NATIONAL SENIOR CERTIFICATE EXAMINATION
SUPPLEMENTARY EXAMINATION 2015

# PHYSICAL SCIENCES: PAPER II

Time: 3 hours 200 marks

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**PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY**

1. This question paper consists of 13 pages, an Answer Sheet of 1 page and a Data Sheet of 3 pages (i – iii) with data and formulae. Please remove the Data Sheet and Answer Sheet from the middle of your paper.

2. Please check that your question paper is complete.

3. Read the questions carefully.

4. ALL the questions in this paper must be answered.

5. Question 1 consists of 10 multiple-choice questions. There is only one correct answer to each question. The questions are answered on the Answer Sheet provided on the inside cover of your Answer Book. 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** |
|---|---|---|---|

Here the answer C has been marked.

6. **START EACH QUESTION ON A NEW PAGE.**

7. Use the data and formulae whenever necessary.

8. It is in your own interest to write legibly and to set your work out neatly.

9. Express ALL answers correct to TWO decimal places.

10. Show all the necessary steps in calculations.

11. **Question 3.6.2 must be answered on the Answer Sheet.** Make sure that you hand in the Answer Sheet.

12. Please hand in this question paper.

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## QUESTION 1

In each of the following questions four possible answers are provided. Place a cross over the letter of the corresponding answer, on the Answer Sheet on the inside front cover of your Answer Book.

1.1 Which one of the following organic compounds is a saturated hydrocarbon?

A $C_5H_{10}$
B $C_4H_{10}$
C $C_5H_9OH$
D $C_6H_{10}$

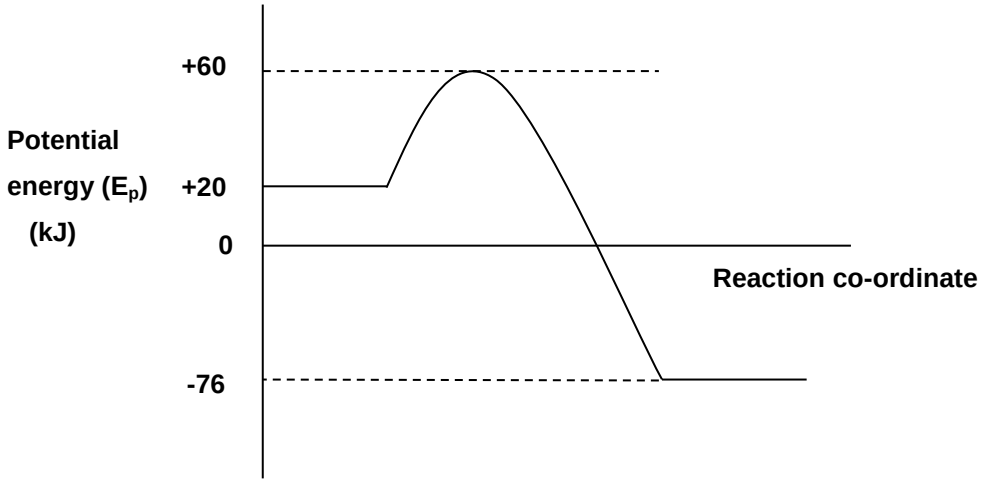
1.2 Which one of the following organic compounds does not belong to the homologous series haloalkanes?

A Trifluoromethane
B Tetrachloromethane
C Tetrachloroethane
D Trifluoroethene

1.3 Dry ice (solid carbon dioxide), when heated, changes directly from the solid phase to the gas phase. Which type of intermolecular forces would one expect to be present between the carbon dioxide molecules to allow for this to happen?

A Covalent forces
B Dipole-dipole forces
C Hydrogen bonding forces
D London forces

1.4 Consider the following energy profile:

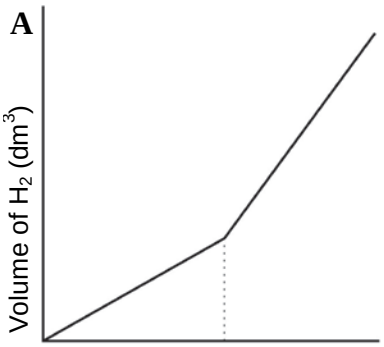


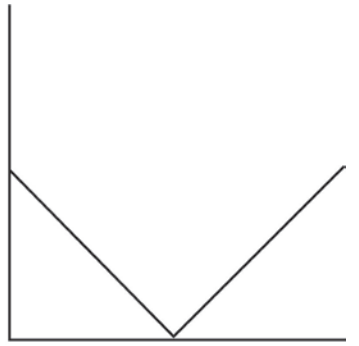

According to this profile, what would be the Activation Energy and Heat of Reaction for the **reverse reaction**?

| | Activation Energy (kJ) | Heat of Reaction (kJ) |
|---|---|---|
| A | –20 | +96 |
| B | +40 | +96 |
| C | –136 | –96 |
| D | +136 | +96 |

1.5 When zinc reacts with dilute hydrochloric acid, hydrogen gas is produced as one of the products. The volume of hydrogen gas evolved is measured every second. Shortly after the reaction started, a catalyst is added to the reaction. Which one of the following graphs is an accurate representation of the course of the reaction?

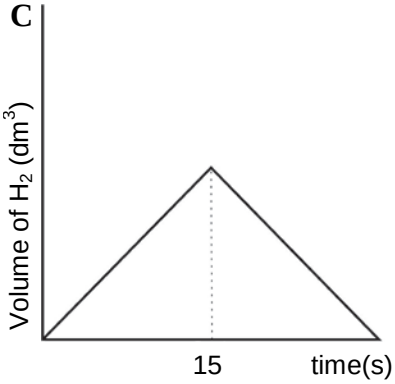
**A**

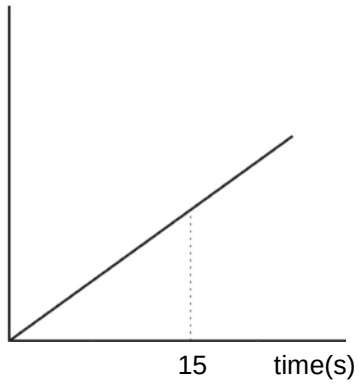


)

**C**




1.6 Which one of the following statements is **true** regarding a reversible chemical reaction? Chemical equilibrium is reached:

A when the forward reaction stops.
B when the concentrations of the products are equal to the concentrations of the reactants.
C the value of $K_c$ is zero.
D when the concentrations of the products and reactants remain constant.

1.7 Consider the following reaction, which has reached chemical equilibrium in a closed container.

$$4HC\ell\,(g) + O_2(g) \rightleftharpoons 2C\ell_2(g) + 2H_2O(g) \quad \Delta H < 0$$

Which one of the following changes in equilibrium conditions will result in an **increase** in the value of the equilibrium constant ($K_c$)?

A Decreasing the pressure on the system by increasing the volume
B Decreasing the temperature of the system
C Increasing the pressure on the system by decreasing the volume
D Increasing the temperature of the system

1.8 Consider the following redox reaction:

$$C\ell_2(g) + 2I^-(aq) \rightarrow 2C\ell^-(aq) + I_2(g)$$

Which one of the statements regarding this reaction is true?

A Iodide ions are oxidised
B Chloride ions are reduced
C Iodine acts as a reducing agent
D Chlorine acts as a reducing agent

1.9 The $E^\theta$ value for the $Cu^{2+}/Cu$ electrode is usually determined using a standard $H^+/H_2$, Pt-electrode as reference electrode. The equation for the half reaction, which occurs at the anode of this cell, is …

A $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$
B $H_2(g) \rightarrow 2H^+(aq) + 2e^-$
C $2H^+(aq) + 2e^- \rightarrow H_2(g)$
D $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

1.10 The emf of a galvanic cell is found to be 1,2 V under standard conditions. The following half-reactions and standard electrode potentials are provided:

$P^+ + e^- \rightleftharpoons P$ $E^\theta = -1,8$ V
$Q^{2+} + 2e^- \rightleftharpoons Q$ $E^\theta = +0,3$ V
$R^+ + e^- \rightleftharpoons R$ $E^\theta = -0,9$ V
$S^{2+} + 2e^- \rightleftharpoons S$ $E^\theta = -0,3$ V

Which of the substances P, Q, R and S will act as the anode and cathode respectively?

A P and R
B R and Q
C R and S
D P and S

**[20]**

## QUESTION 2

2.1 Define the following terms:

2.1.1 Homologous Series (2)
2.1.2 Unsaturated hydrocarbon (4)

2.2 Consider the organic compounds, represented by the letters **A** to **H** below:

| | | | | | |
|---|---|---|---|---|---|
| **A** | $C_3H_7C\ell$ | **B** | $CH_3CHCHCH_3$ | **C** | $C_3H_8$ |
| **D** | $CH_3CH_2COOCH_3$ | **E** | $CH_3CH_2CH(OH)CH_3$ | **F** | $C_4H_{10}$ |
| **G** | $CH_3CH_2CH_2CH_2COOH$ | **H** | $CH_3C(CH_3)CH_2$ | | |

2.2.1 To which homologous series does each of the following belong?

(a) **B** (1)
(b) **G** (1)
(c) **H** (1)

2.2.2 **Name** the functional group in each of the following:

(a) **A** (1)
(b) **E** (1)
(c) **G** (1)

2.2.3 Give the IUPAC names for **G** and **H** respectively. (4)

2.2.4 Consider compound **D**.

(a) Draw the structural formula and give the IUPAC name of each of the two organic compounds from which this substance is made. (4)

(b) Name the type of organic chemical reaction by which this compound is made. (1)

(c) Give two reasons why sulphuric acid is used in the reaction in Question 2.2.4 (b). (2)

2.2.5 The balanced chemical equation for the complete combustion of **C** is:

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$$

108 g of $C_3H_8$ initially reacted completely with oxygen.

(a) Determine the number of moles of $C_3H_8$ that was initially present. (2)

(b) Calculate the volume of $O_2(g)$, at STP, that was used up in the reaction. (3)

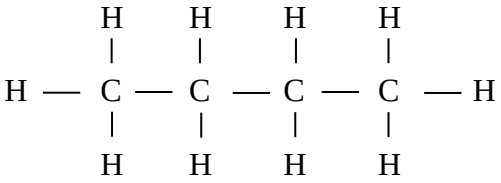
(c) Calculate the mass of $CO_2$ that was formed when 108 g of $C_3H_8$ reacted completely. (3)

(d) When an additional amount of $C_3H_8$ was added to the reaction mixture, an extra 67,2 $dm^3$ of oxygen, at STP, was required to react completely with it. Calculate the additional mass of $C_3H_8$ that was added. (4)

2.2.6 (a) Define the term *isomers*. (2)

(b) Compound **F** can exist in two isomeric forms, one of which is illustrated below.



Draw the structural formula and give the IUPAC name of the second isomer. (4)

(c) Which one of the two isomers in Question 2.2.6 (b) will have the lower boiling point? Use the concept of intermolecular forces to explain your answer. (4)

2.2.7 Consider compound **G**. Compound **G** is an example of an organic molecule which exhibits functional isomerism.

(a) Explain what is meant by the term 'functional isomerism'. (2)

(b) Draw the structural formula and give the IUPAC name of a functional isomer of compound **G**. (4)

2.2.8 Consider the chemical reactions of compounds **E**, **H** and **A** below.

**E:** $CH_3CH_2CH(OH)CH_3 \rightarrow CH_3CH_2CHCH_2 + H_2O$

**H:** $CH_3C(CH_3)CH_2 + H_2O \rightarrow CH_3CH(CH_3)CH_2OH$

**A:** $C_3H_7C\ell + NaOH \rightarrow C_3H_7OH + NaC\ell$

(a) Identify the type of reaction depicted in reactions **E**, **H** and **A** respectively. (3)

(b) What other name is given to reaction **E**? (2)

**[56]**

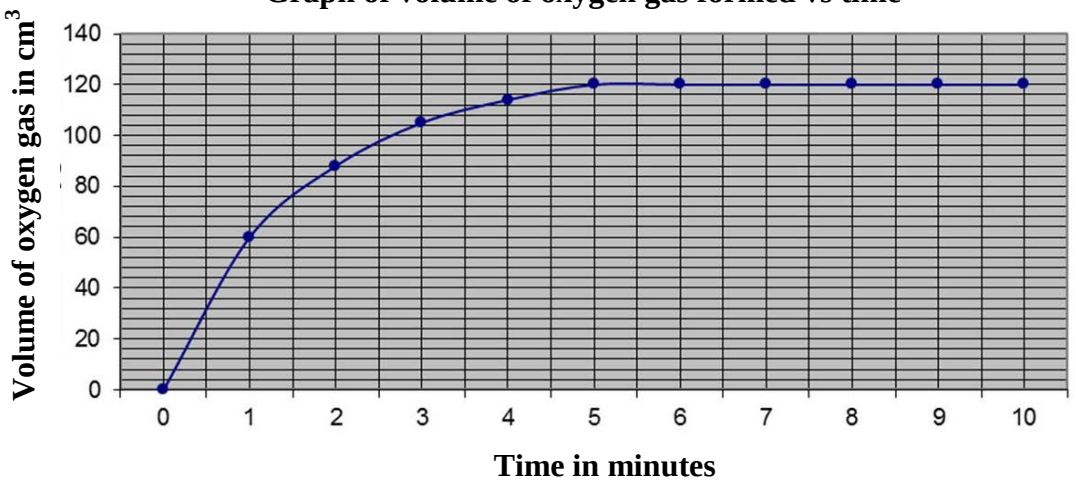
## QUESTION 3

Manganese dioxide ($MnO_2$) catalyses the decomposition of a hydrogen peroxide solution ($H_2O_2(aq)$) into water and oxygen.

$$2H_2O_2(aq) \xrightarrow{MnO_2 \text{ catalyst}} 2H_2O(\ell) + O_2(g)$$

0,1 g of manganese dioxide ($MnO_2$) was added to 200 $cm^3$ of a 0,2 $mol \cdot dm^{-3}$ solution of hydrogen peroxide ($H_2O_2(aq)$). The oxygen gas produced was collected at standard temperature and pressure and measured every minute using a gas syringe. The readings were plotted to give the following graph:

**Graph of volume of oxygen gas formed vs time**




3.1 Explain why the gradient of the graph decreases as the reaction proceeds. (2)

3.2 The reaction stops before reaching completion. Write down the time at which the reaction stopped. (1)

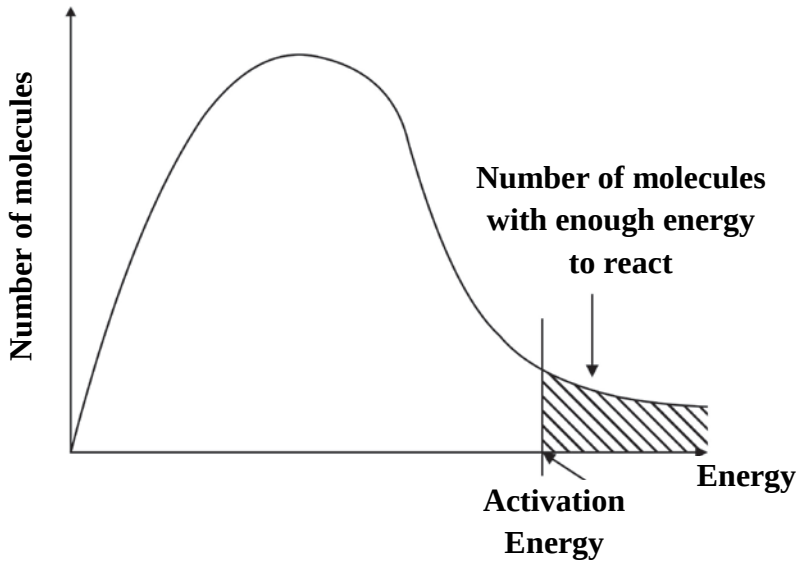
3.3 Define the term 'catalyst'. (2)

3.4 How much of the catalyst manganese dioxide, $MnO_2$, remains at the end of the reaction? (2)

3.5 Using the information provided and the graph, calculate the concentration of the hydrogen peroxide **after** the reaction has stopped. (6)

3.6 The Maxwell-Boltzmann distribution curve below shows the decomposition of the $H_2O_2$ without using a catalyst.




3.6.1 Explain in terms of the collision theory how the $MnO_2$ catalyst increases the rate of decomposition of the $H_2O_2$. (4)

3.6.2 On the Answer Sheet provided, show how the activation energy changes when the decomposition reaction is carried out with the $MnO_2$ catalyst. (2)
**[19]**

## QUESTION 4

Ammonia gas is produced by the reaction between nitrogen gas and hydrogen gas in a closed 250 $cm^3$ container. Equilibrium is reached at 400 $^oC$ according to the following chemical equation:

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

Initially 3 mol of $N_2(g)$ was injected into the container with an unknown amount of $H_2(g)$. When equilibrium was established it was found that 2,2 mol of $NH_3(g)$ was present while 1,5 mol of $H_2(g)$ remained in the container.

4.1 Determine how many moles of $H_2(g)$ were used up in the reaction. (2)

4.2 Determine how many moles of $N_2(g)$ was present at equilibrium. (3)

4.3 Determine the amount of $H_2(g)$, in moles, present at the start of the reaction. (2)

4.4 Write down the expression for the equilibrium constant ($K_c$) for this reaction. (2)

4.5 Calculate the value of the equilibrium constant for this reaction at 400 $^oC$. (5)

4.6 State Le Chatelier's Principle. (3)

4.7 When the temperature of the reaction mixture was decreased from 400 $^oC$ to 275 $^oC$, the equilibrium concentrations of both $N_2(g)$ and $H_2(g)$ decreased. Based on the information given, is the forward reaction exothermic or endothermic? Use Le Chatelier's principle to explain your answer. (4)

**[21]**

## QUESTION 5

5.1 Define an acid and a base in terms of the Brønsted-Lowry theory. (2)

5.2 Nitric acid is a strong acid that ionises in water while ammonium hydroxide is a weak base that dissociates in water.

5.2.1 Explain the difference between the processes of ionisation and dissociation. (4)

5.2.2 Define the terms:

(a) strong acid (2)
(b) weak base (2)

5.2.3 Write down a balanced chemical equation for the ionisation of nitric acid in water. (3)

5.3 *Milk of Magnesia*, a brand of antacid tablets contains magnesium hydroxide ($Mg(OH)_2$) as its active ingredient. Magnesium hydroxide reacts with hydrochloric acid in the stomach according to the following balanced chemical equation:

$$Mg(OH)_2(s) + 2HC\ell(aq) \rightarrow MgC\ell_2(aq) + 2H_2O(\ell)$$

Quality control is performed on *Milk of Magnesia* tablets by titrating them with a solution of $HC\ell$ of concentration 0,2 $mol \cdot dm^{-3}$ in the presence of a suitable indicator. It is found that 20 $cm^3$ of the $HC\ell$ solution completely neutralises the $Mg(OH)_2$ in one tablet.

5.3.1 Explain what is meant by the term 'neutralisation'. (2)

5.3.2 Calculate the number of moles of $HC\ell$ used to neutralise the magnesium hydroxide. (3)

5.3.3 Calculate the mass of $Mg(OH)_2$ present in one Milk of *Magnesia* tablet. (5)

In order to choose the most suitable indicator, analysts in Quality Control are presented with a list of indicators giving their pH sensitivity ranges.

| Indicator | pH range |
|---|---|
| Phenolphthalein | 8,2 – 10,0 |
| Bromothymol blue | 6,8 – 7,6 |
| Bromocresol green | 4,0 – 5,6 |

5.3.4 Explain, using hydrolysis, which one of the above indicators would be the most suitable to use in this titration. (4)

**[27]**

## QUESTION 6

6.1 Consider the substances listed below:

$H_2O$ C $KC\ell$ $CH_4$ $CO_2$ $HC\ell$

Which substance or substances matches each of the statements below? (Each substance may be used more than once in your answer or not at all).

6.1.1 Made up of polar molecules.

6.1.2 Is made up of non-polar molecules.

6.1.3 Has mainly hydrogen bonding between the particles in the solid and liquid phases.

6.1.4 Will form a network solid.

6.1.5 Made up of an ionic crystal lattice.

6.1.6 Is a poor conductor of electricity in the solid phase, but conducts well in aqueous solution. (8)

6.2 The table below gives the boiling points and the molar masses of the hydrides of some of the **group 16** elements.

| **Formula of Compound** | **Molar mass ($g \cdot mol^{-1}$)** | **Boiling Points ($^0C$)** |
|---|---|---|
| $H_2O$ | 18 | 100 |
| $H_2S$ | 34 | -61 |
| $H_2Se$ | 80 | -41 |
| $H_2Te$ | 130 | -2 |

A learner in a science class performs an experiment to investigate how the boiling point varies with the molar mass for the **group 16 hydrides**. Use the information in the table to answer the following questions:

6.2.1 Name the type of intermolecular force that occurs between the molecules in the compounds $H_2S$ to $H_2Te$. (1)

6.2.2 Explain why the boiling points of the compounds from $H_2S$ to $H_2Te$ increase. (3)

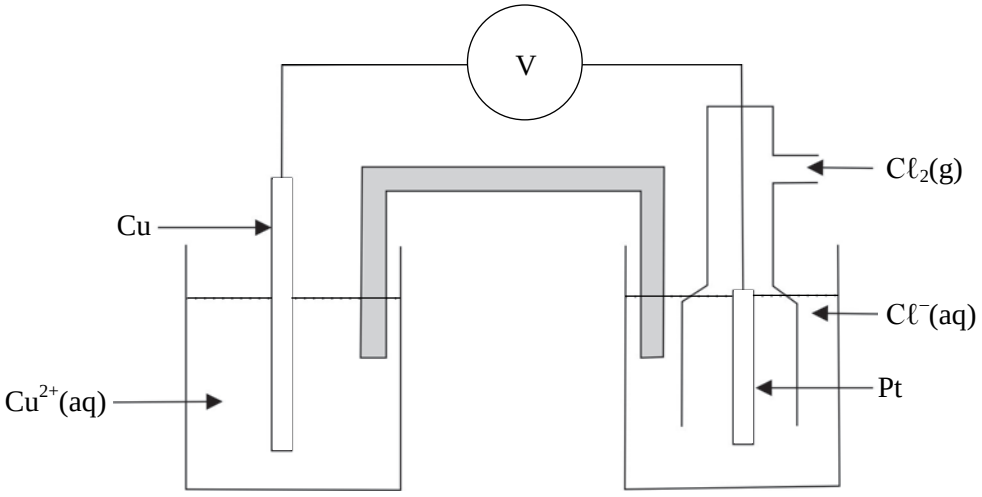
6.2.3 Water does not fit in with the trend shown by the other compounds in the table. Use intermolecular forces to explain why water has a much higher boiling point than the other **group 16 hydrides**. (3)

**[15]**

## QUESTION 7

A galvanic cell is constructed under standard conditions by connecting a copper half-cell and a chlorine half-cell using a salt bridge. In the chlorine half-cell, a platinum electrode is placed in the electrolyte. The diagram below represents this galvanic cell.




7.1 State the standard conditions that are applicable to this galvanic cell. (3)

7.2 Write down the chemical formula of a suitable electrolyte that could be used in the copper half-cell. (2)

7.3 For this galvanic cell, write down the following reactions taking place:

7.3.1 oxidation half-reaction (2)

7.3.2 reduction half-reaction (2)

7.3.3 net cell reaction (2)

7.4 Calculate the initial emf of this galvanic cell. (4)

7.5 Write the cell notation for this cell. (4)

7.6 Explain why an electrode made from platinum is used in the chlorine half-cell. (2)

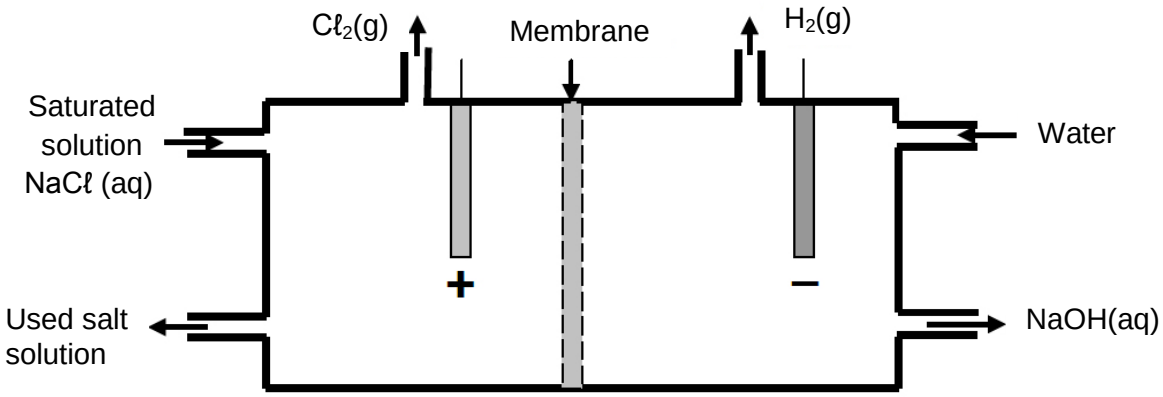
7.7 Identify a suitable electrolyte that can be used in the salt bridge. (2)

7.8 One of the functions of the salt bridge is to maintain the neutrality of the electrolytes in each half-cell. Explain in terms of the electrolyte used in the salt bridge, how it works to maintain this neutrality. (4)

**[27]**

## QUESTION 8

Chlorine gas is produced in industry by the electrolysis of a saturated solution of aqueous sodium chloride (NaCℓ(aq)). Other products of this process are hydrogen gas and sodium hydroxide. The diagram below illustrates a cell that can be used in this process.




8.1 Give another name for an aqueous solution of sodium chloride. (1)

8.2 State the main function of the membrane in the membrane cell. (2)

8.3 Write down the half-reaction that takes place at the cathode. (2)

8.4 Use the relative strengths of the oxidising agents present to explain why sodium metal is NOT produced at the cathode in the membrane cell. (2)

8.5 A **constant** current of 4 000 A is passed through a chlor-alkali cell for 2,5 minutes. Calculate the volume of chlorine gas produced, at STP, at the anode during this period of time. (8)
**[15]**

**Total: 200 marks**