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ST. MARY'S DSG KLOOF

Physical Sciences

Paper 2

**GRADE 12
Trials 2018**

Chemistry

**Time: 3 hours
Marks: 200**

Examiner: K. Bolton

Moderator: G. Main

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of 20 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 a new page where instructed in question paper so answers can be collated as per point 14 below.
14. Answers are to be collated in three separate parts:
 1. Question 1 (answer sheet)-3
 2. Question 4-5, and question 10
 3. Question 6-9

ACKNOWLEDGEMENTS:

AS CHEMISTRY May 2017 AQA

AS CHEMISTRY Paper 2: Organic and Physical Chemistry June 2017

WJEC GCE AS – NEW AS B410U20-1 CHEMISTRY – Component 2 June 2016

WJEC GCE AS/A LEVEL CHEMISTRY – Specimen paper Unit 1 2016

AS Level Chemistry B (Salters) H033/02 2016

OCR 2014 H433/01A Level Chemistry B (Salters) H433/01 Sample paper

AS Level Chemistry B OCR May 2016

AQA Paper 2 June 2017

St Alban's College Prelim P2 2017

GCE AS/A LEVEL CHEMISTRY AS UNIT 2 SPECIMEN PAPER 2016

GCE A LEVEL CHEMISTRY A2 UNIT 3 specimen paper 2016

DBE/Feb.–Mar. 2017

CHEMISTRY Cambridge International Examinations Cambridge International
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2017

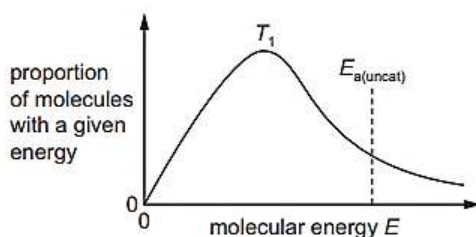
Cambridge International General Certificate of Secondary Education CHEMISTRY
Paper 1 Multiple Choice (Core) May/June 2016

Cambridge International General Certificate of Secondary Education CHEMISTRY
0620/21 Paper 2 Multiple Choice (Extended) May/June 2016

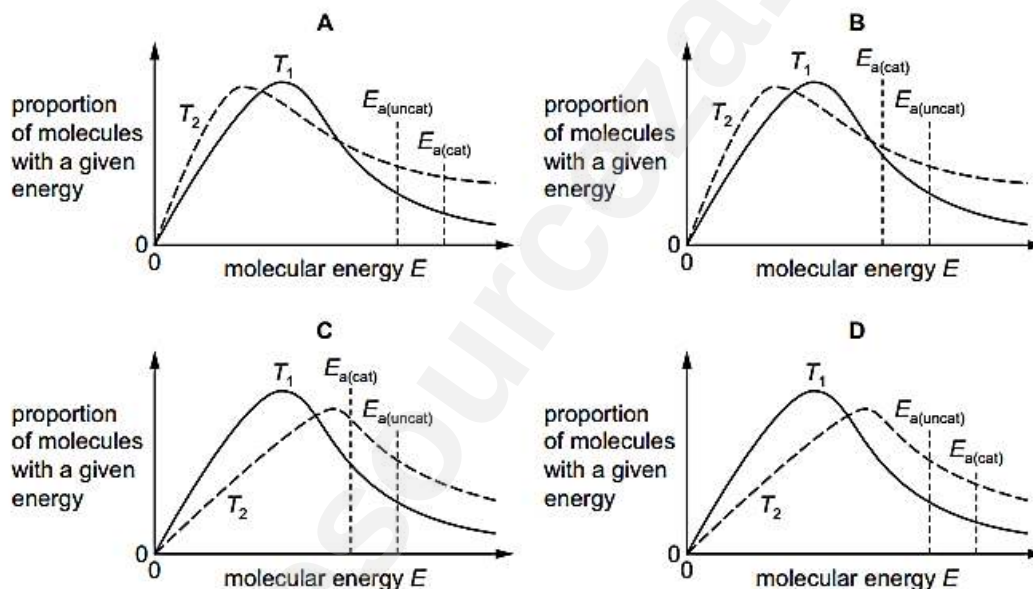
QUESTION 1 – MULTIPLE CHOICE - Answer these questions on the multiple-choice answer grid on your Answer Sheet. Make a cross (X) in the box corresponding to the letter that you consider to be correct.

- 1.1 In a 20 g sample of molecules, which sample below has the greatest number of moles?
- A NH_3
 - B N_2
 - C CO_2
 - D H_2
- 1.2 Which statement describes the attractive forces between molecules (intermolecular forces)?
- A They are strong covalent bonds which hold molecules together.
 - B They are strong ionic bonds which hold molecules together.
 - C They are weak forces formed between covalently-bonded molecules.
 - D They are weak forces which hold ions together in a lattice.

- 1.3 The diagram shows the distribution of molecular energies in a sample of gas at a temperature T_1 . The activation energy for an uncatalysed reaction of this gas, $E_{a(\text{uncat})}$, is shown.



Which diagram correctly shows the new distribution and new activation energy, $E_{a(\text{cat})}$, when the temperature is increased to T_2 , and a catalyst is used that increases the rate of the reaction?



- 1.4 Ammonia is formed by a reversible reaction. $\text{N}_{2(\text{g})} + 3\text{H}_{2(\text{g})} \rightleftharpoons 2\text{NH}_{3(\text{g})}$ The forward reaction is exothermic. Which changes in conditions would increase the yield of ammonia?

	increase in pressure	increase in temperature
A	✓	✓
B	✓	x
C	x	✓
D	x	x

1.5 Consider the following:

I.	PO_4^{3-}
II.	HPO_4^{2-}
III.	H_2PO_4^-
IV.	H_3PO_4

The term amphiprotic can be used to describe

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

1.6 Which statement is always correct for an oxidation reaction?

- A It involves the gain of oxygen by an element.
- B For one reactant to be oxidised a different reactant must be reduced.
- C The element or ion being oxidised will gain electrons.
- D The oxidation number of the element being oxidised will increase.

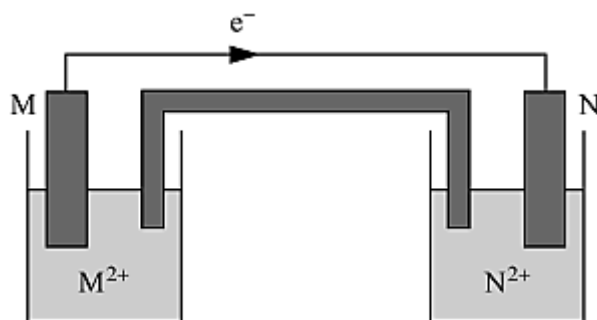
1.7 Solutions containing chlorate(I) ions are used as household bleaches and disinfectants. These solutions decompose on heating as shown.



Which oxidation state is shown by chlorine in each of these three ions?

	ClO^-	ClO_3^-	Cl^-
A	+1	+3	-1
B	-1	+3	+1
C	+1	+5	-1
D	-1	+5	+1

1.8 Which of the following is true of the cell represented below?



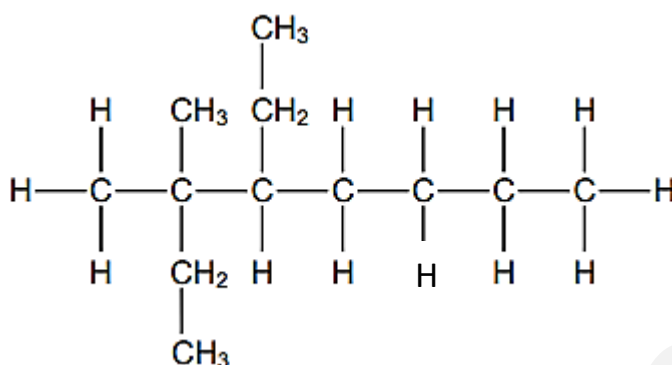
- A Metal M is being oxidised
- B Metal N is the reducing agent
- C N^{2+} ions are being oxidised
- D M^{2+} are being reduced

1.9 Which of the compounds shown in the table below are in the same homologous series?

1	CH_3OH
2	CH_3CH_2OH
3	CH_3COOH
4	$CH_3CH_2CH_2OH$

- A 1, 2 and 3
- B 1, 2 and 4
- C 1, 3 and 4
- D 2, 3 and 4

1.10 Choose the correct name for the compound below:



- A 4-ethyl-3,3-dimethyloctane
- B 2,3-diethyl-2-methylheptane
- C 5,6-diethyl-6-methylheptane
- D 5-ethyl-6,6-dimethyloctane

[2x10=20]

QUESTION 2 – CHEMICAL BONDING

2.1 Write down the formula for:

2.1.1 the dichromate ion

2.1.2 potassium sulphite

2.1.3 ammonium hydroxide

(6)

2.2 Draw a Lewis diagram to show the bond formation in magnesium fluoride.(3)

- 2.3 The melting temperature and electrical conductivity were measured for the following five substances. The results of the experiment are shown in the table:

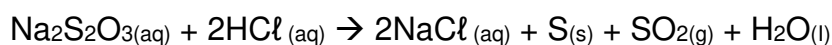
Substance	Melting temperature / °C	Conditions required for electrical conductivity
A	3550	does not conduct in any state
B	801	conducts when molten
C	3642	conducts as a solid
D	1535	conducts as a solid
E	114	does not conduct in any state

- 2.3.1 Write down the letter of the substance which you conclude is sodium chloride. State, explaining how you reached your conclusion, which of the substances is sodium chloride. (2)
- 2.3.2.1 Write down the letters of the two substances which are diamond and iodine. (2)
- 2.3.2.2 State which of the above physical properties would allow you to distinguish between these two solids. Include in your answer the reasons for the two solids behaving differently. (4)
- 2.3.3 Describe a different physical property which could be used to distinguish between iodine and sodium chloride. (2)

[19]

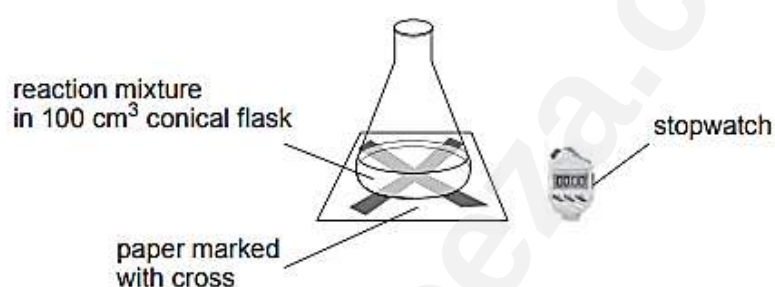
QUESTION 3 – ENERGY CHANGE AND REACTION RATES

Sodium thiosulfate solution reacts with hydrochloric acid to produce a precipitate of sulfur. The equation for the reaction is:



Beverly is asked to investigate the effect of changing the concentration of sodium thiosulfate solution on the rate of reaction. She is given 1 mol.dm^{-3} hydrochloric acid and told to make exactly 250 cm^3 of $0,2 \text{ mol.dm}^{-3}$ sodium thiosulfate solution.

She sets up the apparatus shown below.



In the first experiment, she uses an excess of acid (10 cm^3) and 30 cm^3 of sodium thiosulfate solution.

She starts the stopwatch when the acid is added to the sodium thiosulfate solution in the flask and stops it when she can no longer see the cross on the paper.

She rinses the flask thoroughly and repeats the experiment four times using different concentrations of sodium thiosulfate solution. Each time she uses 10 cm^3 of acid and 30 cm^3 of sodium thiosulfate solution and records the time taken for the cross to disappear.

Since the rate is inversely proportional to the time taken, she calculates $1/\text{time}$ for each concentration and obtains the following results.

Experiment	$\text{Na}_2\text{S}_2\text{O}_3$ concentration (mol.dm^{-3})	$1/\text{time} (\times 1000) (\text{s}^{-1})$
1	0,2	41,7
2	0,16	33,3
3	0,12	25,0
4	0,08	16,7
5	0,04	8,33

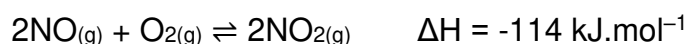
- 3.1 State a suitable aim for this investigation. (2)
- 3.2 Name one variable other than temperature that would need to be controlled during the investigation. (1)
- 3.3 Draw a graph on the graph paper provided of the results obtained. (8)
- 3.4 State a suitable conclusion for this experiment. (2)
- 3.5 Explain your conclusion in terms of particle theory. (3)
- 3.6 Use the graph to find the time taken, in seconds, if the experiment had been carried out using $0,03 \text{ mol.dm}^{-3}$ sodium thiosulfate solution. (2)
- 3.7 Suggest another method that Beverly could have used to follow the rate of this reaction. (1)
- 3.8 Calculate the mass of solid hydrated sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$, Beverly used to make the original solution. (3)
- 3.9 Describe how Beverly prepared the $0,12 \text{ mol.dm}^{-3}$ sodium thiosulfate solution that she used in experiment 3 using 30 cm^3 of the original $0,2 \text{ mol.dm}^{-3}$ solution. Include relevant volumes in your answer. (4)

[26]

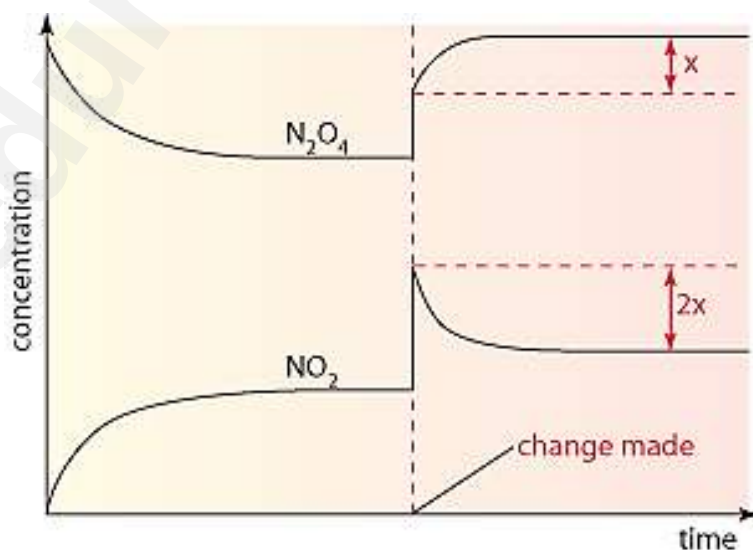
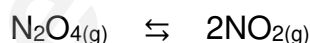
START THIS QUESTION ON A NEW PAGE**Question 4 - CHEMICAL EQUILIBRIUM**

Oxides of nitrogen, NO_x, are important trace species in the atmosphere. Nitrogen monoxide, NO, is a product of the combustion of fuels.

Nitrogen monoxide, NO, reacts with oxygen as below.



- 4.1 Define *heat of reaction*. (2)
- 4.2 Draw a labelled enthalpy profile for the forward reaction. (4)
- 4.3 Describe and explain the effect, if any, of the following changes on the equilibrium concentration of nitrogen monoxide, giving a reason in each case.
- 4.3.1 Increasing the pressure at constant temperature. (3)
- 4.3.2 Increasing the temperature at constant pressure. (3)
- 4.4.1 Write a K_c expression for the reaction above. (2)
- 4.4.2 Use the expression for K_c to explain how the position of this gaseous equilibrium would change if some of the NO₂ was removed, assuming the overall temperature remained constant. (2)
- 4.5 The graph below shows the changes in the concentrations of reactants and products for the following chemical equilibrium:

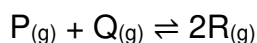


4.5.1 Is the system in equilibrium just before the change was made (as indicated on the graph)? Explain your answer. (2)

4.5.2 The conditions surrounding the equilibrium were changed as indicated on the graph. What change was made? (2)

4.5.3 According to the graph the NO_2 decreased in concentration by $2x$ and the N_2O_4 increased by x in order to restore the system to equilibrium. Please use relevant scientific principles to explain these changes. (2)

4.6 When substances P and Q react together to form substance R an equilibrium is established according to the equation:



The equilibrium constant expression is:

$$K_c = \frac{[\text{R}]^2}{[\text{P}][\text{Q}]}$$

1 mol of P and 1 mol of Q were mixed in a container with volume 1 dm^3 . At equilibrium, x mol of P had reacted.

4.6.1 Deduce in terms of x the amount, in moles, of R in the equilibrium mixture. (2)

4.6.2 At 25°C (298 K) the value of the equilibrium constant $K_c = 3,6$. Calculate a value for the equilibrium concentration, in $\text{mol}\cdot\text{dm}^{-3}$, of R. (3)

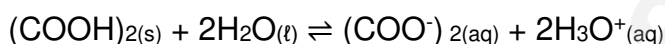
[27]

Question 5 - ACIDS AND BASES

The K_a values for two weak acids, oxalic acid and carbonic acid, are as follows:

NAME	FORMULA	K_a
Oxalic acid	$(\text{COOH})_2$	$5,6 \times 10^{-2}$
Carbonic acid	H_2CO_3	$4,3 \times 10^{-7}$

- 5.1 Define the term *weak acid*. (2)
- 5.2 Which acid, OXALIC ACID or CARBONIC ACID, is stronger? Give a reason for the answer. (2)
- 5.3 Oxalic acid ionises in water according to the following balanced equation:



- 5.3.1 Define the term *Lowry-Brønsted base*. (2)
- 5.3.2 Write down the FORMULAE of the TWO bases in this equation. (2)
- 5.4 This question involves a method to determine the percentage purity of sodium carbonate in a mixture.

Elinor is given the mixture and she carries out a two-step experiment to determine the percentage of sodium carbonate in the mixture.

In step 1, she accurately weighs 2,05 g of the mixture, transfers all of it to an appropriate container, adds 100 cm³ of distilled water to ensure that it all dissolves and accurately makes up the solution to 250 cm³ with distilled water.

In step 2, she pipettes 25 cm³ of the solution into a container, adds 3 drops of an appropriate indicator and titrates this solution with hydrochloric acid of concentration 0,1 mol.dm⁻³. She repeats this procedure three times and obtains the following results.

Titration	1	2	3	4
Volume of HCl (cm ³)	23,1	23,95	23,2	23,15

5.4.1 Name a suitable container to make up the solution that could be used in step 1. (1)

5.4.2 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

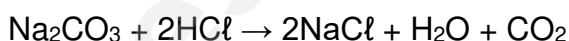
State which indicator would be most suitable for this titration. (1)

5.4.3 Define the term *neutralisation*. (2)

5.4.4 Calculate the mean (average) volume of HCl that Elinor should use in her calculations. (2)

5.4.5 Comment on the preciseness of Elinor's results. (2)

5.4.6 The equation for the reaction between sodium carbonate and hydrochloric acid is given below.



Use your answer to Q 5.4.4 to calculate the number of moles of HCl used in the titration. (3)

5.4.7 Calculate the number of moles of Na_2CO_3 in 25 cm^3 of the solution in step 2. (3)

5.4.8 Calculate the percentage purity of Na_2CO_3 in the original mixture. (3)

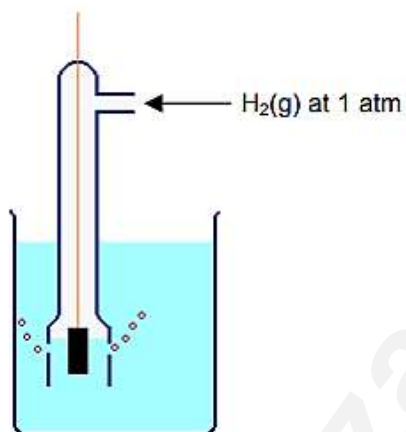
5.5 The reaction of aqueous sulfuric acid with the weak base ammonia produces ammonium sulfate solution. State and explain the pH you would expect for a solution of ammonium sulfate. (4)

[29]

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QUESTION 6 – GALVANIC CELL

The standard electrode potential for a half-cell can be measured by connecting it to the standard hydrogen electrode shown below.



- 6.1 Name the solution in the beaker and state its concentration. (2)
- 6.2 The table below shows the standard electrode potential values for aluminium and silver that can be determined using the reference electrode.

	E^θ (V)
$\text{Al}^{3+} + 3 \text{e}^- \rightleftharpoons \text{Al}$	-1,66
$\text{Ag}^+ + \text{e}^- \rightleftharpoons \text{Ag}$	+ 0.80

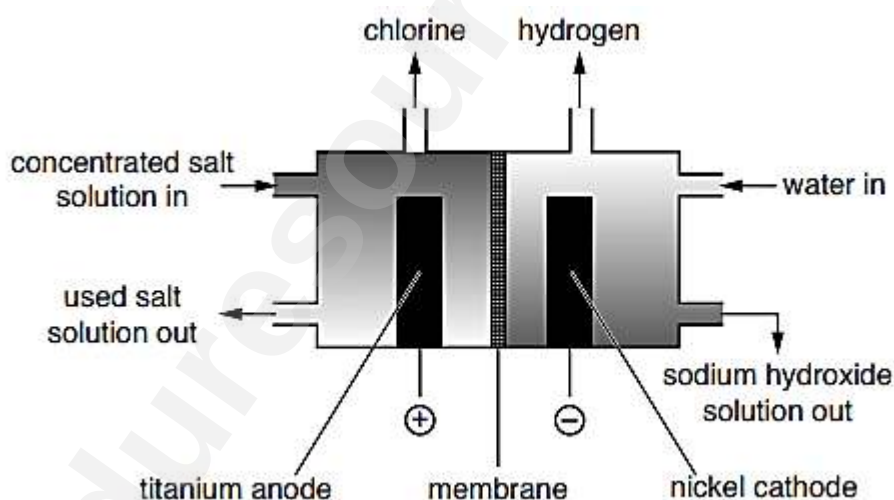
- Explain why the E^θ values are negative for aluminium and positive for silver. (2)
- 6.3 Using cell notation, give the overall ionic reaction for the silver-hydrogen cell. You do not need to include phases or standard conditions. (3)
- 6.4 Aluminium can be used to clean silver cutlery that has been 'tarnished' by a layer of black silver sulfide. The silver object is placed in a hot solution of sodium carbonate in contact with a piece of aluminium foil. An electrochemical reaction occurs and the tarnished silver becomes shiny again. A galvanic cell could be set up in a laboratory to measure the E^θ value of the reaction involved in cleaning tarnished silver.
- 6.4.1 What is the energy conversion that occurs in a galvanic cell? (2)

- 6.4.2 A salt bridge is required to connect the silver half-cell to the aluminium half-cell. Why would potassium chloride NOT be a suitable electrolyte for use in the salt bridge? (2)
- 6.4.3 Define the term *anode*. (2)
- 6.4.4 Write down the half-reaction that occurs at the anode. (2)
- 6.4.5 Calculate the initial E^θ of the cell. (3)
- 6.4.6 Explain how the EMF of the galvanic cell would change if the concentration of the electrolyte solution in the silver half-cell was increased. (2)
- 6.4.7 The cell is allowed to discharge for a period of time during which the mass of the aluminium electrode changes by 3,2 g. Calculate the expected mass change of the silver electrode. (Assume that the change in mass is only a result of the oxidation-reduction reaction occurring as the cell discharges.)(3)

[23]

QUESTION 7 – ELECTROLYSIS

Chlorine is usually manufactured from sodium chloride using a membrane cell.



- 7.1 Why is the use of a membrane cell preferable to that of using a diaphragm or a mercury cell? Give one environmental constraint and one industrial constraint. (2)
- 7.2 Some ions in the solution can move through the membrane whilst others cannot. List the ions which can. (1)

7.3 All three products from the membrane cell are used in the chemical industry.
Write the overall equation for the formation of these three products in the cell.

(2)

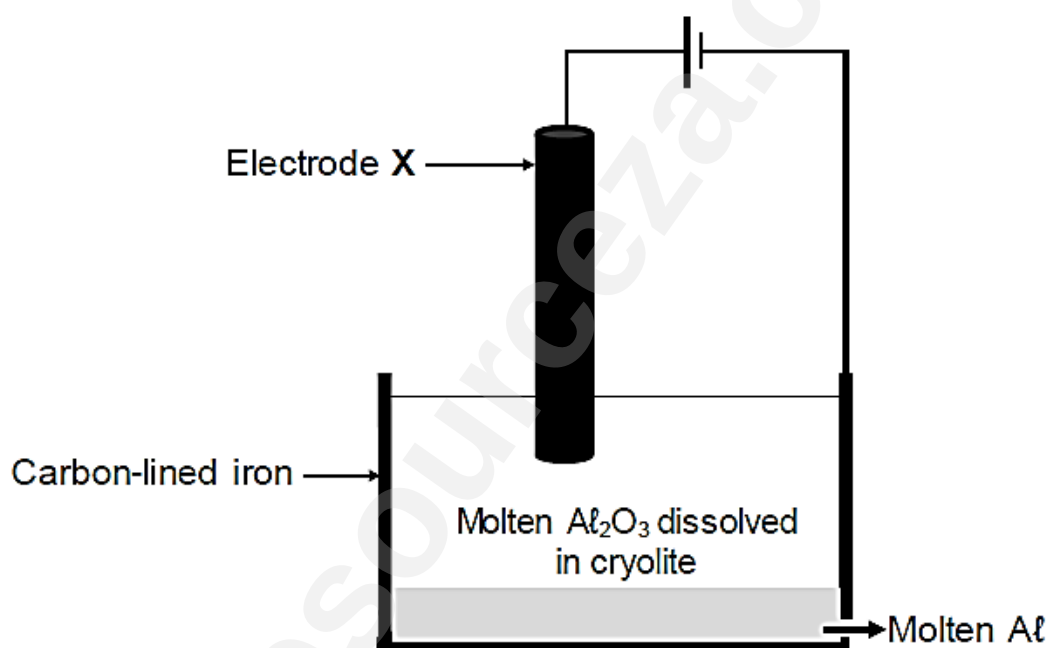
7.4 Explain why chlorine is produced at the anode and not oxygen gas.

(3)

[8]

QUESTION EIGHT

Aluminium is produced by the electrolysis of molten aluminium oxide, Al_2O_3 . The simplified diagram below shows an electrolytic cell used in the industrial extraction of aluminium (Al) from aluminium oxide at temperatures as high as $1\,000\text{ }^\circ\text{C}$.



The cell reaction that takes place is as follows:



8.1 Write down the name of the ore used as the source of aluminium oxide. (1)

8.2 Identify the substance of which electrode X would be made. (1)

8.3 Which half-reaction (OXIDATION or REDUCTION) takes place at electrode X? (1)

8.4 What is the function of the cryolite? (1)

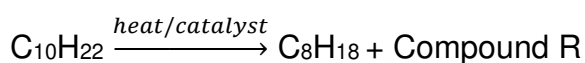
8.5 Write the equation for the reaction at the cathode when molten aluminium oxide is electrolysed. (2)

- 8.6 Calculate the electric charge required to produce 0,500 kg of aluminium from alumina in the cell. (5)
- 8.7 Aluminium is not produced when a solution of an aluminium salt is electrolysed. A solution of aluminium sulfate is electrolysed. Suggest equations for the reaction at the cathode. (2)

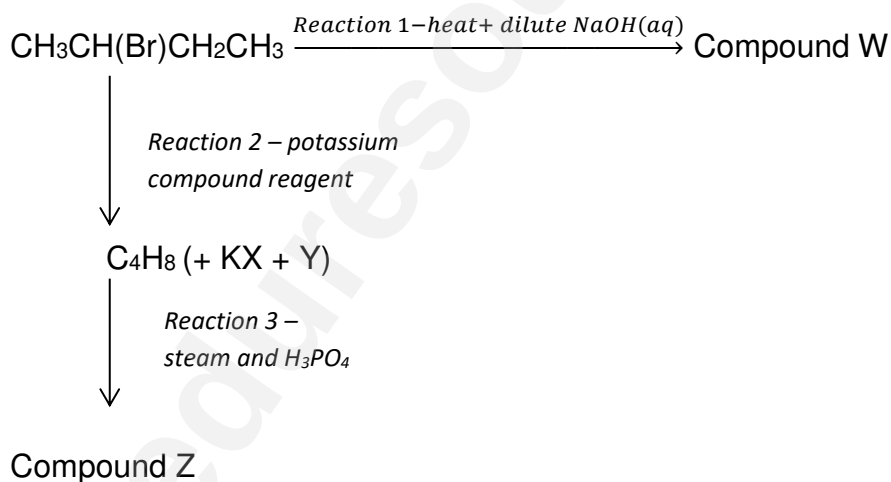
[13]

QUESTION 9 – ORGANIC CHEMISTRY

Petroleum companies use an elimination reaction to break longer hydrocarbons into shorter, more useable hydrocarbons. An example of such a reaction is given:



- 9.1 Name the TYPE of elimination reaction referred to above. (1)
- 9.2 Define the term *homologous series*. (2)
- 9.3 Name the homologous series to which C_8H_{18} belongs. (1)
- 9.4 Draw the structural formulae for Compound R. (2)
- 9.5 Write down a balanced equation for the complete combustion of C_8H_{18} . (4)
- 9.6 The flow diagram shows some compounds made from a haloalkane.



- 9.6.1 Name the haloalkane used as a starting compound in the reactions. (2)
- 9.6.2 Name Compound W (organic molecule) - the product of Reaction 1. (2)
- 9.6.3 Name the type of reaction represented by Reaction 1. (1)
- 9.6.4 Identify the potassium compound reagent and the conditions used in Reaction 2. (2)

- 9.6.5 Identify product Y in Reaction 2. (1)
- 9.6.6 C_4H_8 is an unsaturated compound. Define what is meant by *unsaturated compound*. (2)
- 9.6.7 Draw the structural formula for a chain isomer of C_4H_8 . (2)
- 9.6.8 Give the molecular formula for compound Z in Reaction 3. (1)
- 9.6.9 Name the type of reaction represented by reaction 3. (1)

[24]**START THIS QUESTION ON A NEW PAGE****QUESTION TEN**

Some students were asked to prepare butyl ethanoate from butan-1-ol and ethanoic acid.

Some necessary data is given in the table

Name	M_r	Boiling temperature / °C
butan-1-ol	74	117
ethanoic acid	60	118
1-butyl ethanoate	116	126

- 10.1 Name the homologous series to which butyl ethanoate belongs. (1)
- 10.2 Draw the structural formula for butyl ethanoate. (3)
- 10.3 Account for the differences in the boiling points of butan-1-ol and ethanoic acid. Refer to MOLECULAR STRUCTURE, INTERMOLECULAR FORCES and the ENERGY NEEDED to explain the answer. (4)
- 10.4 Name the functional group of ethanoic acid. (1)
- 10.5 Give the name for a functional group isomer of butyl ethanoate. (2)

[11]