SECTION A:

Answer **THREE** *questions from this section*

1. (a) Explain what is meant by the term **partition coefficient.** (02 marks)

(b) Describe an experiment used to determine partition coefficient of phenol between water and methyl benzene. (5 ½ marks)

(c) State **four** conditions under which the partition law is valid. (02 marks)

(d) 50 cm^3 of 1.5M aqueous ammonia solution were shaken with 50 cm^3 of trichloromethane and the mixture left to settle to attain equilibrium at 200K. At equilibrium, 20cm^3 of trichloromethane layer required 23.0 cm^3 of 0.05M hydro chloric acid for neutralization. Calculate the partition coefficient of ammonia between water and trichloromethane at 200K. (3 ½ marks)

(e) 1.5 g of an impure ore of zinc was dissolved in excess ammonia and the resultant solution shaken with trichloromethane and mixture left to settle to attain equilibrium. At equilibrium, 50 cm^3 of the organic layer required 30cm^3 of 0.062M hydrochloric acid for neutralization which 20 cm^3 of the aqueous layer required 40cm^3 of 0.5M hydrochloric acid for neutralization using methyl orange as indicator. The partition coefficient of ammonia between water and trichloromethane is 25.0 at 20°C and 1 mole of zinc complexes 4 moles of ammonia $(Zn(NH_3)_4^{2+}$. Calculate;

(i) Concentration of ammonia in trihloromethane in $moldm^{-3}$. (1½ marks)

(ii) Concentration of free ammonia in aqueous layer in $moldm^{-3}$. (1½ marks)

(iii) Concentration of complexed ammonia in aqueous layer in $moldm^{-3}$.

(iv) Percentage purity of the zinc ore. (Zn = 65) (04 marks)

2. An organic compound Q contains 40% carbon, 6.67% hydrogen, the rest being oxygen.

(a) Determine the simplest formula of Q. (C=12, H = 1, O=16). (03 marks)

(b) A solution of 28.145g of Q in 250g of water had a freezing point of -3.49°C.

(i) Determine the molecular formular of Q if cryoscopic constant K_f of water is 1.86°C mol^{-1} per kg^{-1}. (3 ½ marks)

(ii) Write structural formulae and IUPAC names of all possible isomers of Q. (02 marks)

(c) When sodium hydrogen carbonate was added to Q there was no observable change.

(i) Name Q

(ii) Using equations, show how Q is synthesized from bromomethane. (½ mark)

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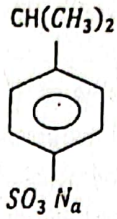
(d) (i) Write equation for the reaction between Q and water in presence of alkali catalyst and heat. (1 ½ mark)

(ii) Outline a mechanism for the reaction in (d) (i). (½ mark)

(e) Name the process in (d) and state **one** practical application of it. (02 marks) (01 mark)

(f) (i) By means of equations only show how  can be formed from Ethyne. (04 marks)

(ii) State one practical application of the reactions in (f) (i) and one advantage and disadvantage of the product. (02 marks)

3. (a) (i) Name the major ore from which copper is extracted. (½ mark)

(ii) Describe how copper is extracted from the ore you have named in (a) above. (06 marks)

(b) Describe the reaction of copper with acids. (Include equations for the reaction). (08 marks)

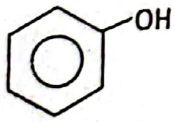
(c) State what is observed and in each case explain your observation when;

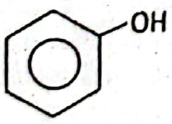
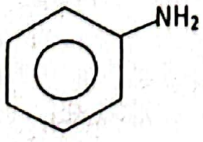
(i) Dilute sulphuric acid is added to copper (I) oxide. (2 ½ marks)

(ii) Ammonia solution is added to a solution of copper (II) sulphate drop wise until in excess. (03 marks)

4. (a) Name a reagent which is added to each of the following pairs of organic compounds, give the same or similar observations in each case. State what is observed and write equations for the reaction that takes place.

(i) $CH_3CH_2C \equiv CH$ *and* $CH_3CH = CHCH_3$ (04 marks)

(ii)  and $CH_3CH_2CH_2OH$ (03 marks)

(iii)  and  (05 marks)

(b) For each of the pairs of organic compounds shown in (a)(i) and (a) (ii), name a reagent which is used to distinguish in each case state what is observed and write equations for the reaction that takes place. (08 marks)

SECTION B
Attempt TWO questions only

5. (a) State two Faradays laws of electrolysis. (02 marks)

(b) A current of 3A was passed for 20 minutes through a cell containing dilute sulphuric acid. Calculate the volume of hydrogen produced at the cathode collected at 25°C and 120KNm^{-2} (IF = 96500C). (05 marks)

(c) The molarity of a sample of hydrochloric acid approximately 0.1M was determined accurately by measuring the conductivity of the solution as 1.0M sodium hydroxide solution was added to 50 cm^3 of the acid and the results shown in the table below:

Conductivity ($\Omega^{-1}cm^1$)	4.1	3.3	2.4	1.7	1.5	1.8	2.2	2.5
Volume of 1M NaOH(cm^3)	1	2	3	4	5	6	7	8

(i) Plot a graph of conductivity against volume of 1M sodium hydroxide added. (03 marks)

(ii) Calculate the molarity of hydrochloric acid. (02 marks)

(iii) Explain the shape of your graph. (4 ½ marks)

(d) 2.72g of anhydrous zinc chloride was dissolved in water to make one litre of solution with distilled water. The conductivity of the solution was found to be $5.175 \times 10^{-3}\,\Omega^{-1}\,cm^{-1}$ at 25°C. Determine the molar ionic conductivity of chloride ions. (molar conductivity of zinc ions is $106\Omega^{-1}cm^2mol^{-1}$ $Zn = 64.5, Cl = 35.5$). (3 ½ marks)

6. The atomic numbers and boiling points of some of period 3 elements is shown below:

Element	P	S	Cl	Ar
Atomic number	15	16	17	18
Boiling point (°C)	500	550	400	0

(a) (i) Plot a graph of boiling point against atomic number of the elements. (1 ½ marks)

(ii) Explain the shape of your graph. (3 ½ marks)

(b) Describe the reaction of phosphorus, sulphur and chlorine with sodium hydroxide. (5 ½ marks)

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(c) During extraction of aluminium from Baxite; the ore is first roasted crushed into powder and digested with hot concentrated sodium hydroxide and filtered.

State why:

(i) The ore is roasted (½ mark)

(ii) Digested with sodium hydroxide and filtered. (½ mark)

(d) Write equation(s) for the reaction(s) in (c) (ii). (01 mark)

(e) Briefly describe how pure aluminium can be obtained from the product of the reaction in (c) (ii). (5 ½ marks)

(f) (i) Write equations for the reactions between aluminium and trimanganese tetra oxide. (½ mark)

(ii) Name the process in (f) (i). (½ mark)

(g) Write equation to show how pure anhydrous aluminium chloride can be prepared. (½ mark)

7. Explain the following observations;

(a) When a solution of sulphur dioxide is added to potassium dichromate (VI) solution, orange solution turns to colourless. (02 marks)

(b) Hydrogen fluoride is liquid at room temperature while hydrogen chloride is gas at room temperature. (03 marks)

(c) An aqueous solution of chromium (III) chloride turns blue litmus paper to red. (2 ½ marks)

(d) Tin (II) chloride is polar while boron trichloride is non – polar. (05 marks)

(e) Methanoic acid is a stronger acid than ethanoic acid. (05 marks)

(f) When a limited amount of chlorine is bubbled through sodium thiosulphate solution, a yellow solid is deposited. (2 ½ marks)

8. (a) In the laboratory preparation of 2, 3 – dibromobutane, 50g of but – 2 – ene gas was passed through 80g of liquid bromine covered by a layer of tetra chloromethane. (1 ½ marks)

(i) State what was observed.

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(ii) Write equation for the reaction that took place and suggest mechanism for the reaction. (3 ½ marks)

(iii) Assuming that all the bromine reacted with the alkene, calculate the mass of 2, 3, - dibromobutane that was formed. (4 ½ marks)

(iv) If the actual mass of 2, 3 – dibromo butane was 43.2g, calculate the percentage yield of 2,3 – dibromobutane from the reaction. (C=2, H=1, Br=80). (01 mark)

(b) 1, 2 – dibromo ethane was heated with excess alcoholic aqueous potassium hydroxide solution.

Write equation for the reaction and suggest mechanism for the reaction. (05 marks)

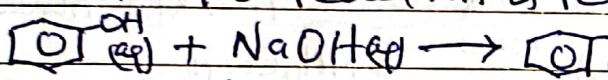
(c) By means of words only, show how the product in (b) can be converted to propanone. (4 ½ marks)

END

P525/2 CHEMISTRY
UTEC 2022 MARKING GUIDE

1(a) Partition coefficient is the ratio of the concentration of a solute between two immiscible liquid solvents in the same container at constant temperature. ✓ 2

(b) A known mass of phenol is dissolved in a known volume of methylbenzene in a separating funnel. A known volume of water is added to the separating funnel shaken for sometime and left to stand at a fixed temperature.
After settling, a known volume of methylbenzene layer is pipetted and titrated with a standard solution of sodium hydroxide using phenolphthalein indicator. The reaction is represented by the equation,



The concentration of phenol in methylbenzene is determined by calculation.
The concentration of phenol in water is determined by substraction. 5½
The partition coefficient is obtained from the expression

$$K_D = \frac{[\text{Phenol}] \text{ in methylbenzene}}{[\text{Phenol}] \text{ in water}}$$

(c) - The temperature of the entire system should be constant
- The solute should not react with the solvents
- The solute should be in the same molecular state in both solvents 2
- The solution should not be saturated.

(d) $\text{Moles of HCl} = \frac{23.0 \times 0.05}{1000} = 1.15 \times 10^{-3} \text{ moles}$

$NH_3(aq) + HCl(aq) \longrightarrow NH_4Cl(aq)$

mole ratio of $HCl : NH_3 = 1:1$

$\therefore$ moles of $NH_3 = 1.15 \times 10^{-3}$ moles

Original moles of NH_3 in aqueous layer $= \frac{1.5 \times 50}{1000} = 0.075$

Moles of NH_3 that remained in water:

Moles of NH_3 in 20 cm^3 of $CHCl_3$ $= \frac{50 \times 1.15 \times 10^{-3}}{20}$

$= 2.875 \times 10^{-3}$ moles

Moles of NH_3 that remained in water $= 0.075 - 2.875 \times 10^{-3}$

$= 0.072125$

$K_D = \frac{[NH_3] \text{ in aqueous layer}}{[NH_3] \text{ in } CHCl_3}$ 3½

$= \frac{0.072125}{2.875 \times 10^{-3}}$

$K_D = 25.1$

(e) (i) Moles of $HCl = \frac{0.062 \times 30}{1000} = 1.86 \times 10^{-3}$ moles

$NH_3(aq) + HCl(aq) \rightarrow NH_4Cl(aq)$

Moles of $NH_3 = 1.86 \times 10^{-3}$ moles

$[NH_3]$ in $CHCl_3 = \frac{1.86 \times 10^{-3} \times 1000}{50} = 0.0372M$ 1½

(ii) $K_D = \frac{[NH_3] \text{ free in aqueous layer}}{[NH_3] \text{ in organic layer}}$

$[NH_3]$ free in aqueous layer $= 25 \times 0.0372 = 0.93M$ 1½

(iii) Moles of $HCl = \frac{0.5 \times 40}{1000} = 0.02$ moles

Moles of NH_3 in aqueous layer $= 0.02$ moles

$[NH_3]$ in aqueous layer $= \frac{0.02 \times 1000}{20} = 1.0M$

$[NH_3]$ complexed = Total $[NH_3]$ in aq. layer − $[NH_3]$ free in aq. layer 2

$= 1.0 - 0.93 = 0.07M$

(iv) $\frac{[NH_3] \text{ complexed}}{[Zn^{2+}]} = 4$, $[Zn^{2+}] = \frac{0.07}{4} = 0.0175M$

Mass of $Zn^{2+} = 0.0175 \times 65 = 1.1375$ g 2

% purity of $Zn = \frac{1.1375}{1.5} \times 100 = 75.83\%$

5½

0.075 ✓

OR: 4moles of NH_3 reacts with 1mole of Zn^{2+} ✓

0.07moles of NH_3 reacts with $\left(\frac{0.07 \times 1}{4}\right)$ moles of Zn^{2+} ✓

$= 0.0175M$ ✓

2.(a) Percentage of oxygen $= 100 - (40 + 6.67) = 53.33$ ✓

Elements	C	H	O
moles	40/12	6.67/1	53.3/16 ✓
	= 3.33	6.67	3.33
	3.33/3.33	6.67/3.33	3.33/3.33 ✓
simplest ratio	1	: 2	: 1 ✓

∴ Empirical formula of Q is CH_2O ✓ 4

(b) (i) Depression in freezing point $= 0 - (-3.49) = 3.49°C$ ✓

$250cm^3$ of water dissolved 28.145g of Q. ✓

$1000cm^3$ of water dissolved $\left(\frac{28.145 \times 1000}{250}\right)$g of Q ✓

$= 112.58g$ of Q. ✓

3.49°C is the depression caused by 112.58g of Q ✓

1.86°C is the depression caused by $\left(\frac{112.58 \times 1.86}{3.49}\right)$g of Q ✓

$= 60g$ ✓

$(CH_2O)_n = 60$

$12n + 2n + 16n = 60$ ✓

$30n = 60$

$n = 2$ ✓ 6

∴ molecular formula of Q is $C_2H_4O_2$ ✓

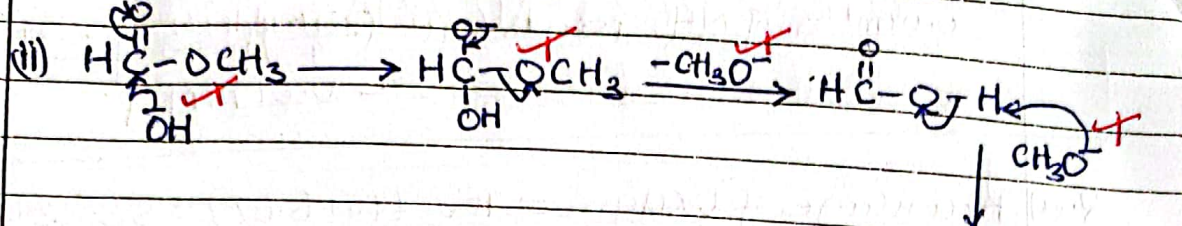
(ii) CH_3COOH ✓ Ethanoic acid ✓

$HCOOCH_3$ ✓ Methylmethanoate. ✓ 2

(c) (i) Methylmethanoate ✓ ½

(ii) $CH_3Br \xrightarrow[\text{heat}]{NaOH(aq)} CH_3OH \xrightarrow[\text{heat}]{HCOOH/H^+} HCOOCH_3$ ✓ ✓ ✓ 1½

(d) (i) $HCOOCH_3 + H_2O \underset{\text{heat}}{\overset{OH^-(aq)}{\rightleftharpoons}} HCOO^- + CH_3OH$

(ii) 

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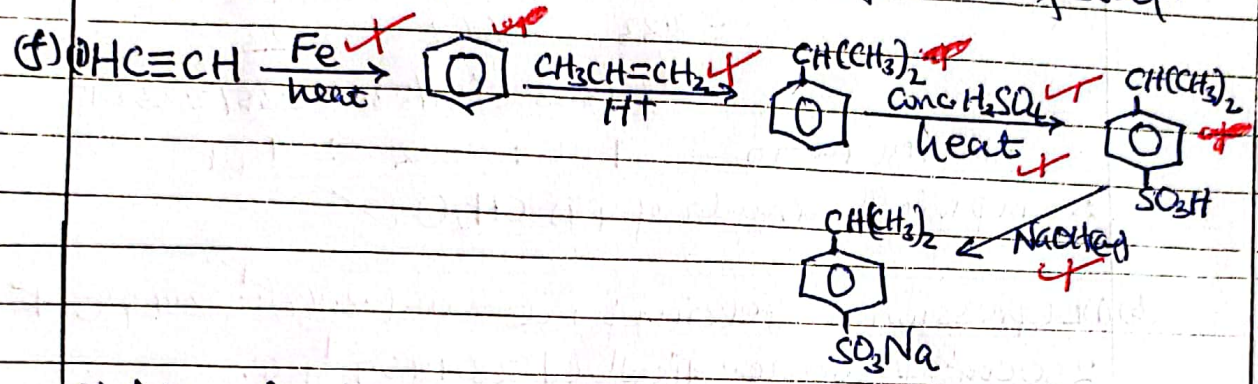
(e) Saponification; used in manufacture of soap.

1

(f) (i) 

(ii) Manufacture of soapless detergents

Advantage:

Disadvantage:

$2\frac{1}{2}$

20

3. (a) (i) Copper pyrites.

$\frac{1}{2}$

(ii) Copper pyrites is crushed (pulverised) and it is agitated with water and frothing agent. Air is blown into a mixture and a froth formed; the ore rises to the surface in a froth. Earthly materials are wetted with water and sink to the bottom.

The froth is skimmed off and acid is added to the froth to break it down. The froth is filtered, and the ore is dried and roasted in air to obtain copper(I) sulphide, iron(II) oxide and sulphur dioxide gas.

$2CuFeS_{2(s)} + 4O_{2(g)} \longrightarrow Cu_2S_{(s)} + 2FeO_{(s)} + 3SO_{2(g)}$

The copper(I) sulphide is heated in a controlled amount of air which convert it to impure copper and sulphur dioxide.

$Cu_2S_{(s)} + O_{2(g)} \longrightarrow 2Cu_{(s)} + SO_{2(g)}$

The impure copper is used as the anode and pure copper as the cathode. An electric current is passed through acidified copper(II) sulphate solution. Copper anode dissolves to give copper(II) ions.

$Cu_{(s)} \longrightarrow Cu^{2+}_{(aq)} + 2e$

copper(II) ions are deposited at the cathode to form deposit of pure copper. 6

$Cu^{2+}_{(aq)} + 2e \longrightarrow Cu_{(s)}$

The iron(II) oxide combines with silicon(IV) oxide (silica) to form iron(II) silicate which is removed as slag.

$FeO_{(s)} + SiO_{2(s)} \longrightarrow FeSiO_{3(l)}$

OR

Copper(I) sulphide is oxidised by air to copper(I) oxide.

$2Cu_2S_{(s)} + 3O_{2(g)} \longrightarrow 2Cu_2O_{(s)} + 2SO_{2(g)}$

The copper(I) oxide reacts with the remaining copper(I) sulphide to form copper which is tapped off.

$Cu_2S_{(s)} + 2Cu_2O_{(s)} \longrightarrow 6Cu_{(l)} + SO_{2(g)}$

(b) Copper reacts with hot concentrated hydrochloric acid to form dichlorocuprate(I) ion and hydrogen gas

$2Cu_{(s)} + 2H^+_{(aq)} + 4Cl^-_{(aq)} \longrightarrow 2CuCl_2^-{}_{(aq)} + H_{2(g)}$

Hot concentrated sulphuric acid oxidises copper to copper(II) sulphate and itself reduced to sulphur dioxide and water

$Cu_{(s)} + 2H_2SO_{4(l)} \longrightarrow CuSO_{4(aq)} + SO_{2(g)} + 2H_2O_{(l)}$

Hot concentrated nitric acid oxidises copper to copper(II) nitrate and itself reduced to nitrogen dioxide and water.

$Cu_{(s)} + 4HNO_{3(aq)} \longrightarrow Cu(NO_3)_{2(aq)} + 2NO_{2(g)} + 2H_2O_{(l)}$

Cold dilute nitric acid oxides copper to copper(II) nitrate and itself reduced to nitrogen monoxide and water.

$3Cu(s) + 8HNO_3(aq) \longrightarrow 3Cu(NO_3)_2(aq) + 2NO(g) + 4H_2O(l)$

(c) (i) ~~Red~~ solid dissolves forming a blue solution and brown ~~dep~~ solid.

$Cu_2O(s) + H_2SO_4(aq) \longrightarrow Cu(s) + CuSO_4(aq) + H_2O(l)$

Copper(I) oxide reacts with dilute sulphuric acid to form copper(I) sulphate which is unstable and undergoes disproportionation to form copper and copper(II) sulphate. 2½

(ii) Blue precipitate soluble in excess to form a deep blue solution.

Copper(II) ions reacts with hydroxide ions to form insoluble copper(II) hydroxide.

$Cu^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Cu(OH)_2(s)$ 3

The copper(II) hydroxide reacts with excess ammonia to form a soluble complex tetraammine copper(II) ions

$Cu(OH)_2(s) + 4NH_3(aq) \rightleftharpoons Cu(NH_3)_4^{2+}(aq) + 2\bar{O}H(aq)$ 20

(a) (i) Reagent: Bromine water

Observation: Reddish-brown solution turns colourless

Equation:

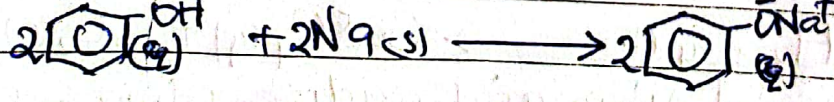
$CH_3CH_2C\equiv CH(g) \xrightarrow{Br_2(aq)} CH_3CH_2\overset{O}{\overset{\|}{C}}CH_2Br(g)$

$CH_3CH=CHCH_3(g) \xrightarrow{Br_2(aq)} CH_3\overset{OH}{C}H\overset{Br}{C}HCH_3(g)$ 4

(ii) Reagent: sodium metal

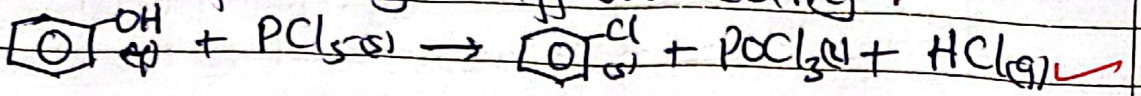
observation: Bubbles of colourless gas

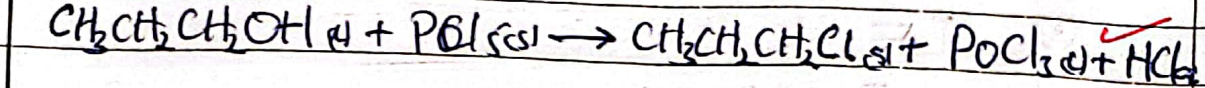
Equation



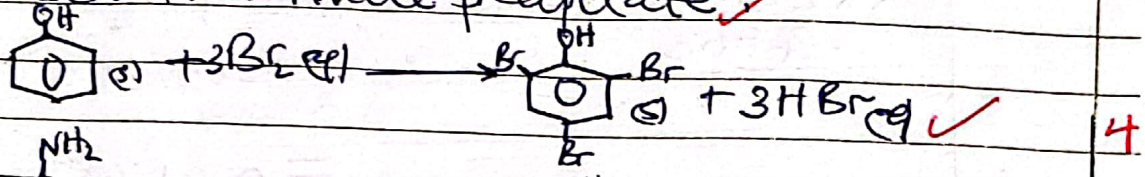
$2CH_3CH_2CH_2OH + 2Na(s) \longrightarrow 2CH_3CH_2CH\bar{O}Na^+(aq) + H_2(g)$ 3

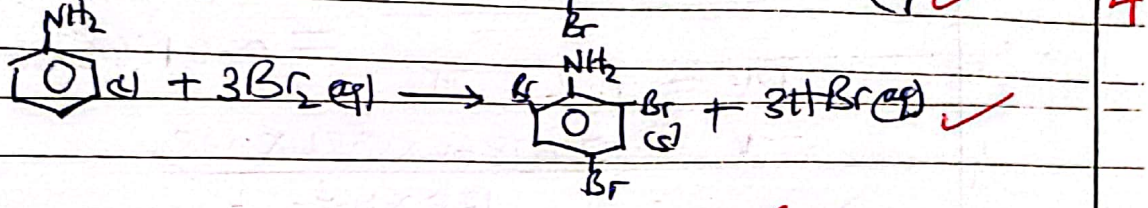
or Phosphorous pentachloride / (V) chloride.
: White fumes given off on heating





(iii) Reagent: Bromine water.
Observation: White precipitate.





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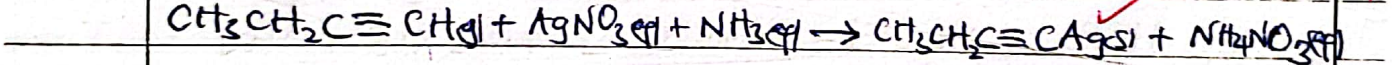
(b) (i) Reagent: Ammoniacal silver nitrate solution.
Observation:
$CH_3CH_2C\equiv CH$ - White precipitate.
$CH_3CH=CHCH_3$ - No observable change.
Equation:



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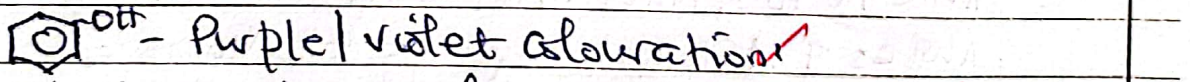
(ii) Neutral iron(III) chloride solution
Observation



- Purple / violet colouration
$CH_3CH_2CH_2OH$ - No observable change.

4

(ii) Neutral iron(III) chloride solution:

20

5(a) Faraday's First Law.
The mass of a substance produced at an electrode during electrolysis is directly proportional to the quantity of electricity which has passed through the cell.

Faraday's second Law:
The quantity of electricity required to liberate one mole of any element is proportional to the charge number of its ions. 2

(b) $Q = It$

$= 3 \times 20 \times 60 = 3600C$

$2H^+_{(aq)} + 2e \longrightarrow H_{2(g)}$

$2 \times 96500C$ liberates 1mole of H_2

$3600C$ liberates $\left(\frac{3600 \times 1}{2 \times 96500}\right)$ moles of H_2

$= 0.01865$ moles of H_2.

$PV = nRT$

$V = \frac{0.01865 \times 8.31 \times 298}{120 \times 10^3}$ 5

$= 3.85 \times 10^{-4} m^3$

(c) (i) Graph paper.

(ii) Volume of sodium hydroxide added at end-point

$= 4.45 cm^3 (4.4 - 4.5) cm^3$.

Moles of $NaOH = \frac{1 \times 4.45}{1000} = 4.45 \times 10^{-3}$ moles

$NaOH_{(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$

Mole ratio of $NaOH : HCl = 1:1$

Moles of HCl that reacted $= 4.45 \times 10^{-3}$ moles

Molarity of $HCl = \frac{4.45 \times 1000}{50} = 0.089M$ 3

(iii) Initially conductivity is high due to many highly mobile and conducting hydrogen ions from fully ionised hydrochloric acid

Conductivity decreases with addition of sodium hydroxide due to neutralisation of hydrogen ions by hydroxide ions. Replacement of the hydrogen ions by slower or less conducting hydroxide ions

At the end-point, all the acid is neutralised, showing minimum conductivity due to sodium ions and chloride ions. 4½

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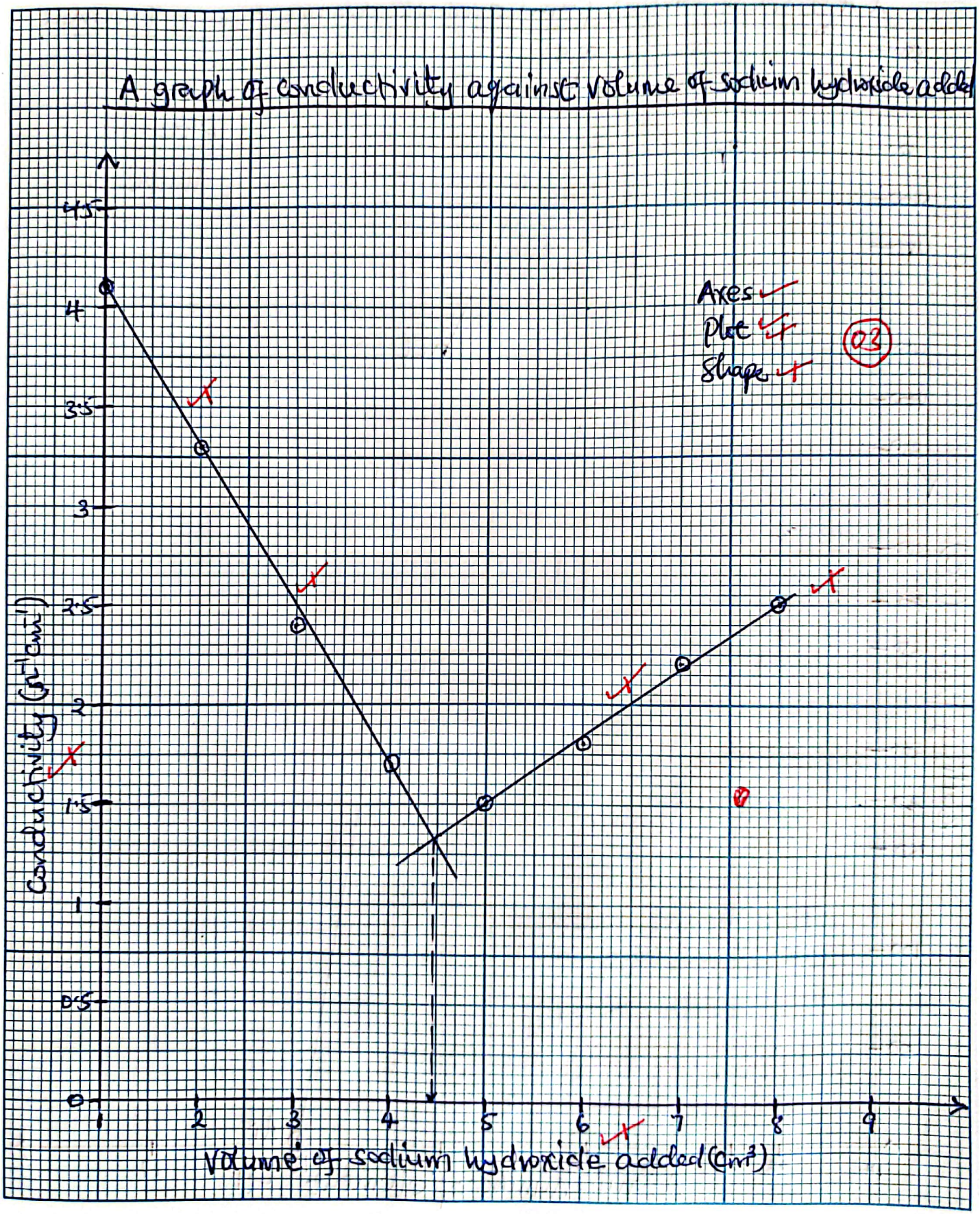

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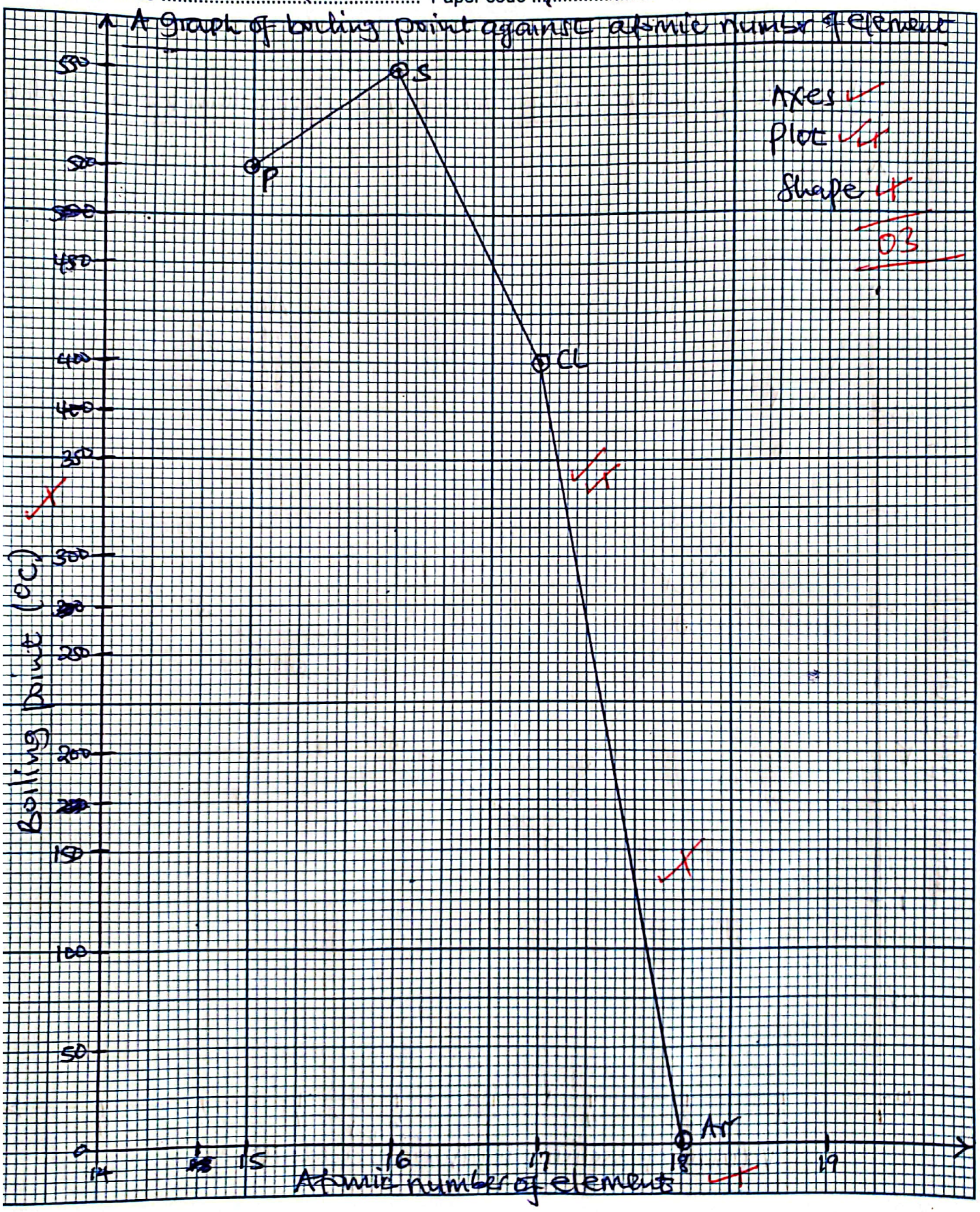


Beyond the end-point, conductivity increases with addition of excess high conducting hydroxide ions.

(d) RFM of $ZnCl_2$ = 64.5 + 35.5 × 2 = 135.5

$[ZnCl_2] = \frac{2.72}{135.5} = 0.02M$

$\Lambda_c = \frac{K \times 10^3}{c} = \frac{5.175 \times 10^{-3} \times 10^3}{0.02} = 258.75 \Omega^{-1} cm^2 mol^{-1}$

$\Lambda_\infty ZnCl_2 = \Lambda_\infty Zn^{2+} + 2\Lambda_\infty Cl^-$

$258.75 = 106 + 2\Lambda_\infty Cl^-$

$\Lambda_\infty Cl^- = \frac{258.75 - 106}{2} = 76.375 \Omega^{-1} cm^2 mol^{-1}$

3½

20

6(a) (i) Graph paper axes ✓; plot

½

(ii) Generally boiling point increases from phosphorous to sulphur and decreases from sulphur to argon. The elements have simple molecular structure held by van der waals forces whose magnitude increase with increase in molecular weight. Sulphur is octahedral, S_8 with high molecular weight and stronger van der waals forces of attraction hence higher boiling point than phosphorous which is tetraatomic, P_4 with relatively low molecular weight and weaker van der waals forces of attraction. Chlorine is diatomic molecule, Cl_2 with low molecular weight, weak van der waals forces of attraction and low boiling point. Argon is monoatomic, Ar with very low molecular weight, very weak van der waals forces of attraction hence very low boiling point.

3½

(b) Phosphorous reacts with hot concentrated sodium hydroxide to form sodium phosphinate, and phosphine

$P_4(s) + 3OH^-(aq) + 3H_2O(l) \longrightarrow 3H_2PO_2^-(aq) + PH_3(g)$

Sulphur reacts with hot concentrated sodium hydroxide to form sodium sulphide, sodium thiosulphate and water.

$4S_{(s)} + 6\bar{O}H_{(aq)} \longrightarrow 2S^{2-}_{(aq)} + S_2O_3^{2-}{}_{(aq)} + 3H_2O_{(l)}$

Chlorine reacts with cold dilute sodium hydroxide to form sodium chloride, sodium chlorate (I) and water

$Cl_{2(g)} + 2\bar{O}H_{(aq)} \longrightarrow Cl^-_{(aq)} + ClO^-_{(aq)} + H_2O_{(l)}$ $5\frac{1}{2}$

Chlorine reacts with hot concentrated sodium hydroxide to form sodium chloride, sodium chlorate (V) and water.

$3Cl_{2(g)} + 6\bar{O}H_{(aq)} \longrightarrow 5Cl^-_{(aq)} + ClO_3^-{}_{(aq)} + 3H_2O_{(l)}$

(c) (i) To remove water of crystallisation to obtain anhydrous aluminium oxide.

- To convert all the iron(II) oxide to iron(III) oxide. $\frac{1}{2}$

(ii) To remove iron(III) oxide and titanium (IV) oxide impurity $\frac{1}{2}$

(d) (i) $Al_2O_{3(s)} + 2\bar{O}H_{(aq)} + 3H_2O_{(l)} \longrightarrow 2Al(OH)_4^-{}_{(aq)}$

$Si_2O_{2(s)} + 2\bar{O}H_{(aq)} \longrightarrow Si_2O_3^{2-}{}_{(aq)} + H_2O_{(l)}$ 1

(e) Carbon dioxide is bubbled through the filtrate to precipitate aluminium hydroxide

$2Al(OH)_4^-{}_{(aq)} + CO_{2(g)} \longrightarrow 2Al(OH)_{3(s)} + CO_3^{2-}{}_{(aq)} + H_2O_{(l)}$

OR The filtrate is seeded with pure aluminium hydroxide to precipitate more aluminium hydroxide

$Al(OH)_4^-{}_{(aq)} \xrightarrow{Al(OH)_{3(s)}} Al(OH)_{3(s)} + \bar{O}H_{(aq)}$

Aluminium hydroxide is filtered and strongly heated to obtain anhydrous aluminium oxide. $5\frac{1}{2}$

$2Al(OH)_{3(s)} \longrightarrow Al_2O_{3(s)} + 3H_2O_{(l)}$

The pure aluminium oxide is dissolved in molten cryolite to lower its melting temperature and electrolysed between graphite electrolytes at about 850°C.

Aluminium is discharged at the cathode.

$Al^{3+}_{(l)} + 3e \longrightarrow Al_{(l)}$

(f) (i) $8Al_{(s)} + 3Mn_3O_{4(s)} \longrightarrow 4Al_2O_{3(s)} + 9Mn_{(l)}$ ✓✓ ½

(ii) Reduction process OR Thermit process. ✓ ½

(e) $2Al_{(s)} + 3Cl_{2(g)} \longrightarrow 2AlCl_{3(s)}$ ✓✓ ½

[20]

7.(a) Acidified ~~sulphur dioxide~~ potassium dichromate(VI) oxidises sulphur ~~dioxide~~ dioxide in the presence of water to sulphuric acid and itself reduced to chromium (III) sulphate 2

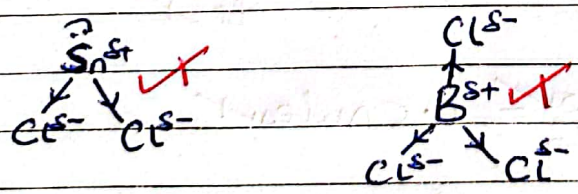
$Cr_2O_7^{2-}{}_{(aq)} + 2H^+_{(aq)} + 3SO_{2(g)} \longrightarrow 2Cr^{3+}_{(aq)} + 3SO_4^{2-}{}_{(aq)} + H_2O_{(l)}$

(b) Fluorine is highly electronegative making hydrogen – fluorine bond highly polar and its molecules are held together by ~~weak~~ strong hydrogen bonds that them close to each other. Hydrogen chloride has simple molecular structure with weak Vandarwaals forces of attraction that can easily break at room temperature 3

(c) Chromium(III) chloride undergo hydrolysis in water to produce hydroxonium ions which make the solution acidic. 2½

$Cr(H_2O)_6^{3+}{}_{(aq)} + 3H_2O_{(l)} \rightleftharpoons Cr(H_2O)_3(OH)_{3(s)} + 3H_3O^+_{(aq)}$

(d)



Boron trichloride is trigonal planar. its bonds are polar but the polarities of the bonds cancel out because the structure is symmetrical hence it is a non-polar molecule

Tin(II) chloride is V-shaped because of the presence of lone pair of electrons on the tin atom. It has polar bonds. The polarity of the bonds in the presence of the lone pair of electrons do not cancel out hence it has a polar molecule. 5

(e) The strength of the acid depends on the ease with which it releases hydrogen ions in solution. Methanoic acid has a hydrogen atom bonded to carboxylic group which neither attract or release electrons (has no inductive effect.

Ethanoic acid has a methyl group bonded to the carboxylic group, it releases electrons to the carboxylic group (or the methyl group has a positive inductive effect. The bond between oxygen and hydrogen atom is strengthened. Therefore methanoic acid ionises more easily than ethanoic acid. 5

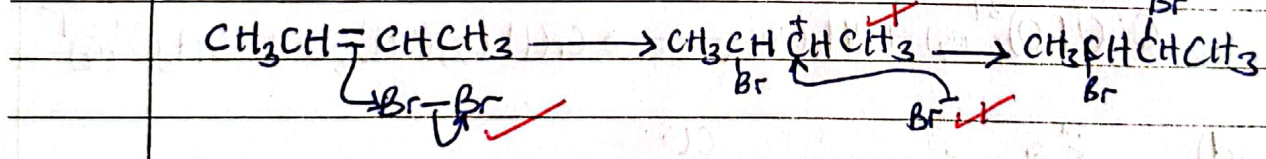
(f) Sodium thiosulphate undergo disproportionation in the presence of chlorine in water to produce sulpher and sulphate ions. 1½

$S_2O_3^{2-}(aq) + Cl_2(g) + H_2O(l) \longrightarrow S(s) + SO_4^{2-}(aq) + 2Cl^-(aq) + 2H^+(aq)$ R0

Reddish liquid turns colourless 1½

(ii) $CH_3CH=CHCH_3 \xrightarrow{Br_2/CCl_4} CH_3\underset{Br}{C}H\underset{Br}{C}HCH_3$

Mechanism



3½

(iii) Moles of $Br_2 = \frac{80}{160} = 0.5$ moles

Mole ratio of Bromine : 2,3-dibromobutane is 1:1

Moles of 2,3-dibromobutane = 0.5 moles

Rfm of $CH_3\underset{Br}{C}H\underset{Br}{C}HCH_3 = (12\times4)+(1\times8)+(80\times2) = 216$ 4½

Mass of 2,3-dibromobutane = $0.5\times216 = 108g$

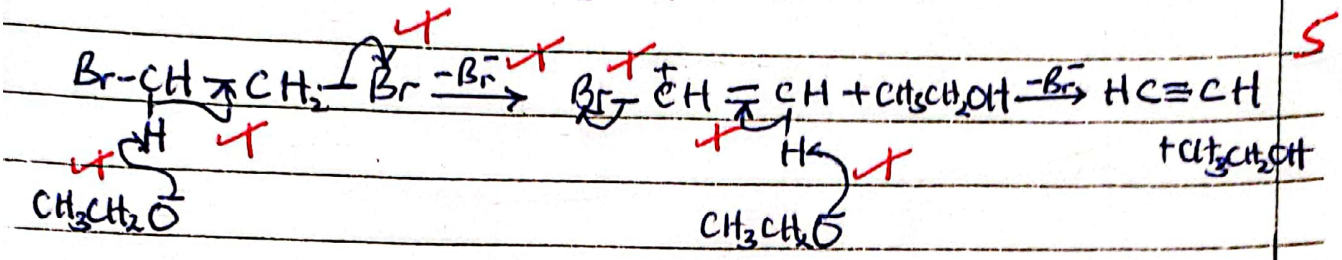
(iv) % yield $= \frac{432}{108} \times 100 = 40\%$ 1

$BrCH_2CH_2Br \xrightarrow[\text{heat}]{KOH(aq)/\text{Excess Ethanol}} HC\equiv CH$ ✓

Mechanism

$CH_3CH_2OH + KOH \longrightarrow CH_3CH_2\bar{O}K^+ + H_2O$ ✓

$CH_3CH_2\bar{O}K^+ \longrightarrow CH_3CH_2\bar{O} + K^+$



5

Ethyne is reacted with sodium in liquid ammonia followed by bromomethane to form propyne. Propyne is reacted with concentrated sulphuric acid in the presence of mercury (II) sulphate at 60°C to form propanone.

4½

20

END