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ST. MARY'S DSG KLOOF

Physical Sciences

Paper 2

Chemistry

GRADE 12

Trials 2017

Time: 3 hours

Marks: 200

Examiner: K. Bolton

Moderators: T. Kirsten and G. Main

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of 19 pages, a yellow Answer Sheet of 1 page and a green Data Sheet of 3 pages (i–iii).
2. Please make sure that your question paper is complete.
3. Write your examination number on the yellow Answer Sheet.
4. Read the questions carefully.
5. ALL of the questions in this paper must be answered.
6. Question 1 consists of 10 multiple-choice questions. There is only one correct answer to each question. The questions must be answered on the answer grid provided on the Answer Sheet. The letter that corresponds with your choice of the correct answer must be marked with a cross as shown in the example below:

A	B	C	D
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Here the answer C has been marked

7. Please ensure that you number your answers as the questions are numbered.
8. Use the data and formulae whenever necessary.
9. You may use an approved, non-programmable and non-graphical calculator, unless otherwise stated.
10. Show the necessary steps in calculations.
11. Where appropriate take your answers to 2 decimal places.
12. It is in your own interest to write legibly and to set your work out neatly.
13. Start every question on a new page.
14. Answers are to be collated in three separate parts:
 1. Question 1 (answer sheet), 3 and 4
 2. Question 2 and 8
 3. Question 5-7

ACKNOWLEDGEMENTS:

DBE MAY/JUN 2016 P2

DBE FEB/MAR 2016 P2

DBE JUN 2017 P2

IEB Supplementary 2017 P2

WJEC GCE A level Jun 2016

WJEC GCSE May 2016

WJEC GCE AS/A level May 2012

Cambridge Pre-U Certificate May/June 2015

Cambridge GCSE Chemistry May/June 2015

Sacred Heart 2016

Bishop Bavin 2016

QUESTION 1 – MULTIPLE CHOICE

Answer these questions on the multiple-choice answer grid on your Answer Sheet. Make a cross (X) in the box corresponding to the letter that you consider to be correct.

- 1.1 Which one of the following gives the correct number of atoms in 10 g of $\text{NH}_3(\text{g})$?
- A $\frac{10}{10} \times 6,02 \times 10^{23} \times 4$
- B $\frac{10}{17} \times 4$
- C $\frac{10}{17} \times 6,02 \times 10^{23} \times 4$
- D $\frac{10}{17} \times 6,02 \times 10^{23}$
- 1.2 An atom, group of atoms or a bond that gives a group of organic compounds its characteristic physical and chemical properties is called a ...
- A isomer.
- B monomer.
- C homologous series.
- D functional group.
- 1.3 In a chemical reaction, the difference between the potential energy of the products and the potential energy of the reactants is equal to the ...
- A enthalpy of the reaction.
- B enthalpy change of the reaction.
- C rate of the reaction.
- D total potential energy of the particles.

- 1.4 The activation energy for a certain reaction is $50 \text{ kJ}\cdot\text{mol}^{-1}$. Energy is absorbed when this reaction takes place.

Which ONE of the following is CORRECT for the REVERSE reaction?

	ACTIVATION ENERGY (E_A)	HEAT OF REACTION (ΔH)
A	$E_A > 50 \text{ kJ}\cdot\text{mol}^{-1}$	$\Delta H > 0$
B	$E_A > 50 \text{ kJ}\cdot\text{mol}^{-1}$	$\Delta H < 0$
C	$E_A < 50 \text{ kJ}\cdot\text{mol}^{-1}$	$\Delta H < 0$
D	$E_A < 50 \text{ kJ}\cdot\text{mol}^{-1}$	$\Delta H > 0$

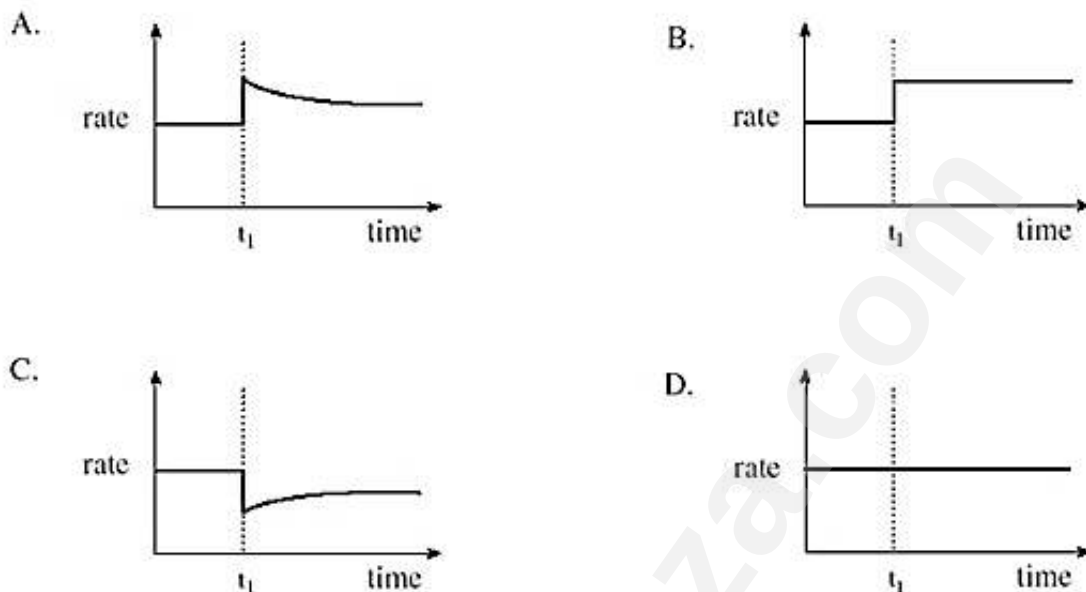
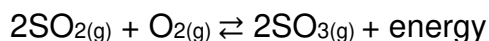
- 1.5 HPO_4^{2-} can act as an ampholyte. In which one of the following reactions does HPO_4^{2-} act as a Lowry-Bronsted acid?

- A $\text{HPO}_4^{2-} + \text{H}_2\text{O} \rightarrow \text{PO}_4^{3-} + \text{H}_3\text{O}^+$
 B $\text{HPO}_4^{2-} + \text{HPO}_4^{2-} \rightarrow 2 \text{HPO}_4^{2-}$
 C $\text{HPO}_4^{2-} + \text{H}_2\text{O} \rightarrow \text{H}_2\text{PO}_4^- + \text{OH}^-$
 D $\text{HPO}_4^{2-} + \text{H}^+ \rightarrow \text{H}_2\text{PO}_4^-$

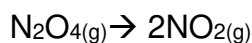
- 1.6 The pH of a solution of NaOH is 10,5. What is the correct proportion of the following ions in this solution?

- A $[\text{OH}^-] = [\text{H}_3\text{O}^+]$
 B $[\text{Na}^+] > [\text{OH}^-]$
 C $[\text{H}_3\text{O}^+] < [\text{OH}^-]$
 D $[\text{OH}^-] < [\text{H}_3\text{O}^+]$

- 1.7 Which of the graphs below shows the reverse rate of reaction for the reaction that follows when a catalyst is added to the equilibrium at time = t_1 ?



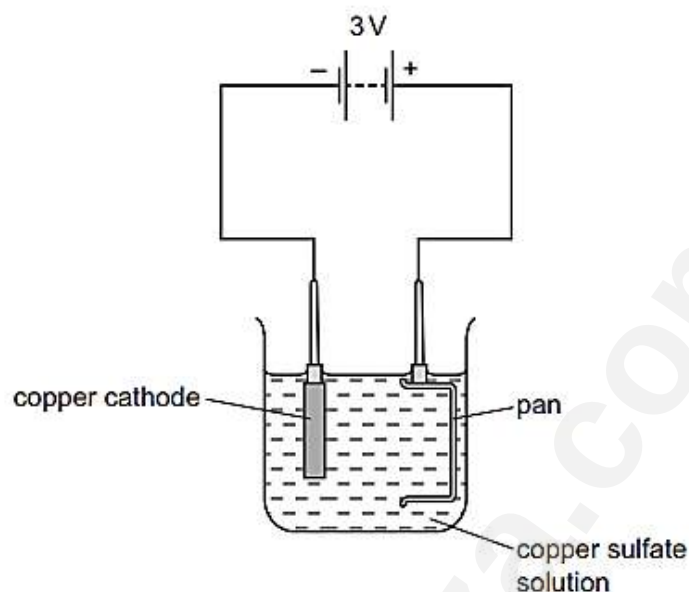
- 1.8 1 mole of $\text{N}_2\text{O}_{4(g)}$ was placed in an empty 1 dm^3 container and allowed to reach equilibrium according to the following equation:



At equilibrium, x mole of $\text{N}_2\text{O}_{4(g)}$ had dissociated. What is the value of the equilibrium constant, K_c , at the temperature of the experiment?

- A $\frac{2x}{1-x}$
- B $\frac{2x}{(1-x)^2}$
- C $\frac{4x^2}{1-x}$
- D $\frac{x^2}{1-x}$

- 1.9 The diagram shows a failed attempt to copper-plate a pan. Which action will plate the pan with copper?



- A Add solid copper (II) sulfate to the electrolyte.
 B Increase the temperature of the electrolyte.
 C Replace the copper electrode with a carbon electrode.
 D Reverse the connections to the battery.
- 1.10 Which ONE of the following is formed at the cathode in the cell used to recover aluminium from bauxite?

- A Oxygen
 B Aluminium
 C Carbon dioxide
 D Carbon

[2x10=20]

QUESTION 2 – CHEMICAL BONDING

2.1 Name the following compounds:



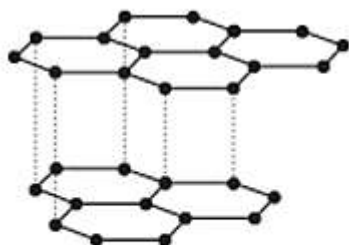
2.2 Write the formula of each of the following compounds:

2.2.1 Iron (III) permanganate

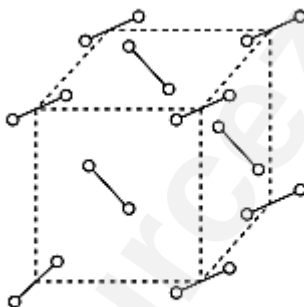
2.2.2 Manganese (IV) sulphide (4)

2.3 The diagrams below show the structures of solid graphite, iodine and diamond.

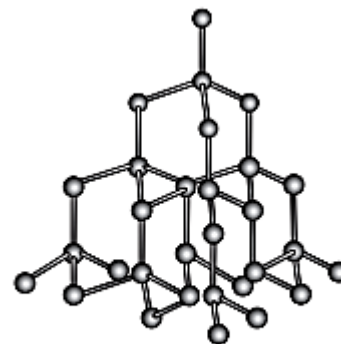
Both diamond and graphite have giant covalent structures. Use these diagrams to help you explain the following questions.



Graphite



Iodine



Diamond

2.3.1 Describe the type of bonding in graphite and diamond. (3)

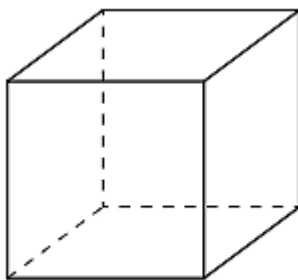
2.3.2 Name the two solids that cannot conduct electricity. (2)

2.3.3 Draw a Lewis diagram to show the bonding in iodine. (2)

2.3.4 Explain why solid iodine can be converted into a vapour at a much lower temperature than diamond. Diamond does not vaporise until about 3550°C .

(4)

- 2.4 Potassium iodide has the same cubic crystal lattice structure as sodium chloride. Use the diagram below to help you answer the questions that follow.

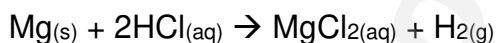


- 2.4.1 Identify the particles which make up the crystal lattice structure in potassium iodide and identify the type of bonding in potassium iodide. (3)
- 2.4.2 Potassium iodide is soluble in water whereas iodine is not. By referring to the relevant intermolecular forces in your answer, explain why this is so. (4)

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QUESTION 3 – ENERGY CHANGE AND REACTION RATES

Judith carried out three experiments to study the reaction between powdered magnesium and hydrochloric acid. The equation for the reaction is given below.



She used a gas syringe to measure the volume of hydrogen evolved, at standard temperature and pressure, at set intervals. In each case, the amount of acid used was sufficient to react with all the magnesium.

The details of each experiment are shown in Table 1 below.

Table 1: Details of each experiment A-C

Experiment	Mass of magnesium / g	Volume of HCl / cm ³	Concentration of HCl / mol dm ⁻³
A	0.061	40.0	0.50
B	0.101	40.0	1.00
C	0.101	20.0	2.00

The results obtained in experiment **C** are shown in Table 2 below.

Table 2: Results obtained in each experiment

Time / s	Volume of hydrogen / cm ³
0	0
20	50
40	75
60	88
80	94
100	100
120	100

The results for experiments **A** and **B** have already been plotted on the grid on your ANSWER SHEET.

3.1.1 On the same grid, plot the results for experiment **C** and draw a trend line. (2)

3.1.2 State in which experiment the reaction begins most rapidly and **use the graph** to explain your choice. (2)

3.1.3 By referring to Table 1, and the collision theory give an explanation for your answer in Q 3.1.2. (3)

3.1.4 State the volume of hydrogen evolved after 30 seconds in experiment **B**. (2)

3.1.5 Define the term *reaction rate*. (2)

3.1.6 Use information from graph B to calculate the average rate of the reaction in Experiment B over the first 132 s. Give your answer in units of mol of H₂ gas per second (mol.s⁻¹). The experiment was done at STP. Give your answer to 3 decimal places. (4)

3.1.7 Using **only** the values in Table 1 and suitable calculations, show that the acid is in excess in experiment **C**. (5)

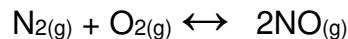
3.1.8 In experiment **A**, 0,061 g of magnesium produces 60 cm³ of hydrogen. If 0,122 g of magnesium were used, under the same conditions, then 120 cm³ would be produced. Explain why using 0,610 g would not produce 600 cm³ of hydrogen. (2)

3.1.9 State one method of slowing down the reaction in experiment **C**. Assume that the quantities of magnesium and hydrochloric acid are the same as those in Table 1. (2)

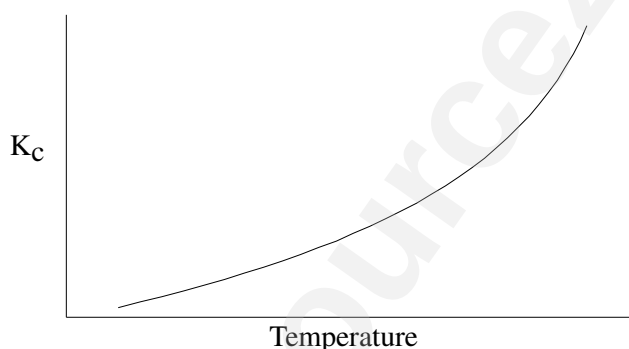
[24]

QUESTION 4 – EQUILIBRIUM

- 4.1 As a first step in the manufacture of nitric acid it has been suggested that nitrogen monoxide, NO, can be formed from nitrogen and oxygen in a reversible reaction according to the equation below.



- 4.1.1 State *Le Chatelier's principle*. (3)
- 4.1.2 Explain whether reducing the volume of the reaction container will increase the yield of nitrogen monoxide that is obtained? Explain by referring to Le Chatelier's principle. (5)
- 4.1.3 Write an expression for the equilibrium constant, K_c . (2)
- 4.1.4 The sketch graph below shows how the value of K_c for this reaction changes with temperature.



Use this graph to deduce whether the FORWARD reaction is exothermic or endothermic. Explain your answer. (5)

- 4.2 In an experiment, 1 mol of gas X and 1 mol of gas Y is introduced into a container at a certain temperature. The container is then sealed and gas X and gas Y react to form gas Z. The reaction taking place reaches dynamic chemical equilibrium for the first time after a period of 20 s.

The number of moles of each gas present with time over 30 s is given in the table below.

Time (s)	Number of moles of gas (mol)		
	Gas X	Gas Y	Gas Z
0	1	1	0
5	0,86	0,63	0,25
10	0,82	0,44	0,37
15	0,79	0,36	0,43
20	0,78	0,34	0,44
25	0,78	0,34	0,44
30	0,78	0,34	0,44

- 4.2.1 State what is meant by dynamic chemical equilibrium. (2)
- 4.2.2 How can one tell from the data that the system has reached dynamic chemical equilibrium after a time period of 20 s? (1)

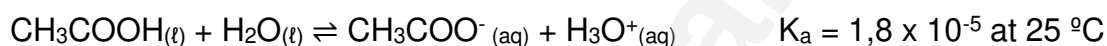
The **incomplete** graph on your ANSWER SHEET shows the number of moles of gas X and gas Z over the period 0 to 30 s. Certain information has been omitted from the graph.

- 4.2.3 Complete the graph by providing the information requested below.
- 4.2.3.1 Write down a suitable heading for the graph on the lines provided above the graph on your ANSWER SHEET. (1)
- 4.2.3.2 Write down a suitable label for the x-axis in the empty block provided on your ANSWER SHEET. (2)
- 4.2.3.3 Determine the scale used on the y-axis and fill in the numbers in the empty blocks provided on your ANSWER SHEET. (1)

- 4.2.3.4 Draw a best fit line graph, on the same set of axes, to represent the number of moles of gas **Y** over the period 0 to 30 s. Use of a SHARP, DARK PENCIL is recommended. (3)
- 4.2.4 Copy the equation given below for the formation of gas **Z** and use the data and the graph to deduce the missing coefficients required to balance the chemical equation. (3)
- $$\underline{\quad} \text{X} + \underline{\quad} \text{Y} \rightleftharpoons \underline{\quad} \text{Z}$$
- [28]

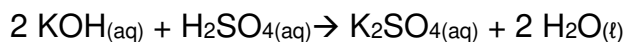
QUESTION 5 – ACIDS AND BASES

- 5.1 Ethanoic acid is a monoprotic acid that ionises in water according to the equation.



- 5.1.1 Give the Bronsted-Lowry definition for an acid. (2)
- 5.1.2 Explain the term *monoprotic*. (1)
- 5.1.3 Write down the NAME or FORMULA of the conjugate base of ethanoic acid. (1)
- 5.1.4 Is ethanoic acid a STRONG or WEAK acid? Refer to the given information to give a reason. (2)
- 5.2 A certain compound has sodium carbonate (Na_2CO_3) as the main ingredient. To determine the amount of sodium carbonate present in the impure sample of the compound, 100 cm^3 of a $0,8 \text{ mol.dm}^{-3}$ solution of sulphuric acid was added to the sample in a flask.
- The sulphuric acid solution is in EXCESS. The impurities do not react with the sulphuric acid.**
- The equation below shows the reaction taking place in the flask.
- $$\text{Na}_2\text{CO}_{3(\text{s})} + \text{H}_2\text{SO}_{4(\text{aq})} \rightarrow \text{Na}_2\text{SO}_{4(\text{aq})} + \text{CO}_{2(\text{g})} + \text{H}_2\text{O}_{(\text{l})} \quad \text{Reaction 1}$$
- 5.2.1 Calculate the number in moles of sulphuric acid added to the flask. (3)

In a titration exactly 35 cm^3 of a $0,3 \text{ mol.dm}^{-3}$ potassium hydroxide solution neutralises the excess amount of sulphuric acid left over in **Reaction 1** according to the balanced equation shown below.



Reaction 2

- 5.2.2 The choice of indicator used in the titration is dependent on the end-point of the neutralisation reaction (which is determined by the hydrolysis of the salt formed). The table below lists three common indicators and the pH range in which they are most effective:

Indicator	pH range
Methyl Orange	3,2 – 4,4
Bromothymol Blue	6,0 – 7,6
Phenolphthalein	8,2 – 10,0

Predict the approximate pH of the solution at the end-point of the titration of sulphuric acid with potassium hydroxide and hence state which indicator would be most suitable for this titration. (2)

- 5.2.3 Calculate the number of moles of sulphuric acid that were neutralised by the potassium hydroxide solution. (4)

- 5.2.4 Calculate the mass of sodium carbonate present in the impure sample. (4)

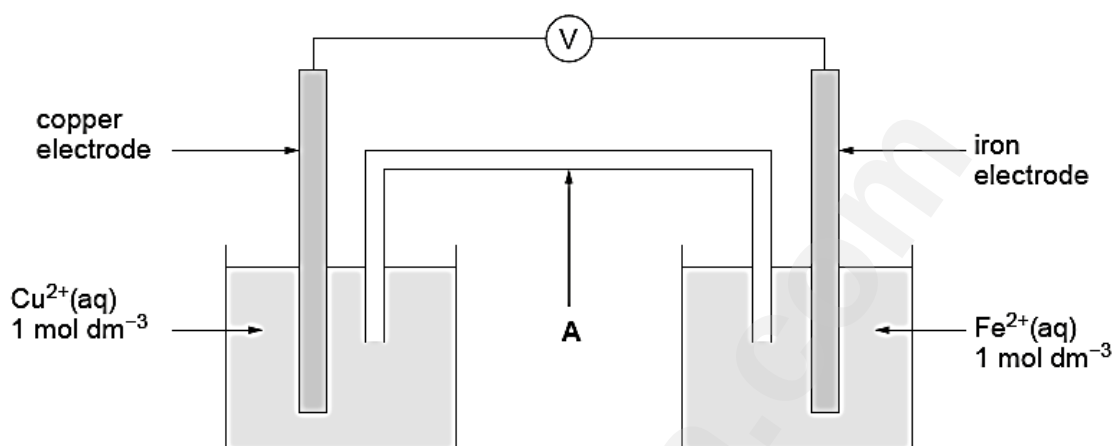
- 5.2.5 Define *hydrolysis* of a salt. (2)

- 5.2.6 Using suitable equations, explain whether sodium carbonate is a weakly basic or weakly acidic salt. (4)

[25]

QUESTION 6 – GALVANIC CELL

The diagram below shows the apparatus that was used to measure the emf of a Cu^{2+}/Cu , Fe^{2+}/Fe electrochemical cell.



Some standard electrode potentials, E^θ , are given below.

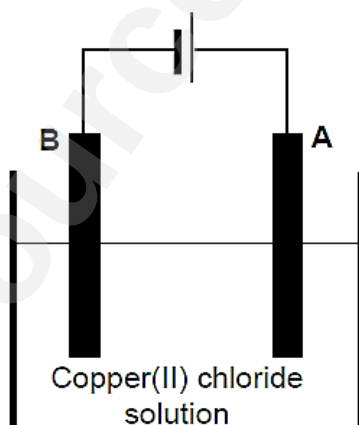
System	E^θ/V
$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Cu}(\text{s})$	+0.34
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Fe}(\text{s})$	-0.44
$\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Ni}(\text{s})$	-0.25

- 6.1 Define the term *cathode*. (2)
- 6.2 Name the part of the cell labelled **A** and state its purpose. (3)
- 6.3 State, giving a reason, which of the electrodes will be the positive terminal in the above cell. (2)
- 6.4 Calculate the standard emf, in volts, for the above cell. (2)
- 6.5 Write down the cell notation for this galvanic cell. Standard conditions do not need to be shown. (3)
- 6.6 Why is it important that the solution in **A** is concentrated? (2)

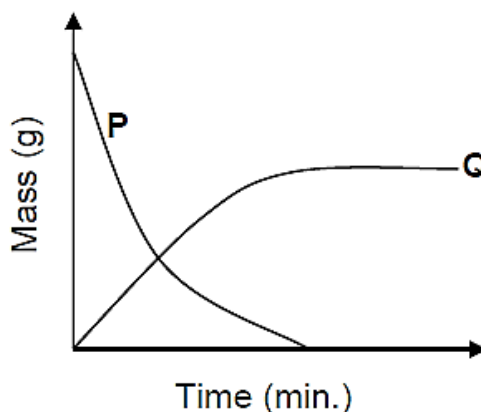
- 6.7 The copper and iron electrodes are replaced with larger electrodes. State the effect of making this change on: (Answer only INCREASES, DECREASES OR NO EFFECT)
- 6.7.1 The current supplied by the cell. (1)
- 6.7.2 The EMF of the cell. (1)
- 6.8 Some granular (solid) CuSO_4 is dissolved in the electrolyte in the copper half-cell. State the effect of making this change on the EMF of the cell. Fully explain your answer. (3)
- 6.9 State whether or not you would expect nickel to react with iron (II) ions. Give a reason for your answer. (2)
- [21]**

QUESTION 7 – ELECTROLYSIS

The diagram below represents an electrochemical cell used to purify copper.

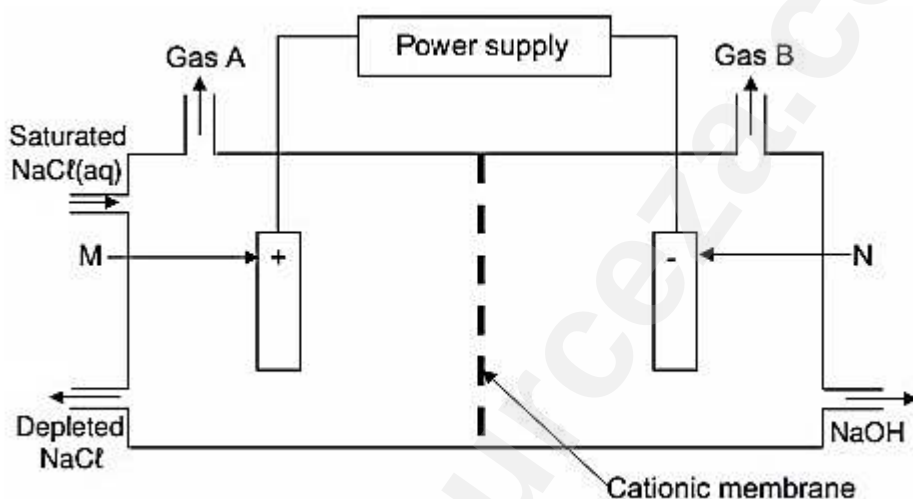


The graph below shows the change in mass of the electrodes whilst the cell is in operation.



- 7.1.1 Define a *reducing agent* in terms of electron transfer. (2)
- 7.1.2 Which graph represents the change in mass of electrode A? (2)
- 7.1.3 Write down the half-reaction that takes place at electrode B. (2)
- 7.1.4 Electrodes A and B are now replaced by graphite electrodes. It is observed that chlorine gas (Cl_2) is released at one of the electrodes. At which electrode (A or B) is chlorine gas formed? Fully explain how it is formed. (3)

7.2 The diagram below shows a type of membrane cell used in the chlor-alkali industry.



- 7.2.1 Name the gases A and B. (2)
- 7.2.2 Why is the membrane called a cationic membrane? (2)
- 7.2.3 Write down the half-reaction that takes place at electrode N. (2)
- 7.2.4 Apart from its use in household products, name ONE industrial use of chlorine. (1)
- 7.2.5 Explain why this electrolytic process cannot be done in one large container without a membrane. (2)
- 7.2.6 Give ONE reason why it is not advisable to build a chlor-alkali plant close to a residential area. (1)

[19]

QUESTION 8 – ORGANIC CHEMISTRY

8.1 The letters **A** to **J** in the table represent ten organic compounds:

A	<pre> H H H H H — C — C — C — C — H H H C — H H </pre>	B	<pre> H H — C — H H H H — C — C — C — H H H H </pre>
C	<pre> H H H H H H — C — C — C — C — C — H H H H H H </pre>	D	<pre> H H H H H H — C — C — C = C — C — H H H H </pre>
E	<pre> H H — C — H H H H H — C — C — C — C — H H H H H </pre>	F	<pre> Br CH₃CHCHCH₂CH₂CH₃ CH₂CH₃ </pre>
G	C₅H₁₂O	H	Methyl ethanoate
I	2,3-dimethylbutane	J	Ethanoic acid

8.1.1 Draw the structural formula of the isomer of C₅H₁₂ **not** shown. (2)

8.1.2 Name the compound drawn in Q 8.1.1 (2)

8.1.3 Describe a chemical test to distinguish between compounds **C** and **D**. (3)

8.1.4 Write down the:

8.1.4.1 HOMOLOGOUS SERIES to which compound **F** belongs (1)

8.1.4.2 NAME of the functional group found in compound **J** (1)

8.1.5 Write down the IUPAC name of:

8.1.5.1 Compound **F** (3)

8.1.5.2 Compound **G** (2)

8.1.5.3 A FUNCTIONAL ISOMER of compound **J** (2)

8.1.6 Compound **H** is prepared from the reaction of a carboxylic acid and an alcohol in the presence of an inorganic acid catalyst. A water bath is used to heat the reaction mixture. Write down the:

8.1.6.1 NAME or FORMULA of the inorganic acid catalyst (1)

8.1.6.2 MOLECULAR FORMULA of compound **H** (2)

8.1.7 Write down the NAME of the TWO products formed during the complete combustion of compound **I**. (2)

8.2 The flow diagram below shows three organic reactions that involve the compound 2-bromobutane.

Reaction A: Alkane + **Y** → 2-bromobutane + HBr

Reaction B: 2-bromobutane + KOH → Compound **X** + KBr + H₂O

Reaction C: 2-bromobutane + KOH → Alcohol + KBr

8.2.1 Write down the type of reaction represented by:

8.2.1.1 Reaction **A** (1)

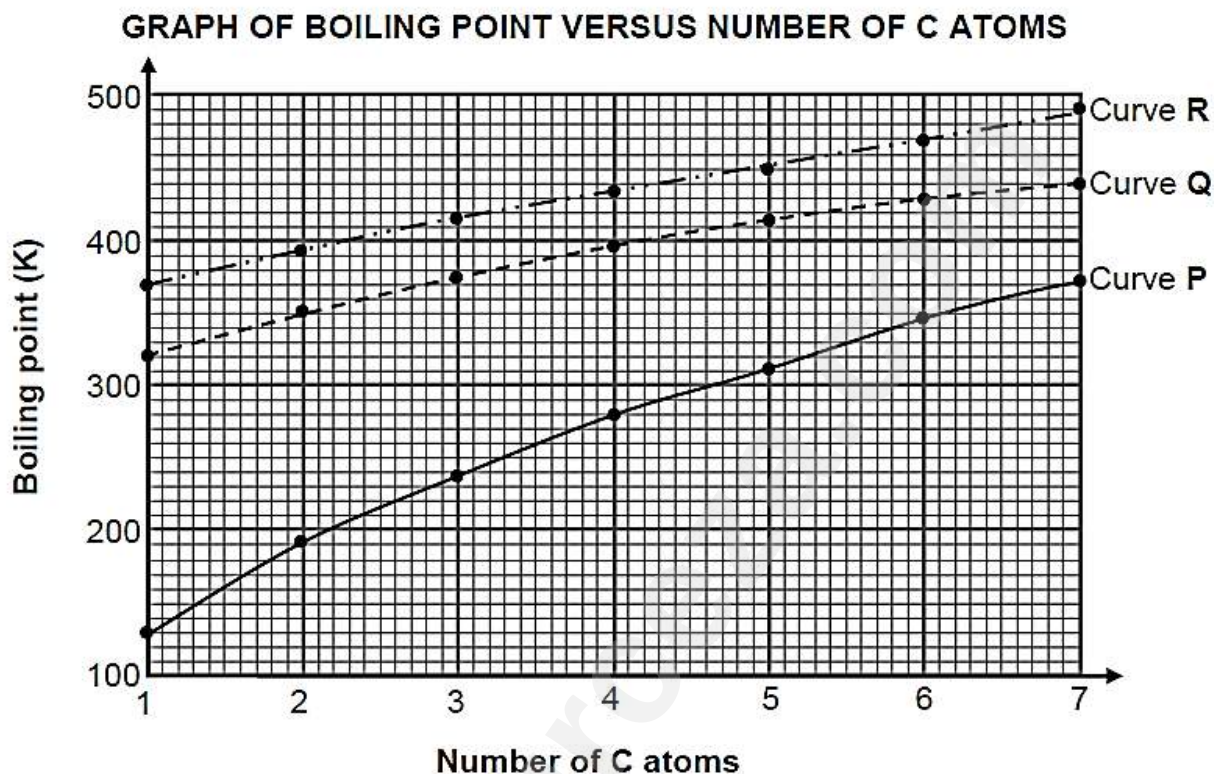
8.2.1.2 Reaction **B** (1)

8.2.2 For reaction **A**, write down the NAME or FORMULA of the inorganic reagent **Y**. (1)

8.2.3 Write down the STRUCTURAL FORMULA of compound **X**, the major organic product produced in reaction **B**. (2)

8.2.4 Write down the STRUCTURAL FORMULA of the alcohol produced in reaction **C**. (2)

- 8.3 The relationship between boiling point and the number of carbon atoms in straight chain molecules of alkanes, carboxylic acids and alcohols is investigated. Curves **P**, **Q** and **R** are obtained.



- 8.3.1 For curve P, write down a conclusion that can be drawn from the above results.

(2)

- 8.3.2 Identify the curve (P, Q or R) that represents each of the following:

8.3.2.1 Alkanes

(1)

8.3.2.2 Carboxylic acids

(1)

- 8.3.2.3 Explain the answer to Q 8.3.2.1 and Q 8.3.2.2 by referring to the:

- Types of intermolecular forces present in alkanes, carboxylic acids and alcohols
- Relative strengths of these intermolecular forces
- Energy needed

(5)

[37]