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HeronBridge
COLLEGE

PHYSICAL SCIENCE
EXAMINATION
PAPER 2 - CHEMISTRY

GRADE 12

SEPT 2021

TIME: 3 hrs

MARKS:200

Examiner: M Janneker

Moderator: B Beukes / K Wilke

INSTRUCTIONS

1. This examination consists of:
 - a question paper of 17 pages;
 - an answer sheet of 4 pages; and
 - a data and formulae booklet (pages i – iii).

Please make sure that your question paper is complete.

2. Read the questions carefully.
3. It is in your own interest to write legibly and to set your work out neatly.
4. Use the data and formulae whenever necessary.
5. Show your working in all calculations.
6. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.

NAME: _____ **TEACHER:** _____

QUESTION 1 MULTIPLE CHOICE

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Answer this question on the ANSWER SHEET. Mark the answer of your choice with an X.

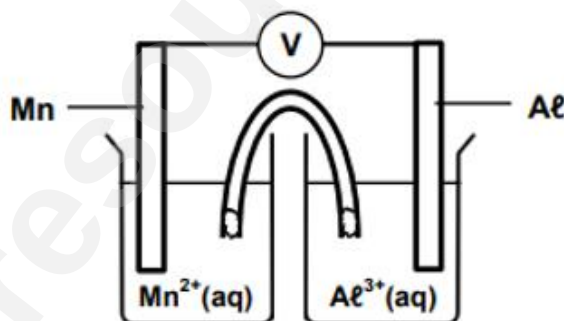
1.1 Identify the predominant intermolecular force in pure, liquid CH_4 .

- A London forces
- B Dipole-dipole interactions
- C Hydrogen bonds
- D Ionic bonds

1.2 Which one of the following has a tetrahedral shape?

- A HBr
- B CCl_4
- C PH_3
- D SO_2

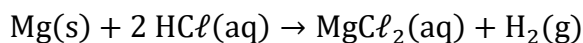
1.3 A galvanic cell is set up as shown below, with ONE of the electrolyte solutions having a non-standard concentration. All other conditions are standard. The initial cell emf is found to be 0,55 V.



Which one of the following shows the correct **anode** for this cell and the non-standard **concentration** used in the corresponding electrolyte?

	Anode	Concentration of electrolyte
A	Al	Less than $1 \text{ mol} \cdot \text{dm}^{-3} \text{ Al}^{3+}(\text{aq})$
B	Al	More than $1 \text{ mol} \cdot \text{dm}^{-3} \text{ Al}^{3+}(\text{aq})$
C	Mn	Less than $1 \text{ mol} \cdot \text{dm}^{-3} \text{ Mn}^{2+}(\text{aq})$
D	Mn	More than $1 \text{ mol} \cdot \text{dm}^{-3} \text{ Mn}^{2+}(\text{aq})$

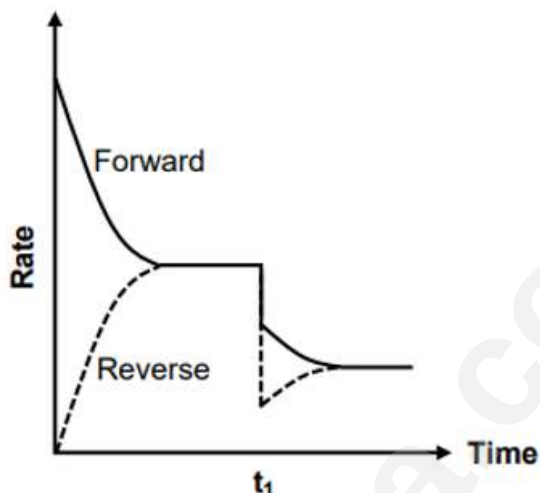
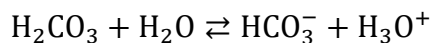
- 1.4 Which one of the following options is the best description of *reaction rate* for the following reaction?



The reaction rate is

- A the time it takes to use up all the reactants.
- B the decrease in concentration of the Mg per unit time.
- C the time it takes for one of the reactants to be used up.
- D the increase in concentration of the MgCl_2 per unit time.
- 1.5 A system is at chemical equilibrium. Which of the following will change as the temperature of the equilibrium mixture is changed?
- I K_c
- II Total mass of the reactants and products
- III Rate of the forward reaction
- A I only.
- B I and III only.
- C II and III only.
- D I, II and III.
- 1.6 Which one of the following is true for a BASIC / ALKALI solution at 25°C ?
- A $[\text{H}_3\text{O}^+] > [\text{OH}^-]$
- B $[\text{OH}^-] = \text{zero}$
- C $K_w < 10^{-14}$
- D $\text{pH} > 7$

- 1.7 Consider the reaction rate versus time graph for the following reaction:



At t_1 there was a TEMPERATURE change. Which one of the following combinations is true for the FORWARD reaction and the pH change that occurs at time t_1 ?

	FORWARD reaction	pH change after time t_1
A	Exothermic	Increases
B	Exothermic	Decreases
C	Endothermic	Increases
D	Endothermic	Decreases

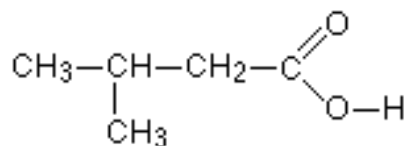
- 1.8 Which one of the following molecular formulae represents a diene?

- A C_4H_{10}
- B $(\text{C}_2\text{H}_5)_2$
- C C_4H_8
- D C_4H_6

- 1.9 Which one of the following reactions will not take place with an alkene?

- A Hydrohalogenation
- B Combustion
- C Hydrogenation
- D Dehydration

1.10 The IUPAC name for the following compound is:

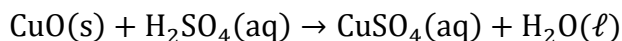


- A 2-methylbutanoic acid
- B pentanoic acid
- C 3-methylbutanoic acid
- D butanoic acid

[10x2=20]

QUESTION 2

Consider the reaction between copper (II) oxide and sulphuric acid:



100 cm³ of H₂SO₄ of concentration 0,8 mol.dm⁻³ is allowed to react completely with an unknown mass of powdered copper (II) oxide. The reaction mixture is heated gently, and the black oxide reacts with the acid turning the resultant solution blue.

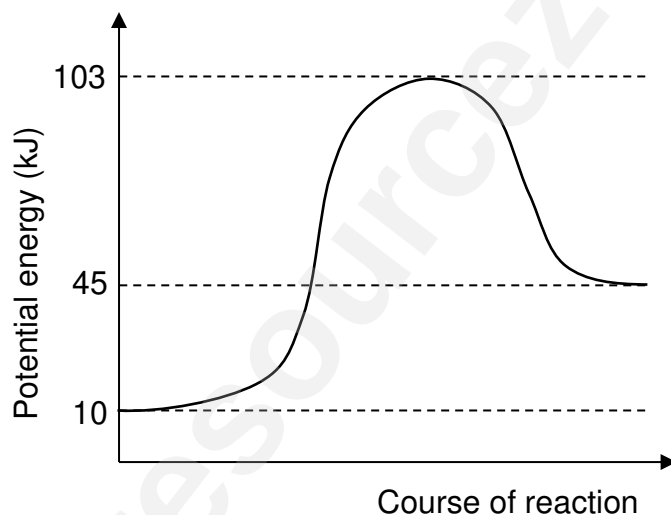
2.1 Copper (II) oxide is an example of a/an: Choose either:

Molecular solid OR Network solid OR Ionic solid (1)

2.2 Calculate the initial number of moles of acid available to react. (3)

2.3 Calculate the mass of copper (II) oxide that reacts with the acid. (3)

The potential energy profile for this reaction is illustrated below.



2.4 Define **activation energy**. (1)

2.5 Calculate the activation energy (in kJ) for the reaction. (2)

2.6 Is the reaction exothermic or endothermic? (1)

2.7 Calculate the change in enthalpy (in kJ.mol⁻¹) for the reaction. (2)

2.8 The concentration of H₂SO₄ is decreased to 0,4 mol.dm⁻³.

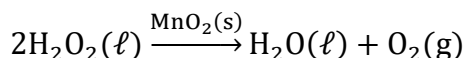
2.8.1 How would this affect the rate of the reaction? (1)

2.8.2 Use the molecular collision theory to explain your answer to in 2.8.1. (3)

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QUESTION 3

Hydrogen peroxide undergoes spontaneous *catalytic decomposition* to form water and oxygen according to the reaction equation below.



In the presence of a suitable catalyst, e.g. manganese dioxide (MnO_2), the oxygen gas is released at a suitable rate to collect and measure its volume.

3.1 Define the term ***catalyst***. (2)

The table below shows the volume of oxygen gas collected per unit time.

Time (minutes)	Volume (cm^3)
0	0
1	44
2	88
3	113
4	124
5	132
6	136
7	140
8	142
9	142

3.2 Plot a graph for the given data on the graph paper supplied on the ANSWER SHEET. (5)

3.3 Calculate the average rate of reaction during the first 2 minutes of the reaction. (3)

3.4 The hydrogen peroxide that was used above was not pure, but actually a 20% solution of hydrogen peroxide and water.

Pure hydrogen peroxide has a melting point of $-0,43^\circ\text{C}$ and boiling point of $150,2^\circ\text{C}$. Pure hydrogen peroxide is *miscible* in water due to its ability to form *hydrogen bonds* with water molecules. Pure hydrogen peroxide is also slightly *more viscous* than water.

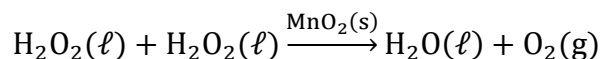
3.4.1 Draw a sketch graph on your graph plotted in 3.2 to indicate the shape and form of the graph that would be obtained if pure hydrogen peroxide were used instead. (2)

3.4.2 What are *hydrogen bonds* AND give a brief account for the higher boiling point of hydrogen peroxide compared to water. (3)

- 3.4.3 A liquid that is said to be more viscous than water has a greater resistance to being poured or is 'less runny' or is 'thicker' than water.

Give a brief explanation for pure hydrogen peroxides' increased viscosity when compared to water. (2)

The decomposition of hydrogen peroxide is an example of a *redox reaction*. This is an unusual example of a redox reaction in that hydrogen peroxide is both the *oxidizing agent* and a *reducing agent*. The reaction equation can also be represented as follows:



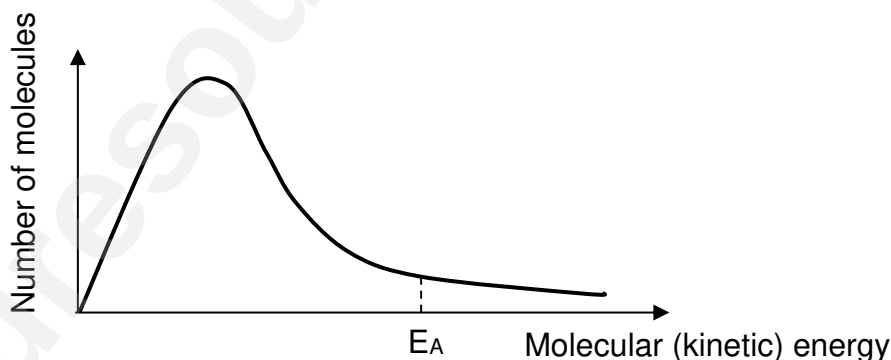
- 3.5 Use your standard electrode potential table to write a half reaction for hydrogen peroxide acting as:

3.5.1 an oxidizing agent. (2)

3.5.2 a reducing agent. (2)

- 3.6 Manganese dioxide acts as a catalyst in the above reaction. It can also act as an oxidizing agent in some reaction. Rank hydrogen peroxide and manganese dioxide in terms of their relative strengths as oxidizing agents, weakest first. (1)

- 3.7 The graph below shows the number of molecules against kinetic energy at a given temperature (Maxwell-Boltzmann distribution) for a system.

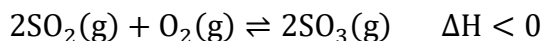


- 3.7.1 THE ABOVE DIAGRAM HAS BEEN REPRODUCED ON THE ANSWER SHEET. EXPLAIN briefly how the addition of a suitable catalyst will affect the rate of the reaction. Indicate on the graph on the ANSWER SHEET the change(s) due to the addition of the catalyst. Provide a suitable label. (4)
- 3.7.2 EXPLAIN briefly how conducting the reaction at a higher temperature will affect the rate of the reaction. On the ANSWER SHEET, draw a sketch graph to show the effect of an increase in temperature on the number of molecules against their kinetic energy. (4)

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QUESTION 4

The following equation represents a key reaction in the preparation of sulphuric acid:



The reaction is controlled in such a way that the temperature inside the container remains between 370°C and 550°C to optimize the yield of sulphur trioxide (SO₃).

- 4.1 What is represented by the double arrow? (1)
- 4.2 The reaction is carried out in a **closed system**. Define a closed system. (2)
- 4.3 In terms of rate of reaction, explain why the temperature in the system is not allowed to decrease below 370°C. (2)
- 4.4 Explain the effect on the yield of SO₃ if the temperature in the system is allowed to increase beyond 550°C. (3)
- 4.5 For the process above, the following information is obtained from the analysis of the equilibrium mixture at 400°C:

Volume of container	= 200 dm ³
Initial quantity of SO ₂	= 50 mol
Equilibrium quantity of SO ₃	= 22 mol
K _c at 400°C	= 7,328

Use the above information to:

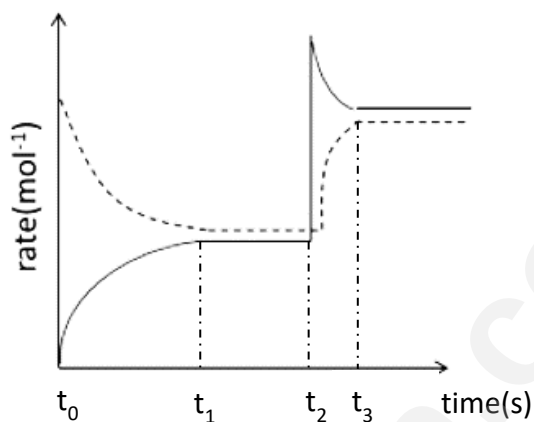
- 4.5.1 Calculate the number of moles of SO₂ that is present in the system at equilibrium. (2)
- 4.5.2 Write a K_c expression for the system AND hence calculate the concentration of oxygen at equilibrium in the system. (Answer to 3 decimal places.) (3)
- 4.5.3 Determine the mass of oxygen that was used for this reaction. (3)

Original question: (if paper needs more challenge! Level 4?)

Use the above information to determine the mass of oxygen that was used in this reaction. (To replace 4.5.1 to 4.5.3)

- 4.6 The graph below represents the changes in the system when SO_2 was allowed to react with excess O_2 . At t_2 , the temperature of the process above is increased to 500°C .

Consider the following graph:

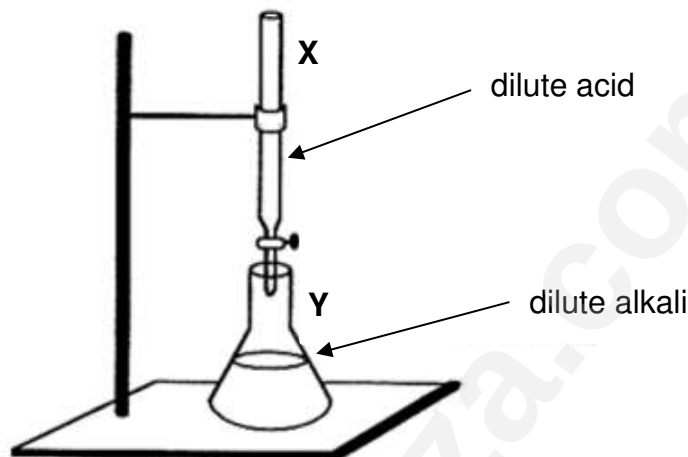


- 4.6.1 Name the phenomenon observed between t_1 and t_2 . (1)
- 4.6.2 Explain the observed changes in the graphs due to the change in temperature at t_2 . Your explanation must make reference to Le Chatelier's principle. (4)
- 4.6.3 Explain the effect, if any, on the K_c value due to the change at t_2 . (3)

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QUESTION 5

The following apparatus is used for the titration of a dilute $\text{Ba}(\text{OH})_2$ solution with a dilute $(\text{COOH})_2$ solution. $\text{Ba}(\text{OH})_2$ is considered a *strong alkali* whilst $(\text{COOH})_2$ is considered a *weak organic diprotic acid*.



- 5.1 What is meant by saying $\text{Ba}(\text{OH})_2$ is a **strong alkali**? (2)
- 5.2 What is a **diprotic acid**? (1)
- 5.3 Name the dilute alkali. (1)
- 5.4 Name the apparatus labelled **X**. (1)

During the titration, 25 cm^3 of the alkali is added to the flask labelled **Y**. A few drops of phenolphthalein indicator are added to the flask and the colour of the alkali solution changes to red. The acid is initially added rapidly to the flask **Y**. As the reaction approaches the *equivalence point*, it is added slowly, dropwise until a permanent colour change is observed.

- 5.5 What is meant by the **equivalence point** of the titration? (2)
- 5.6 The concentration of the alkali solution was $0,2\text{ mol}\cdot\text{dm}^{-3}$. $18,6\text{ cm}^3$ of the acid is needed to neutralize 25 cm^3 of the alkali during the titration.
- 5.6.1 Write a balanced chemical equation for the neutralization reaction. (2)
- 5.6.2 Calculate the number of moles of alkali available at the start of the reaction. (3)
- 5.6.3 Hence calculate the concentration of the acid. (3)

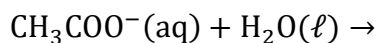
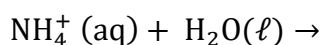
- 5.7 State whether each of the following INCREASES, DECREASES or REMAINS CONSTANT, while the acid is being added before the end point is reached.

5.7.1 $[\text{Ba}^{2+}]$ (1)

5.7.2 $[\text{OH}^-]$ (1)

5.7.3 pH (1)

- 5.8 Small quantities of ammonium chloride (NH_4Cl) and sodium acetate (CH_3COONa) are added to pure water in separate test tubes. Each test tube is shaken gently until the solid is completely dissolved. The pH of the resulting solutions is less than 7 and greater than 7 respectively. The incomplete equations for the reaction of ions of the solids in water is given below:



- 5.8.1 Re-write and complete the 2 equations above to show how the cation and anion of the two salts decompose the water molecules. (4)

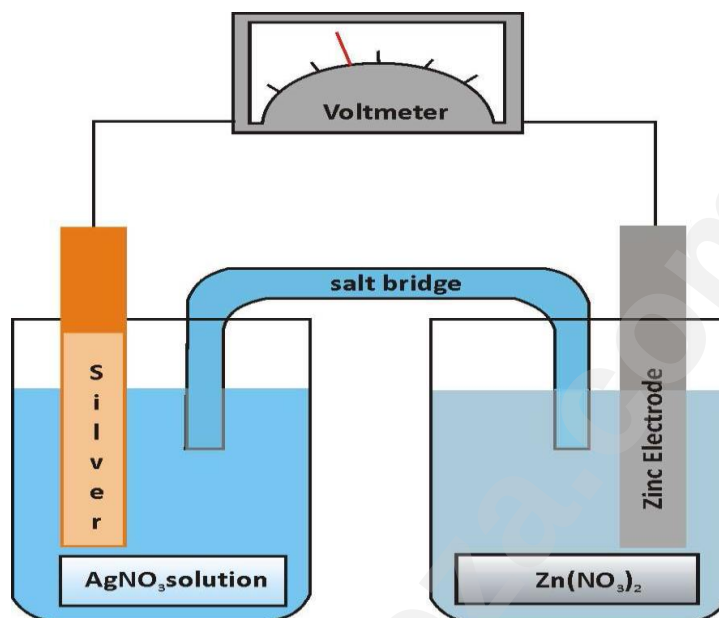
- 5.8.2 Name the phenomenon described in 5.8.1 above. (1)

- 5.8.3 Explain the pH change observed in the test tube containing the acetate ion. (2)

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QUESTION 6

Consider the Zn-Ag electrochemical cell below that operates under standard conditions.



6.1 Is this cell a Galvanic or electrolytic cell? Explain your answer. (3)

6.2 Write down the reduction half-reaction that occurs in this cell. Include states/phases. (2)

6.3 Write down the oxidation half-reaction that occurs in this cell. Include states/phases. (2)

6.4 Write down the overall balanced ionic cell reaction. (2)

Lufuno, a grade 12 learner says: '*The silver electrode will begin to dissolve*'.

6.5 Is she correct? (1)

6.6 Explain your answer to 6.6. (2)

Liam, another learner says: '*As the reaction progresses the zinc ions will move through the salt bridge and will coat the silver electrode with zinc*'.

6.7 Criticize Liam's statement. (4)

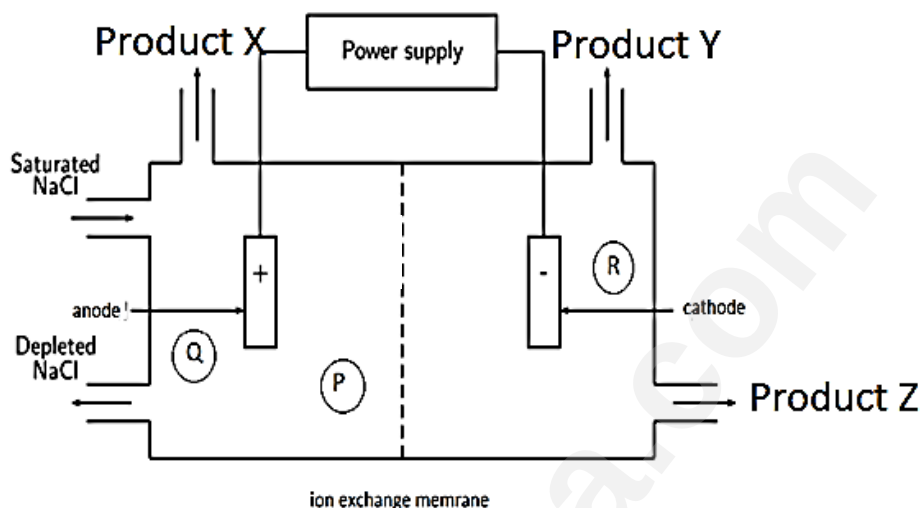
6.8 Name 2 functions of the salt bridge. (2)

6.9 Calculate the emf of the above cell if it operates under standard conditions. (3)

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QUESTION 7

7.1 The diagram below represents one of the cells used in the Chlor-Alkali process.



7.1.1 NAME the three products shown as **X**, **Y** and **Z**. (3)

7.1.2 Q is attracted to the anode; P goes through the membrane and R is attracted to the cathode.

Write down the FORMULA of the ions or molecules P, Q, and R. (3)

7.1.3 Write down the half reaction for the reaction taking place at the cathode. (2)

7.1.4 The *ion exchange membrane* can also be called a *cationic membrane* or *ion selective membrane*. Explain why it is also called an ion selective membrane. (3)

7.1.5 State the advantage(s) of this type of cell over the diaphragm cell that is also used in this industry. (2)

7.1.6 Name the energy changes that occur when this cell is operated. (2)

[15]

7.2 A 40 A current passes through a chlor-alkali cell that operates for 8 hours.

7.2.1 Calculate the amount of charge that flows during this period. (3)

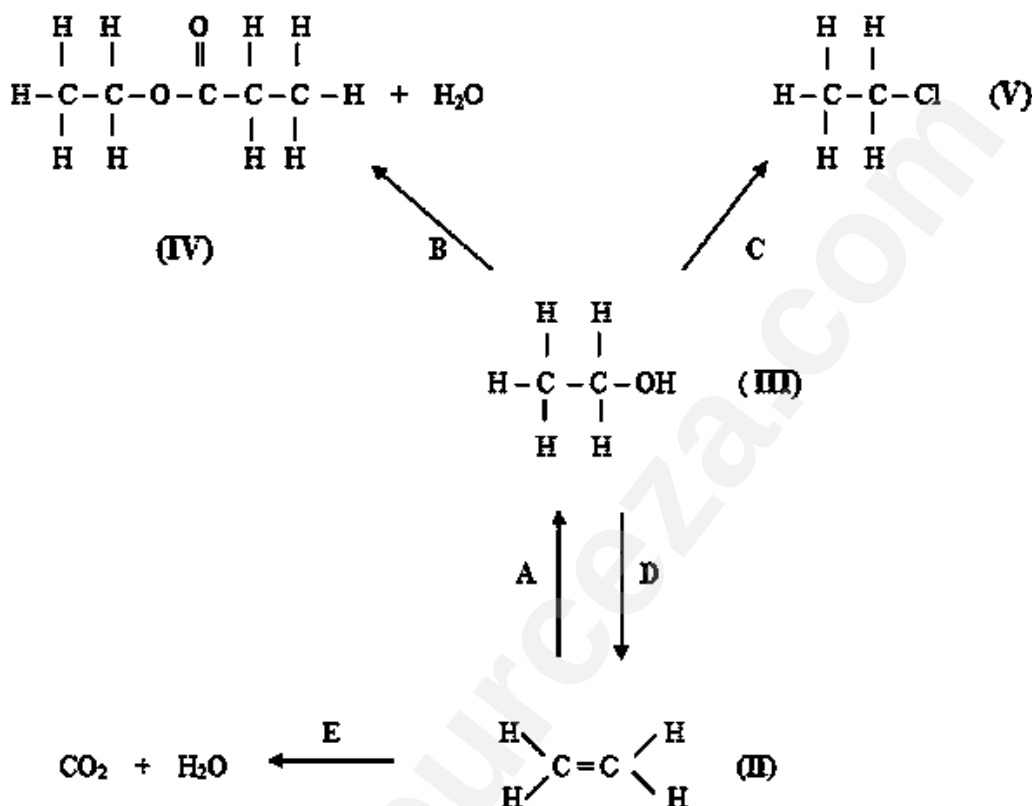
7.2.2 Calculate the volume of chlorine gas produced during this period at STP. (5)

[8]

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QUESTION 8

Consider the following sequence of organic reactions and then answer the questions that follow. Reactions are labelled **A** to **E** while molecules are labelled from **II** to **V**.



- 8.1 What is meant by the term '*homologous series*'? (2)
- 8.2 Identify the homologous series to which the following molecules belong:
- 8.2.1 **II**
- 8.2.2 **III**
- 8.2.3 **IV** (3)
- 8.3 Name the types of reactions labelled **A**, **C**, **D** and **E** in the reaction sequences provided. Provide the **specific** reaction type where applicable. (4)
- 8.4 Consider the reaction **E**. Write a balanced chemical equation using molecular formulas for the reaction. (2)
- 8.5 Molecule **III** is completely soluble in water. Explain in terms of intermolecular forces why this molecule is soluble in water. (3)

- 8.6 Consider reaction **B**. To form the molecule labelled **IV**, a reaction takes place between molecule **III** and another molecule from a different homologous series.

8.6.1 Name the homologous series to which the other molecule belongs. (1)

8.6.2 Give the IUPAC name of the molecule identified in 8.6.1. (2)

8.6.3 Give the IUPAC name of the molecule **IV**. (2)

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QUESTION 9

- 9.1 Question 9.1 and 9.2 refer to the molecule **IV** of Question 8 on page 15.

To prepare molecule **IV** in the laboratory, the two reactants are mixed in a test tube. A few drops of concentrated sulphuric acid are added, and the test tube is placed in a hot water bath and then heated as illustrated.



9.1.1 Why do you think the test tube must be heated in a hot water bath and not directly over a Bunsen burner flame? (2)

9.1.2 What is the function of the sulphuric acid (H_2SO_4) in the reaction? (2)

- 9.2 Molecule **IV** has a functional isomer.

9.2.1 What is meant by the term **isomer**? (2)

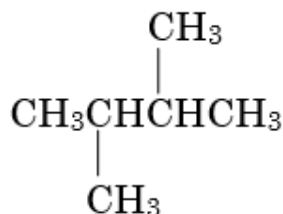
9.2.2 Draw the structural formula of the **functional isomer** of molecule **IV**. (2)

9.2.3 Give the IUPAC name of the molecule in 9.2.3. (2)

- 9.2.4 Each of these 2 isomers (molecule **IV** and the molecule identified in 9.2.3) has a distinctly different boiling point. Which of the isomers would have the higher boiling point? Explain fully. (3)

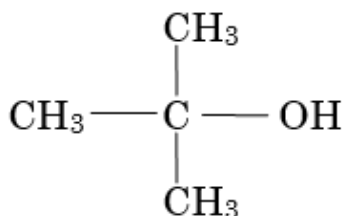
9.3 Give the IUPAC names of the following compounds:

9.3.1



(2)

9.3.2



(2)

9.4 Write the molecular formula for the molecule in 9.3.2 above. (2)

9.5 Draw a structural formula for 3-methyl-2-pentene. (2)

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TOTAL : 200 MARKS