiment, 6.00 mol of PCl_5 was put into an evacuated vessel. When equilibrium was established, 4.50 mol of PCl_5 was present.

The numerical value of the equilibrium constant is

A. 0.375
B. 0.500
C. 2.00
D. unable to be determined from the information provided.

The following information relates to Questions 7 to 9.

Methyl palmitate, $CH_3(CH_2)_{14}COOCH_3(l)$, ($M$ = 270 g mol^{-1}) is a component of one type of biodiesel fuel. The thermochemical equation for the complete combustion of methyl palmitate is shown below:

$$2CH_3(CH_2)_{14}COOCH_3(l) + 49O_2(g) \rightarrow 34CO_2(g) + 34H_2O(g) \qquad \Delta H = -2.14 \times 10^4 \text{ kJ mol}^{-1}$$

Question 7

The heat of combustion of methyl palmitate was determined using a bomb calorimeter. When a 0.350 g sample of methyl palmitate was burned in excess oxygen in the calorimeter, the temperature rose by 4.22°C. The calibration factor of the calorimeter (in kJ °C^{-1}) was

A. 0.0887
B. 3.29
C. 6.57
D. 117

Question 8

The reactions in the following table occur when the fuels listed generate heat energy.

Reaction	Fuel type	Equation
I	natural gas	$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$
II	coal	$C(s) + O_2(g) \rightarrow CO_2(g)$
III	uranium	${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n$
IV	biodiesel	$2CH_3(CH_2)_{14}COOCH_3(l) + 49O_2(g) \rightarrow 34CO_2(g) + 34H_2O(g)$

Which reaction is used in the large scale production of electricity and generates the highest amount of electrical energy per mole of fuel reactant?

A. Reaction I
B. Reaction II
C. Reaction III
D. Reaction IV

Question 9

Fuels may be compared using a number of different criteria. Minimal carbon dioxide production per unit of energy produced when the fuel undergoes combustion is one comparison. Carbon 'neutrality' is another. A 'carbon neutral' fuel does not add to the amount of carbon dioxide gas in the atmosphere overall.

Which of the listed fuels compared in the table below best satisfies each of the criteria given?

	Minimal carbon dioxide production (mol of CO_2 per kJ of energy)	Closest to 'carbon neutral'
A.	natural gas (methane)	natural gas
B.	natural gas (methane)	biodiesel
C.	biodiesel (methyl palmitate)	natural gas
D.	biodiesel (methyl palmitate)	biodiesel

Question 10

The ionisation constant (K_w) of pure water is 1.85×10^{-15} M^2 at 5°C.

It can be concluded that

A. the hydroxide ion concentration in water is 4.30×10^{-8} M at 5°C.

B. the pH of water at 5°C is 7.37 and it is basic.

C. water must be pH 7 as it is always a neutral solution.

D. the self-ionisation reaction of water is exothermic.

Question 11

The rechargeable nickel-cadmium cell is used to power small electrical devices. When the cell is producing electrical energy, the half-reactions at the electrodes are:

Electrode I: $Cd(s) \rightarrow Cd^{2+}(aq) + 2e^-$

Electrode II: $NiO(OH)(s) + H_2O(l) + e^- \rightarrow Ni(OH)_2(s) + OH^-(aq)$

Which of the following shows the correct electrode polarity and half-cell reaction of the anode when the cell is being recharged?

	Polarity	Half-cell reaction
A.	positive	$Cd^{2+}(aq) + 2e^- \rightarrow Cd(s)$
B.	negative	$Ni(OH)_2(s) + OH^-(aq) \rightarrow NiO(OH)(s) + H_2O(l) + e^-$
C.	positive	$Ni(OH)_2(s) + OH^-(aq) \rightarrow NiO(OH)(s) + H_2O(l) + e^-$
D.	negative	$Cd^{2+}(aq) + 2e^- \rightarrow Cd(s)$

Question 12

The charge on one mole of electrons is known as Faraday's constant.

A student performed an electrolysis experiment using copper(II) nitrate solution to determine the value of Faraday's constant. The results are shown below:

- Electrode reaction: $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$
- Current used in electrolysis: 0.81 A
- Time of electrolysis: 387 s
- Mass of copper deposited: 0.102 g

The value of Faraday's constant (in C mol^{-1}) calculated from the experiment is

A. 96 500

B. 96 800

C. 97 600

D. 98 700

The following information relates to Questions 13 to 15.

A number of experiments were conducted using various metals (Zn, Cu, Cr and Cd) and solutions of their ions. The results are shown in the table below.

Experiment	Result
I. cadmium and copper(I) nitrate solution	copper metal deposited
II. cadmium and zinc nitrate solution	no reaction
III. chromium and cadmium nitrate solution	cadmium metal deposited

Question 13

From the results in the table, the relative reducing strength of three of the metals can be deduced. Beginning with the weakest reductant, the order of increasing reductant strength is

A. Cd < Zn < Cr
B. Cu < Cr < Cd
C. Zn < Cd < Cu
D. Cu < Cd < Cr

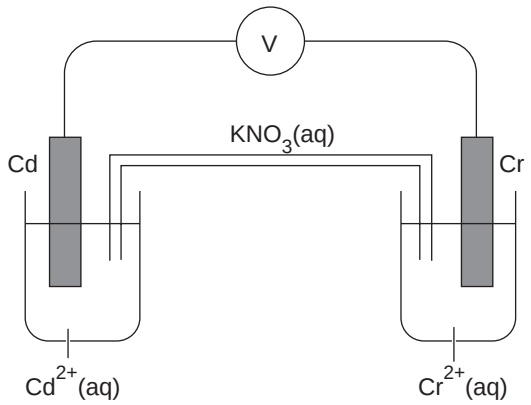
Question 14

Which additional experiment must be conducted to place all four metals in order of their reducing strength?

A. zinc and copper(I) nitrate solution
B. chromium and zinc nitrate solution
C. copper and cadmium nitrate solution
D. cadmium and chromium nitrate solution

Question 15

A galvanic cell is constructed using the results from experiment III.



Which one of the following statements about this galvanic cell is **incorrect**?

A. Electrons travel towards the Cd/Cd^{2+} half-cell where reduction occurs.
B. The chromium electrode is the anode and it will decrease in mass.
C. Negatively-charged ions will travel to the anode in the external circuit.
D. The total charge of the ions in both half-cells will remain constant.

Question 16

Two experiments were conducted to investigate the reaction shown in the following equation:

$$2X(g) + Y(g) \rightleftharpoons 2Z(g) \qquad \Delta H = -180 \text{ kJ mol}^{-1}$$

During each experiment, the temperature of the reaction mixture was held constant. Results obtained are shown in the table below.

Reagent	Experiment 1 equilibrium concentration (M)	Experiment 2 equilibrium concentration (M)
X	0.590	1.48
Y	0.0450	0.0446
Z	0.260	0.650

Based on the data provided it can be concluded that

A. both experiments were conducted at the same temperature.

B. experiment 2 was conducted at a higher temperature than experiment 1.

C. experiment 1 was conducted at a higher temperature than experiment 2.

D. the relationship between the temperatures of the two experiments is unknown.

Question 17

Silver(I) ions and iron(II) ions react according to the following equation:

$$Ag^{+}(aq) + Fe^{2+}(aq) \rightleftharpoons Ag(s) + Fe^{3+}(aq) \qquad K = 3.3 \text{ at } 25°C$$

A galvanic cell using $Ag^{+}(aq)/Ag(s)$ and $Fe^{3+}(aq)/Fe^{2+}(aq)$ half-cells at 25°C produces a voltage of 0.09V. This is three times the voltage predicted by the electrochemical series.

Consider the following statements:

I The electrochemical series does not give any indication of the rate of chemical reactions.

II The conditions used for the galvanic cell could not be standard conditions.

III As the reaction is an equilibrium reaction, the position of equilibrium can be affected by the relative concentrations of reactants and products.

Which of the above statements could explain the difference in predicted and actual voltages?

A. I and II only

B. II and III only

C. I and III only

D. I, II and III

Question 18

Which important feature of a secondary cell distinguishes it from other cell types?

A. A continuous supply of reactants are fed into the cell so that it operates without the need to interrupt the chemical reactions to regenerate depleted reactants.

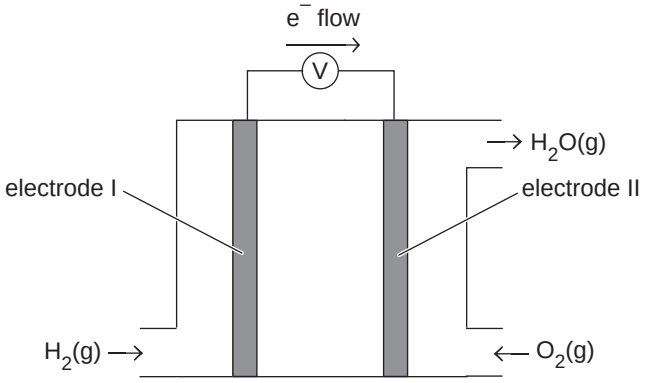
B. Limited amounts of reactants are present in the cell and once these are depleted the chemical reactions and electricity production cease.

C. The products of the cell reaction remain in contact with the electrodes so that once the reactants are used up it is possible for more reactants to be regenerated.

D. Spontaneous redox reactions occur which allow the movement of electrons through a wire connecting the half-cells, producing an electric current.

The following information relates to Questions 19 and 20

A simplified diagram of the phosphoric acid fuel cell (PAFC) is shown below.



The cell operates at 190°C using an electrolyte of liquid phosphoric acid. The electrode reactions are:

$$H_2(g) \rightarrow 2H^+(aq) + 2e^-$$

$$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(g)$$

Question 19

During operation of the PAFC, electrode I is

A. positively charged, and the pH near the electrode will increase.
B. positively charged, and the pH near the electrode will decrease.
C. negatively charged, and the pH near the electrode will increase.
D. negatively charged, and the pH near the electrode will decrease.

Question 20

Consider the following statements in regards to the PAFC:

I The electrodes are likely to be porous and have a catalytic function.

II More electrical energy will be produced in the PAFC for an equivalent mass of hydrogen, than using the fuel to produce steam for the generation of electricity by a turbine and generator.

III The water generated in the cell reaction will dilute the electrolyte progressively and lower the efficiency of the cell.

Which of the above statements about the PAFC are correct?

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

SECTION B: SHORT-ANSWER QUESTIONS

Instructions for Section B

Answer **all** questions in the spaces provided.

To obtain full marks for your responses you should

- give simplified answers with an appropriate number of significant figures to 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 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 highly toxic gaseous compound hydrogen cyanide (HCN) is manufactured in large quantities for use in the mining and petrochemical industries. The chemical reaction used in one manufacturing process is

$$\text{Reaction I: } CH_4(g) + NH_3(g) \rightleftharpoons HCN(g) + 3H_2(g) \qquad \Delta H = +251 \text{ kJ mol}^{-1}$$

The reaction occurs at 1400°C and atmospheric pressure in piping that is internally lined with platinum.

a. Complete the table below by stating one advantage and one disadvantage of each of the reaction conditions listed.

Reaction condition	Advantage	Disadvantage
reaction temperature of 1400°C		
atmospheric pressure		

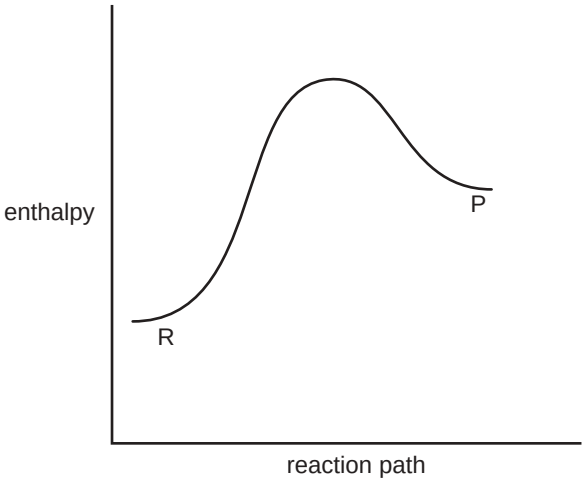
4 marks

b. **i.** Explain how lining the piping with platinum improves the effectiveness of platinum's catalytic role in the chemical reaction.

_____

_____

ii. The energy profile below represents the synthesis of HCN.



Draw on the diagram above any change to the profile that could be expected if the reaction was conducted in piping without the platinum lining.

1 + 1 = 2 marks

c. Research scientists have investigated other reactions producing HCN. The following chemical equation shows a promising alternative reaction:

Reaction II: $2CO(g) + NH_3(g) \rightleftharpoons HCN(g) + CO_2(g) + H_2(g)$ $\Delta H = +10 \text{ kJ mol}^{-1}$

i. Why is Reaction II a more sustainable method of manufacture of HCN than Reaction I?

_____

_____

ii. State a possible environmental problem presented by Reaction II.

_____

_____

1 + 1 = 2 marks

d. The hazardous nature of HCN gas is shown by this information:

- HCN concentrations of 300 mg m^{-3} of air are fatal to humans in ten minutes.
- HCN gas is explosive at concentrations over 5.6%.

Outline one specific safety precaution which must be taken in a HCN manufacturing plant to protect workers.

_____

_____

1 mark

e. During this semester you have studied the industrial production of a chemical of importance.

Circle the chemical you have chosen.

ammonia nitric acid sulfuric acid ethene

Answer the following questions for your chosen chemical.

Chemicals may behave as reductants, oxidants, acids or bases. Your chosen chemical exhibits one or more of these properties. Select one of these properties and write a balanced equation which shows your chosen chemical exhibiting this property.

i. Property exhibited

_____

ii. Equation showing the selected chemical exhibiting this property

_____

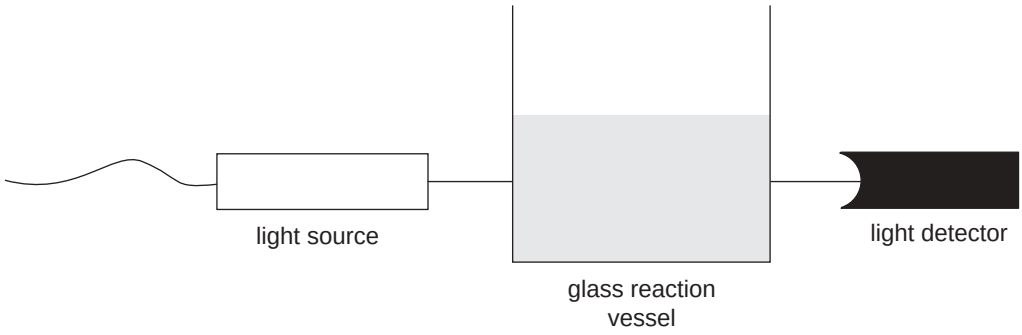
1 + 2 = 3 marks
Total 12 marks

Question 2

A series of experiments was performed in a fume cupboard to investigate the rate of the following reaction:

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

The formation of fine particles of solid sulfur caused the reaction mixture to become increasingly cloudy. This was detected by the reduction in the transmission of light through the reaction mixture using the equipment shown below.



The reaction was initiated by adding 10.0 mL of HCl (an excess) to 50.0 mL of sodium thiosulfate solution in the reaction vessel, and the transmission of light was measured.

In each experiment, the time taken for a 50% reduction in the light transmitted was measured.

a. The rate of some chemical reactions can be determined by measuring the volume of a gaseous product evolved over time.

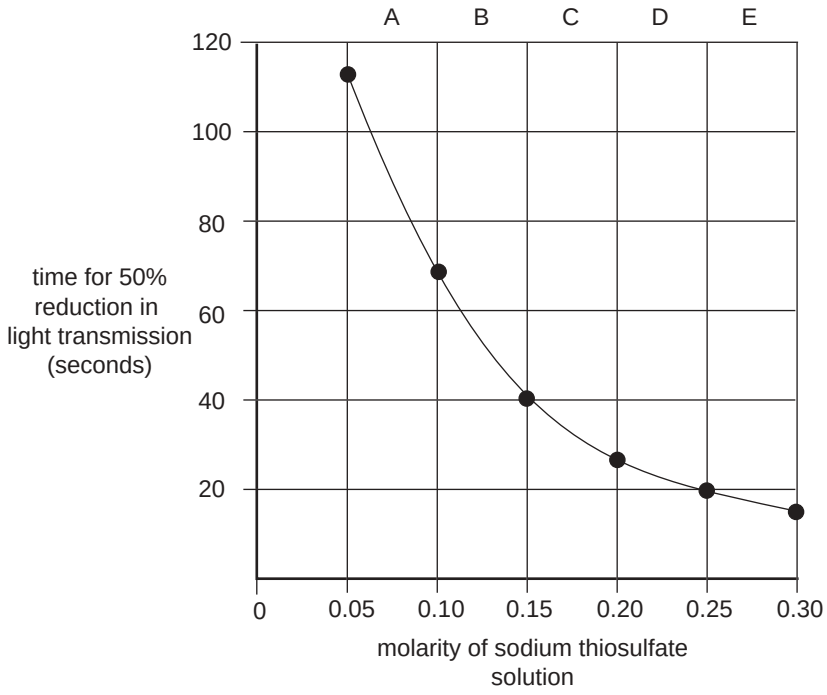
Suggest a reason why this method could not be used for the reaction in this experiment.

_____

_____

1 mark

b. The first experiment involved using different concentrations of sodium thiosulfate solution at 30°C. The results are displayed in the graph below.



The letters A to E represent sections of the graph between each of two plotted points.

i. In which section of the graph (A, B, C, D or E) is the average rate of reaction highest? Circle one of the letters below to indicate your response.

A B C D E

ii. Explain your reasoning for the answer given in part **i**.

_____

_____

_____

iii. Explain why the total volume of reactants in the glass reaction vessel must be kept constant when conducting this experiment.

_____

_____

_____

_____

1 + 1 + 2 = 4 marks

c. The experiment in part **b** was repeated under the same conditions, except that the temperature was 20°C. On the grid above, sketch a graph to show the expected results of this experiment.

1 mark

d. Using the same chemical reaction, the effect of increasing temperature on reaction rate was investigated. Analysis of the results revealed that the rate of reaction doubled for every 10°C rise in temperature.

Use collision theory to provide two reasons for the increase in reaction rate with increasing temperature.

_____

_____

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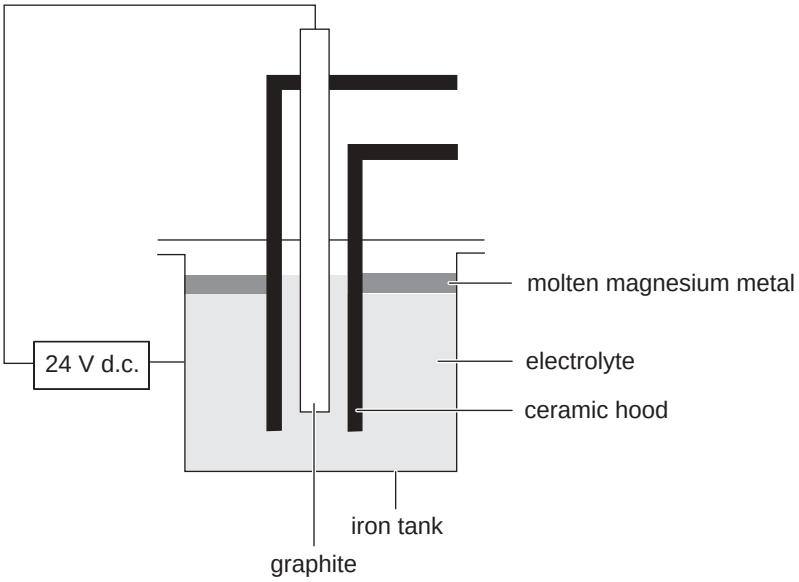
2 marks
Total 8 marks

Question 3

Magnesium is produced by the electrolysis of molten magnesium chloride. The diagram below shows the main features of the electrolytic cell which is used.



a. To obtain the magnesium chloride electrolyte, the following reaction is used:

$$MgO(s) + C(s) + Cl_2(g) \rightarrow MgCl_2(s) + CO(g)$$

Suggest one reason why molten magnesium oxide is not used directly in the electrolytic cell to produce magnesium.

_____

_____

_____

_____

2 marks

b. **i.** Write the half-equation for the process which occurs at the graphite electrode.

_____

ii. Tick one box in the table below to show the identity and polarity of the graphite electrode in the electrolytic cell shown above.

	Positive	Negative
Anode		
Cathode		

iii. Explain a likely role of the ceramic hood.

_____

_____

1 + 1 + 1 = 3 marks

c. It can be predicted from the electrochemical series that the magnesium ions in the electrolyte will not react with the iron tank.

i. What is the basis of this prediction?

_____

_____

_____

ii. This prediction could be unreliable. Explain why.

_____

_____

_____

1 + 2 = 3 marks

d. If the cell is 50% efficient, calculate the amount of energy (in MJ) used per mole of magnesium produced.

_____

_____

_____

_____

_____

4 marks

e. The country which produces magnesium at the cheapest price uses hydroelectricity. This energy source relies on the flow of water from dams through pipes that run downhill to turn turbines, and produce electricity.

i. Of the electricity produced worldwide, only about 25% is hydroelectricity. Give one reason why the development of this energy resource may be restricted.

_____

_____

ii. Apart from cost, give one advantage of hydroelectricity over using coal-fired power stations to generate electricity.

_____

_____

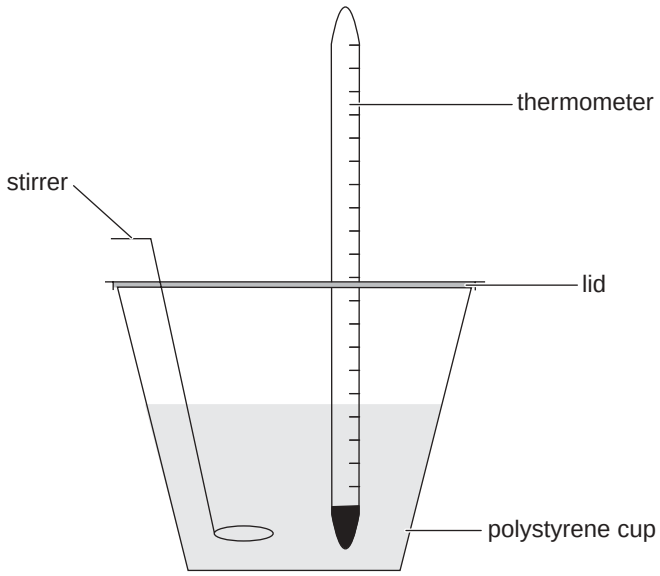
iii. Identify one energy conversion which occurs in producing hydroelectricity but not in generating electricity in a nuclear power station.

_____

1 + 1 + 1 = 3 marks
Total 15 marks

Question 4

Students conducted a series of experiments to determine the heat of neutralisation of various acids using a simple polystyrene cup 'calorimeter', as shown in the diagram below.



Each experiment involved adding 50.0 mL of 2.0 M acid to 50.0 mL of 2.0 M NaOH solution and using the stirrer to agitate the liquid. The highest temperature reached was recorded to determine the temperature change for the neutralisation reaction:

$$H_3O^+(aq) + OH^-(aq) \rightarrow 2H_2O(l)$$

a. When 2.0 M hydrochloric acid was used in the experiment, the temperature increased by 10.1°C.

i. Calculate the heat of neutralisation (in kJ mol^{-1}) for this reaction. You may assume that the specific heat capacity of the solution is the same as that of water.

_____

_____

_____

_____

_____

_____

ii. The magnitude of the accepted heat of neutralisation for this reaction is 57 kJ mol^{-1}.

Explain why the calculated value in part **i** is lower than this accepted value.

_____

_____

_____

3 + 1 = 4 marks

b. The experiment was repeated using 2.0 M sulfuric acid (H_2SO_4).

Explain what temperature change would be expected as a result of using 50.0 mL of sulfuric acid in place of the 50.0 mL of hydrochloric acid.

_____

_____

_____

2 marks

c. The experiment was also conducted using 2.0 M ethanoic acid (CH_3COOH).

i. Calculate the pH of the 2.0 M ethanoic acid solution.

_____

_____

_____

_____

_____

_____

ii. How would the value for the heat of neutralisation using ethanoic acid compare with that when using hydrochloric acid? Circle one of the responses below to indicate your answer.

greater than less than equal to

3 + 1 = 4 marks

d. The accuracy of the results could be improved by calibrating the polystyrene cup 'calorimeter'.

Electrical calibration is not practical in this instance.

Describe how the 'calorimeter' could be calibrated.

_____

_____

_____

_____

_____

2 marks

Total 12 marks

Question 5

An experiment was conducted to investigate the reaction between compound X and oxygen at 600°C, shown by the following equation:

$$2X(g) + O_2(g) \rightleftharpoons 2Z(g) \qquad K = 4.3M^{-1}$$

In a 5.0 L vessel the concentrations of the three chemicals present were as follows:

$$[X] = 0.164M \qquad [O_2] = 0.057M \qquad [Z] = 0.30M$$

a. Show that the system in the vessel is not at equilibrium.

_____

_____

_____

2 marks

b. When the system was allowed to reach equilibrium in the 5.0 L vessel at 600°C, the following concentrations were measured:

$$[X] = 0.274M \qquad [O_2] = 0.112M \qquad [Z] = 0.190M$$

The volume of the reaction vessel was then changed to 7.0 L, and the system allowed to return to equilibrium in the 7.0 L vessel at 600°C.

i. Determine the partial pressure of X inside the 5.0 L vessel at 600°C.

_____

_____

_____

ii. Determine the concentration (in M) of X in the vessel immediately after the change in volume to 7.0 L.

_____

_____

iii. Complete the following table to show the comparison of the value of each characteristic between the system in the 5.0 L vessel and the system in the 7.0 L vessel, both at 600°C.

Characteristic at equilibrium in the 5.0 L vessel	**Value is greater than, less than or equal to**	**Characteristic at equilibrium in the 7.0 L vessel**
total pressure		total pressure
total mass		total mass
molar concentration of X		molar concentration of X

2 + 1 + 3 = 6 marks

Total 8 marks

END OF QUESTION AND ANSWER BOOKLET