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**PHYSICAL SCIENCES: PAPER 2**

Time: 3 hours

200 Marks

Examiner: K Mari

Moderator: C vd Venter

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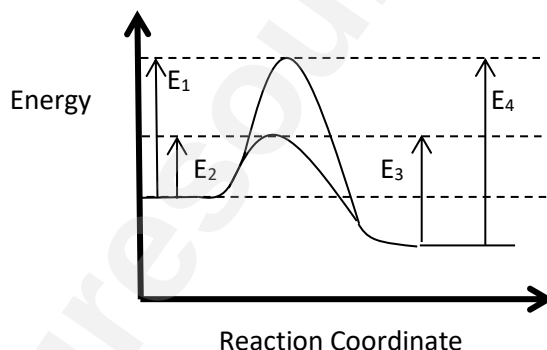
**PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY**

1. This question paper consists of 16 pages, and a green DATA SHEET of 3 pages. Please make sure that your question paper is complete.
  2. Remove the DATA SHEET from the back of this question paper.
  3. Read the questions carefully.
  4. ALL the questions must be answered.
  5. Question 1 consists of 10 multiple-choice questions that must be answered on the Answer Sheet on the inside cover of your Answer Book.
  6. START EACH QUESTION ON A NEW PAGE.
  7. Please ensure that you number your answers as the questions are numbered.
  8. Unless instructed otherwise, you do NOT have to give state symbols (phase indicators) when asked to write a balanced chemical equation.
  9. Use the data and formulae whenever necessary.
  10. Show all the necessary steps in calculations.
  11. Where appropriate, take your answers to two decimal places.
  12. It is in your own interest to write legibly and to present your work neatly.
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**QUESTION 1      MULTIPLE CHOICE**

Answer these questions on the multiple-choice grid on the inside front cover of your Answer Book. Make a cross (X) in the box corresponding to the letter that you consider to be correct.

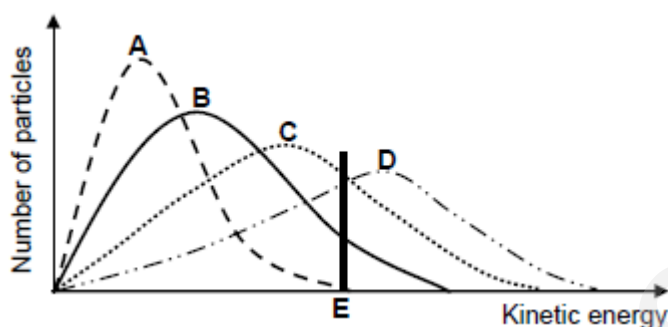
- 1.1 Dipole-dipole interactions occur when ...
- A) an atom in a molecule attracts a shared pair of electrons more strongly to itself creating a polar bond.
  - B) electrons are transferred from one atom to another within a molecule.
  - C) partial charges formed within one molecule are attracted to an opposite partial charge in a nearby molecule.
  - D) electrons accumulate on one side of a molecule creating a momentary dipole.
- 1.2 In which of the following substances is London forces present?
- A)  $\text{CH}_4$
  - B)  $\text{H}_2\text{O}$
  - C)  $\text{NaCl}$
  - D)  $\text{HCl}$
- 1.3 The diagram shows the energy profile for a reaction that occurs with and without a catalyst.



Which one of the following can be deduced from the diagram?

- A)  $E_4$  is the activation energy of the reverse catalysed reaction.
- B) The heat of reaction for the forward reaction is  $(E_4 - E_1)$ .
- C) The heat of reaction for the forward reaction is  $(E_2 - E_3)$ .
- D) The heat of reaction of the reaction is decreased by using a catalyst.

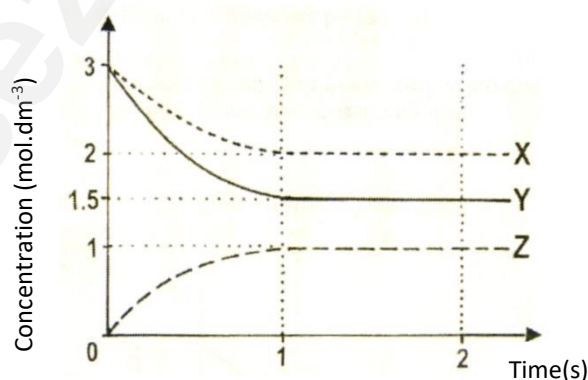
- 1.4 The Maxwell-Boltzmann energy distribution curves below show the number of particles as a function of their kinetic energy for a reaction at four different temperatures. The activation energy for the reaction is represented by E.



Which one of these curves (A to D) represents a reaction which will NOT take place?

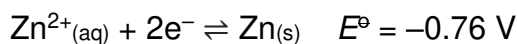
- 1.5 The accompanying graph shows the changes in the amounts of X, Y and Z with time during a reaction. The equation for the reaction can be represented as follows:

- A)  $X + Y \rightleftharpoons Z$   
 B)  $5X + 3Y \rightleftharpoons 2Z$   
 C)  $3X + 3Y \rightleftharpoons Z$   
 D)  $2X + 3Y \rightleftharpoons 2Z$



- 1.6 1,0 mol.dm<sup>-3</sup> solutions of H<sub>2</sub>SO<sub>4</sub>, HCl and CH<sub>3</sub>COOH are prepared. When comparing the three solutions, which one of the following statements is correct?
- A) The H<sub>2</sub>SO<sub>4</sub> solution has the highest [H<sub>3</sub>O<sup>+</sup>].  
 B) The CH<sub>3</sub>COOH solution has the lowest pH.  
 C) The HCl solution has the lowest [OH<sup>-</sup>].  
 D) CH<sub>3</sub>COOH has the highest K<sub>a</sub> value (ionisation constant).

1.7 Consider the following reactions.



Which statement is correct?

- A)  $\text{Cu}^{2+}_{(\text{aq})}$  will oxidise both  $\text{Mg}_{(\text{s})}$  and  $\text{Zn}_{(\text{s})}$ .
- B)  $\text{Zn}_{(\text{s})}$  will reduce both  $\text{Cu}^{2+}_{(\text{aq})}$  and  $\text{Mg}^{2+}_{(\text{aq})}$ .
- C)  $\text{Mg}^{2+}_{(\text{aq})}$  will oxidise both  $\text{Cu}_{(\text{s})}$  and  $\text{Zn}_{(\text{s})}$ .
- D)  $\text{Cu}_{(\text{s})}$  will reduce both  $\text{Mg}^{2+}_{(\text{aq})}$  and  $\text{Zn}^{2+}_{(\text{aq})}$ .

1.8 A metallic object is electroplated with copper using a solution of Copper (II) Sulphate. Which statement is correct?

- A. The positive electrode increases in mass.
- B. The concentration of  $\text{Cu}^{2+}$  ions in the solution decreases.
- C. Reduction occurs at the positive electrode.
- D. The reaction occurring at the negative electrode is  $\text{Cu}^{2+} + 2\text{e}^{-} \rightarrow \text{Cu}$ .

1.9 If the molecular formula of an ester is  $\text{C}_2\text{H}_4\text{O}_2$ , the IUPAC name of the ester is...

- A) ethyl methanoate
- B) methyl methanoate
- C) methyl ethanoate
- D) ethyl ethanoate

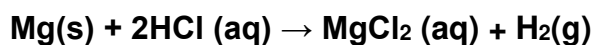
1.10 Between the molecules of which of the given substances would the intermolecular forces be the strongest?

- A)  $\text{CH}_4$
- B)  $\text{C}_2\text{H}_6$
- C)  $\text{C}_3\text{H}_8$
- D)  $\text{C}_5\text{H}_{12}$

[20]

**Question 2**

A group of learners use the reaction between hydrochloric acid and magnesium powder to investigate one of the factors that influence the rate of a chemical reaction. The reaction that takes place is:



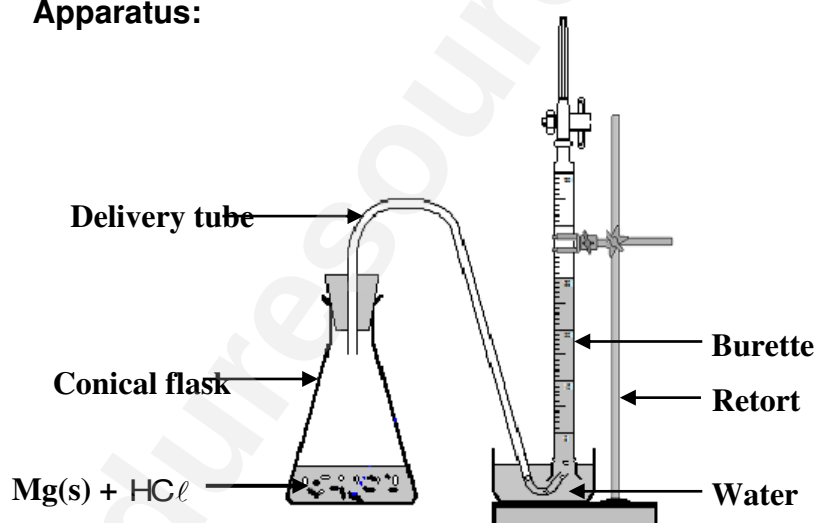
The learners use the apparatus and follow the method shown below to conduct the investigation.

**Method – Experiment 1:**

- Step 1: Place a spatula of magnesium powder in a conical flask and add 50 cm<sup>3</sup> HCl (aq) of known concentration.
- Step 2: Simultaneously start the stopwatch and close the flask with the rubber stopper containing the delivery tube.
- Step 3: Measure the volume of the H<sub>2</sub>(g) formed in time intervals of 20 seconds.

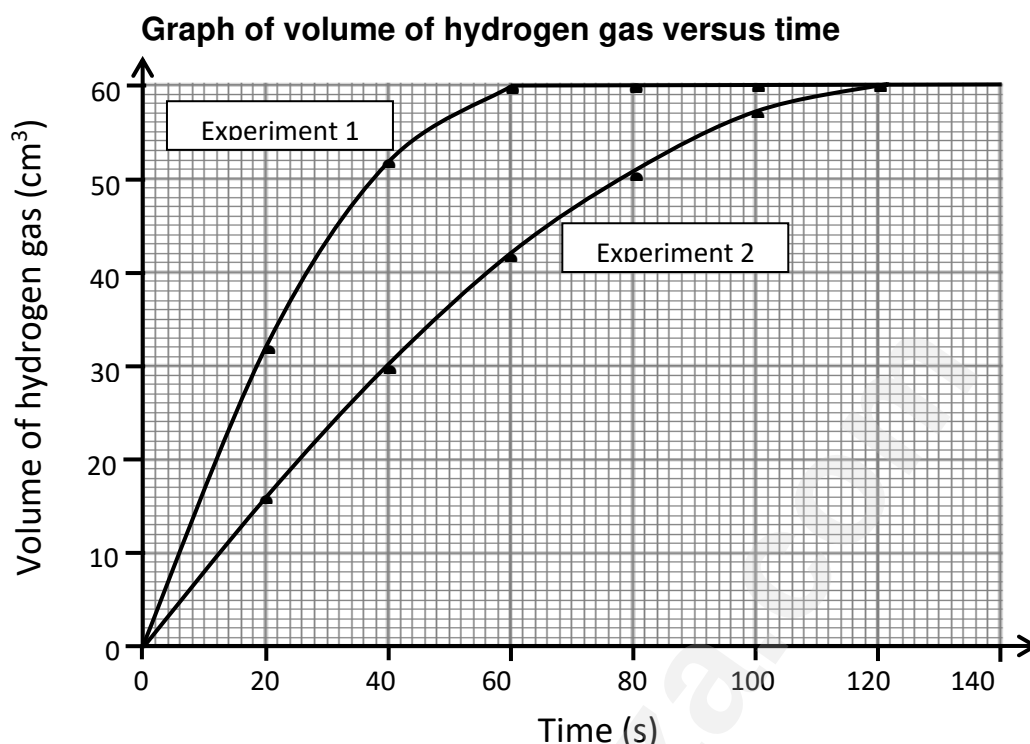
**Method – Experiment 2:**

Repeat steps 1 to 3 above, but use only 25 cm<sup>3</sup> of the same HCl (aq) diluted to 50 cm<sup>3</sup> with distilled water.

**Apparatus:**

- 2.1 How does the concentration of the acid used in Experiment 2 differ from the concentration of the acid used in Experiment 1? Write down only GREATER THAN, SMALLER THAN or EQUAL TO (1)
- 2.2 Write down a hypothesis for this investigation. (2)
- 2.3 Why should the learners ensure that equal amounts of magnesium powder are used in each of the two experiments? (2)

After completing the investigation, the learners used their results to plot the graph below.

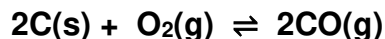


- 2.4 Write down the volume of hydrogen gas formed during the first minute in:
- 2.4.1. Experiment 1 (1)
- 2.4.2 Experiment 2 (1)
- 2.5 Which one of the experiments (Experiment 1 or Experiment 2) took place at the faster rate? Refer to the shape of the curves to motivate your answer. (2)
- 2.6 Give a reason why the final volume of gas produced is the same in both experiments. (2)
- 2.7 What conclusion can the learners draw from the results obtained? (2)
- 2.8 How will an increase in the temperature influence the following?
- Note: In each case write down only INCREASES, DECREASES or REMAINS THE SAME
- 2.8.1 Final volume of gas obtained in each experiment (1)
- 2.8.2 Volume of gas obtained in each experiment after 40s (1)

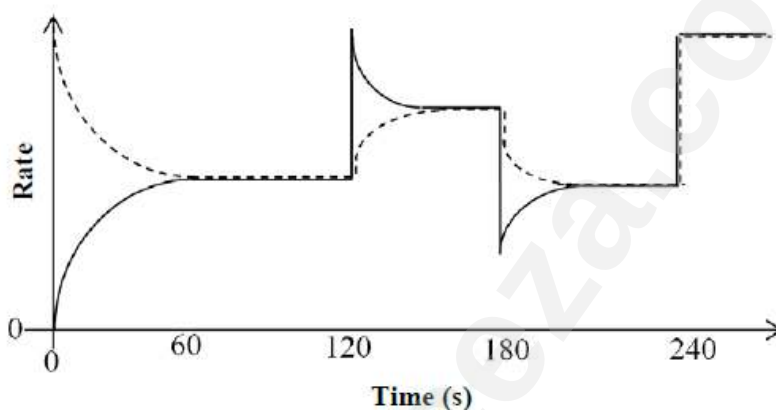
**[15]**

**Question 3**

Graphite reacts with oxygen to form carbon monoxide. The graphite and oxygen are placed into a flask, which is then sealed, and allowed to reach dynamic chemical equilibrium at a certain temperature. The balanced chemical equation for the reaction is:



The graph below shows the changes in the rates of the forward and reverse reactions with time.



- 3.1 State what is meant by dynamic chemical equilibrium. (2)
- 3.2 Write down the equation represented by the solid line. (2)
- 3.3 Explain why the rate of the reverse reaction increases (as shown on the graph) during the first 60 s. (2)
- 3.4 At  $t = 120$  s the volume of the container is decreased whilst maintaining a constant temperature.
  - 3.4.1 Define the term *yield*? (2)
  - 3.4.2 With reference to Le Châtelier's principle, fully explain how the yield of carbon monoxide was affected when the equilibrium was re-established. (4)
- 3.5 At  $t = 180$  s the temperature in the container is decreased.
  - 3.5.1 From the graph, determine and write down which reaction (FORWARD or REVERSE) was initially favoured. (1)
  - 3.5.2 Is the forward reaction EXOTHERMIC or ENDOTHERMIC? Justify your answer with reference to Le Châtelier's principle. (3)
- 3.6 Suggest what change is made at  $t = 240$  s. (1)
- 3.7 How does the number of moles oxygen change (if any) between  $t = 230$  s and  $t = 250$  s? Explain. (2)

- 3.8 Initially 400g of graphite and 9 moles of oxygen are placed into a reaction flask. The flask is then sealed and kept at a constant temperature.

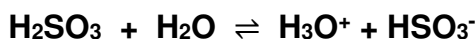
When dynamic chemical equilibrium is established, there is 3 moles of CO in the flask. The concentration of CO in the flask at equilibrium is  $1,2 \text{ mol.dm}^{-3}$ .

- 3.8.1 Calculate the volume of the reaction flask. (2)
- 3.8.2 Write down an expression for the equilibrium constant ( $K_c$ ) for this reaction. (2)
- 3.8.3 Calculate the value of the equilibrium constant ( $K_c$ ) for this reaction at this constant temperature. (5)

[28]

**Question 4**

Sulphur dioxide gas, amongst other gases, is released as a pollutant when coal, a fossil fuel, is burned in a power station. This gas is highly soluble and will dissolve easily in atmospheric water to form sulphurous acid, a form of acid rain. The acid ionizes in water according to the following equation:



- 4.1 Define *an acid* according to Bronsted and Lowry. (2)
- 4.2 What is the name of the  $\text{H}_3\text{O}^+$  ion produced in this reaction? (1)
- 4.3 Rewrite the equation and identify the acid-base conjugate pairs in this reaction. (2)
- 4.4 Define *amphoteric substance*. (2)
- 4.5 Sulphurous acid is a weak acid.
- 4.5.1 Define a *weak acid*. (2)
- 4.5.2 Which of the following indicators would be most suitable to find the end point when sulphurous acid reacts with sodium hydroxide? Explain your reasoning. (3)

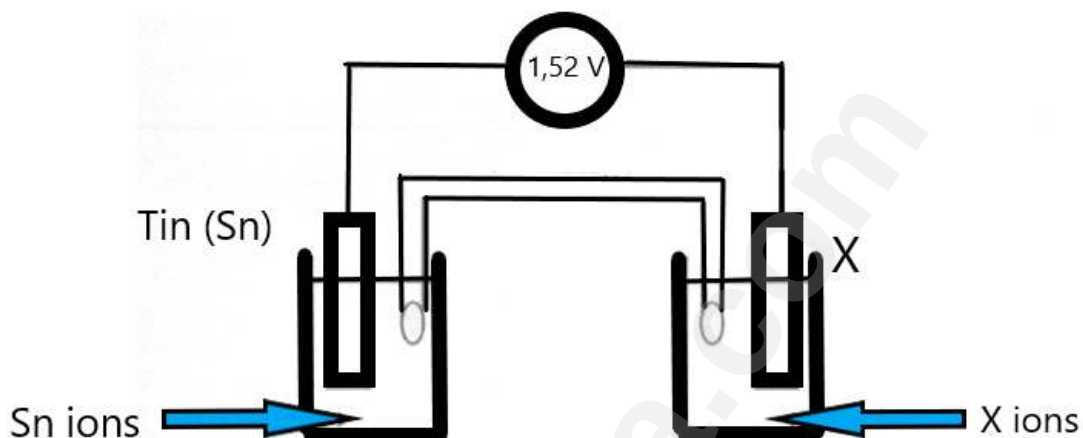
| Indicator        | pH Range  |
|------------------|-----------|
| Phenolphthalein  | 8,2 – 10  |
| Bromothymol Blue | 6,0 – 7,6 |
| Methyl Orange    | 3,2 – 4,4 |

- 4.6 Anita finds some **sulphuric acid** solution in a bottle labeled 'dilute sulphuric acid'. She wants to determine the concentration of the sulphuric acid solution. To do this, she decides to titrate the sulphuric acid against a **standard** sodium carbonate( $\text{Na}_2\text{CO}_3$ ) solution.
- 4.6.1 Define *standard solution*. (2)
- 4.6.2 Calculate the mass of  $\text{Na}_2\text{CO}_3$  which she must use to make  $300 \text{ cm}^3$  of a  $0,2 \text{ mol.dm}^{-3}$   $\text{Na}_2\text{CO}_3$  solution. (3)
- 4.6.3 Explain what a pH reading represents? (2)
- 4.6.4 Write a balanced chemical equation for the reaction between  $\text{H}_2\text{SO}_4$  and  $\text{Na}_2\text{CO}_3$ . (3)
- 4.6.5 During the titration he finds that  $15 \text{ cm}^3$  of the  $\text{Na}_2\text{CO}_3$  solution neutralizes  $20 \text{ cm}^3$  of the  $\text{H}_2\text{SO}_4$  solution. Calculate the concentration of the  $\text{H}_2\text{SO}_4$  solution. (5)

**[27]**

**Question 5**

A galvanic cell was set up **under standard conditions** using tin and an unknown metal X as electrodes, as shown in the diagram below. The voltmeter read 1,52 V. After the cell had been operating for a period of time, there was evidence of corrosion on electrode X.

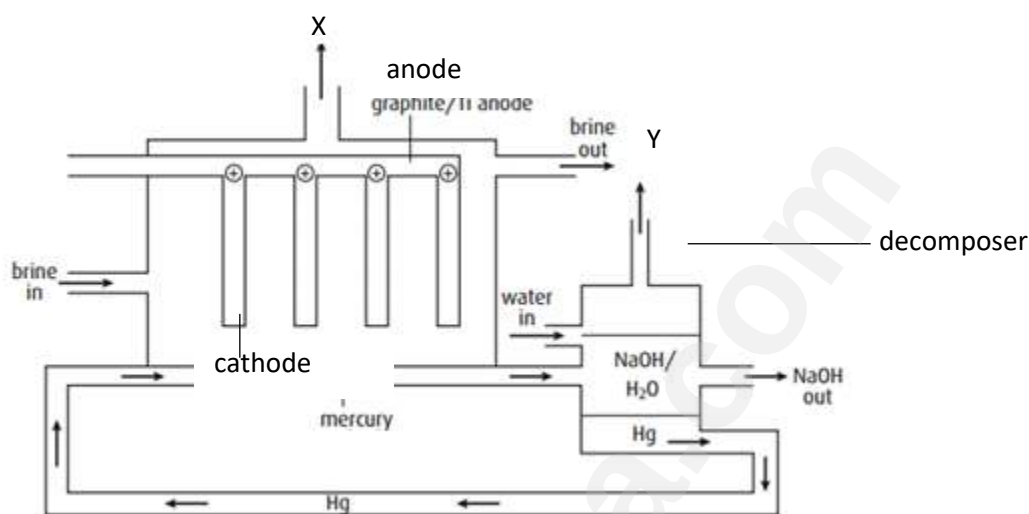


- 5.1 Define the term *oxidation*. (2)
- 5.2 Which electrode, tin or metal X, is the anode? Justify your choice. (3)
- 5.3 Calculate the standard electrode potential of the X half-cell and hence identify metal X. (4)
- 5.4 Determine the equation for the overall cell reaction. Show all working. (3)
- 5.5 Write down the **symbol** of the reducing agent in this reaction. (1)
- 5.6 If the salt bridge is removed from the cell, the cell will stop functioning. Briefly explain the function of the salt bridge, clearly describing the movement of charges through it. (3)

[16]

**Question 6**

The image below shows a flow diagram of the mercury cell used in the chlor-alkali industry. The process uses a brine solution to produce three industrially important chemicals.



[http://pedagogics.ca/cambridge/source\\_data/options/Options\\_C.pdf](http://pedagogics.ca/cambridge/source_data/options/Options_C.pdf)

- 6.1 Brine is an impure solution of sodium chloride dissolved in water.
- 6.1.1 Define *solution*. (2)
- 6.1.2 Name the solvent in the brine solution. (1)
- 6.2. The brine solution used in the chlor-alkali process is made by dissolving rock salt in water. Rock salt is mined from the ground as an impure form of sodium chloride containing 93% NaCl.
- 6.2.1 Consider the ionic compound, sodium chloride. Define:
- a) *ionic bonding*. (2)
- b) *dissociation*. (2)
- 6.2.2 Using the above two definitions, explain why the brine solution is able to conduct electricity. (2)
- 6.2.3 The brine that is used in the mercury cell must have a concentration of at least  $6 \text{ mol.dm}^{-3}$ . Calculate the mass of rock salt (93% NaCl) that must be dissolved to make up  $500 \text{ dm}^3$  of a  $6 \text{ mol.dm}^{-3}$  brine solution. (5)
- 6.3 Chlorine gas is one of the products of this process.
- 6.3.1 Is chlorine extracted at X or Y? (1)
- 6.3.2 Write the half-reaction that shows the production of chlorine gas from the brine. (2)
- 6.3.3 Is this an oxidation or reduction half-reaction? (1)

- 6.4 Give a reason why the two gaseous products of this process must be kept separate. (1)
- 6.5 The half-reaction occurring at the cathode in the mercury cell produces a Na(Hg) amalgam which is fed into the decomposer.
- 6.5.1 Define *cathode*. (1)
- 6.5.2 State the name of the substance which makes up the cathode in this cell. (1)
- 6.5.3 Give the chemical equation showing the half-reaction that occurs at the cathode. (2)
- 6.5.4 How is it possible that the Na(Hg) amalgam is able to be formed at the
- 6.6 The membrane cell is used much more widely in industry than the mercury cell. State two disadvantages of the mercury cell over the membrane cell. (2)
- 6.7 The caustic soda produced in the mercury cell can have a concentration of up to 50% w/v. This is not a molar concentration, but w/v means weight solute/volume solution (that is, there are 50g of NaOH dissolved per 100 cm<sup>3</sup> of solution). Convert the concentration of the sodium hydroxide solution expressed as 50% w/v into the units of mol.dm<sup>-3</sup>. (4)
- 6.8 The overall cell reaction taking place in the mercury cell is:
- $$\text{NaCl} + \text{H}_2\text{O} \rightarrow \text{NaOH} + \text{H}_2 + \text{Cl}_2$$
- 6.8.1 Balance the above chemical equation. (2)
- 6.8.2 During the electrolysis of 500 dm<sup>3</sup> of a 6 mol.dm<sup>-3</sup> solution of NaCl, a volume (measured at STP) of 25 m<sup>3</sup> of H<sub>2</sub> gas is produced. Calculate the percent yield of hydrogen in the reaction. (6)

[38]

**Question 7**

Refer to the compounds A to G below when answering the questions that follow.

| A                       | B                    | C              |
|-------------------------|----------------------|----------------|
|                         | $C_{12}H_{24}$       |                |
| D                       | E                    | F              |
|                         | $CH_3CHFCH(CH_3)CHF$ | Methanoic acid |
| G                       |                      |                |
| 3-ethylpentane-2,3-diol |                      |                |

7.1 Give the name of the functional group of:

7.1.1 compound C. (1)

7.1.2 compound F. (1)

7.2 Give the IUPAC name of:

7.2.1 compound A. (4)

7.2.2 compound E. (4)

7.2.3 compound D. (3)

7.3 Draw the structural formula for compound G. (3)

7.4 Define the term *homologous series*. (2)

7.5 Name the homologous series of the organic product formed when compound A is reacted with hot concentrated sulfuric acid. (2)

- 7.6 To which homologous series do the following compounds belong?
- 7.6.1 compound B. (1)
- 7.6.2 compound C. (1)
- 7.7 It is possible to form ethanol, compound C, from the alkane ethane in a two-step process:
- Step I : ethane must be reacted with  $\text{Cl}_2$  gas in the presence of uv light to be converted to a haloalkane.
- Step II : the haloalkane formed in step I must be reacted to form ethanol by refluxing in a dilute NaOH solution.
- 7.7.1 Name the GENERAL type of reaction that takes place in step I. (2)
- 7.7.2 Using condensed structural formulae, write down the balanced chemical equation that represents the reaction that takes place in step II to produce compound C. (3)
- 7.8 Concentrated sulfuric acid is added to a mixture of compounds C and F which is placed in a hot water bath to react.
- 7.8.1 Why is an open flame not used for this reaction? (1)
- 7.8.2 Give the IUPAC name of the organic product that forms in this reaction. (2)

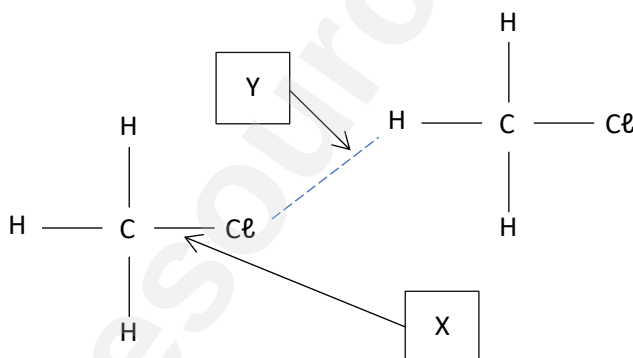
**[30]**

**Question 8**

The boiling points of some organic compounds, represented by the letters A to G, are given in the table below.

|   | Compound       | Boiling point (°C) |
|---|----------------|--------------------|
| A | Methane        | -162               |
| B | Chloromethane  | -24                |
| C | Propane        | -42                |
| D | Pentane        | 36                 |
| E | Methylbutane   | ?                  |
| F | Hexan-1-ol     | 157                |
| G | Pentanoic acid | 186                |

The diagram below illustrates the different forces present in a sample of compound B, chloromethane  $\text{CH}_3\text{Cl}$ .



- 8.1 Define intramolecular bond. (2)
- 8.2 Is the intramolecular bond represented by label X or Y in the diagram above? (2)
- 8.3 State the specific type of intramolecular bond that exists between the two atoms in the C – Cl bond of chloromethane. Use the electronegativities of the atoms to substantiate your answer. (2)
- 8.4 Explain how a dipole-dipole intermolecular force arises. (2)
- 8.5 State the two types of intermolecular forces that exist between the chloromethane molecules. (2)
- 8.6 Explain why compound A (methane) has a much lower boiling point than compound B (chloromethane). (2)

- 8.7 An unknown STRAIGHT CHAIN ALKANE has a boiling point of  $-0.5^{\circ}\text{C}$ . Using the information in the table, give the IUPAC name of this alkane. (2)
- 8.8 Compounds D and E are structural isomers.
- 8.8.1 Define *structural isomer*. (2)
- 8.8.2. What type of structural isomers are compounds D and E? (1)
- 8.8.3. Predict whether Compound E will have a higher or lower boiling point than Compound D. Fully explain your answer, referring to structure and intermolecular force strength. (4)
- 8.9 Compounds F and G have a similar molar mass. Explain the difference in the boiling points of Compounds F and G. (3)

[24]

TOTAL MARKS: 200