1. (a) **Table 1** gives the properties of two compounds, A and B.

Table 1

A	B
white, crystalline, efflorescent	white, crystalline, deliquescent

State and explain the observation made when each of the compounds is left exposed in air:

(i) Compound **A**

Changes from Crystaline solid to a Powder
It loses its water of crystalization
(2 marks) 2

If observation is wrong, explanation is also wrong.

(ii) Compound **B**

Changes from crystaline solid to a Solution
It absorbs water vapour from the atmosphere
(2 marks) 2

(b) In an experiment to determine the formula of hydrated magnesium sulphate, a sample was heated in a crucible until a constant mass was obtained. The results are shown in **Table 2.**

Table 2

Mass of crucible	25.62 g
Mass of crucible + solid before heating	28.08 g
Mass of crucible + solid after heating	26.82 g

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Using the information in **Table 2**, determine the formula of the hydrated salt (Mg = 24.0; S = 32.0; O = 16.0; H = 1.0). (3 marks)

$MgSO_4$ H_2O

Mass of anhydrous: 26.82 − 25.62 = 1.20 ; 28.08 − 26.82 = 1.26 ✓½

RFM: 120 ; 18 ✓½

Moles: $\frac{1.20}{120} = 0.01$; $\frac{1.26}{18} = 0.07$ ✓½

Mole ratio: $\frac{0.01}{0.01}$; $\frac{0.07}{0.01}$

1 : 7 ✓½ (03)

$MgSO_4 \cdot 7H_2O$ ✓1

(c) **Figure 1** shows analysis of an alloy containing two metals.

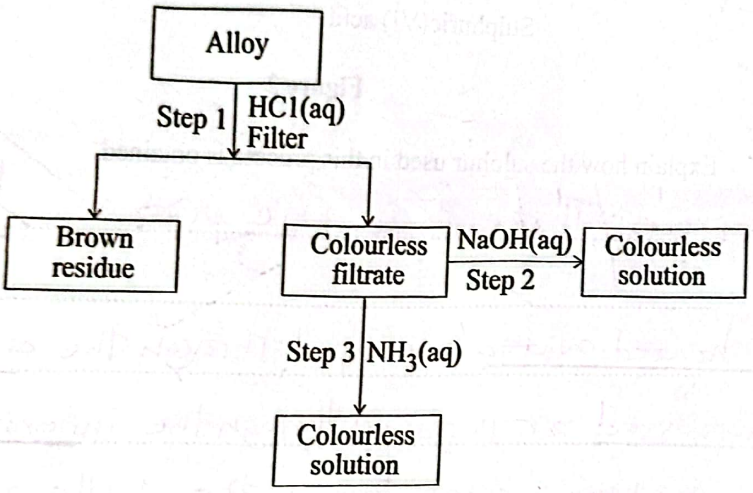


Figure 1

(i) Give the name of another product formed in step 1. (1 mark)

Hydrogen gas ✓

(ii) Write the formula of the complex ion present in the colourless solution obtained in step 2. (1 mark)

$[Zn(OH)_4]^{2-}$ ✓

(iii) Identify the metals in the alloy. (2 marks)

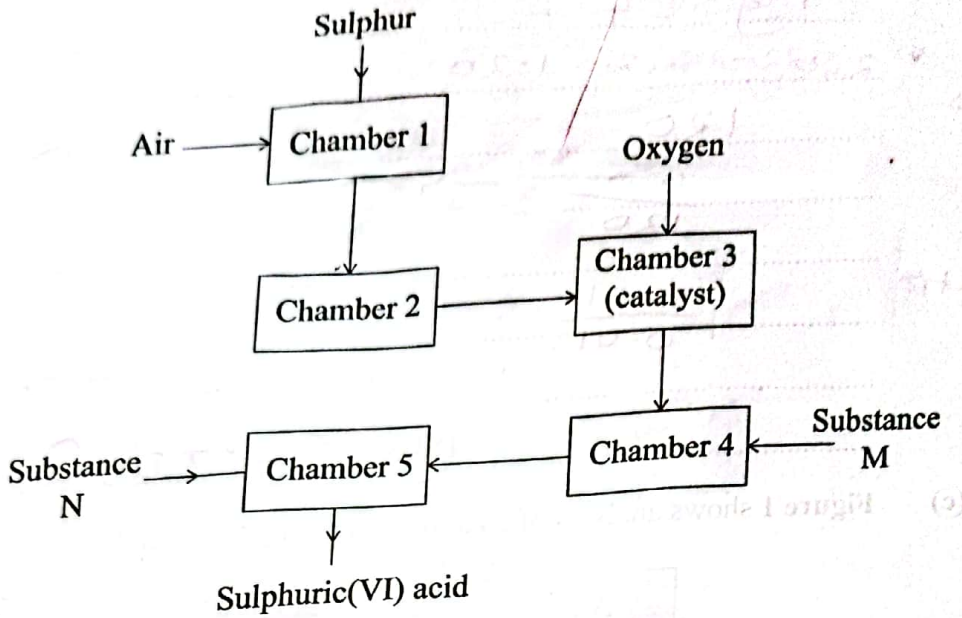
Zinc / Zn ✓

Copper / Cu ✓ (2)

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2. The flow chart in **Figure 2** shows the processes involved in the manufacture of sulphuric(VI) acid.

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Accept correct Diagram

Figure 2

(a) Explain how the sulphur used in this process is obtained. (2 marks)

Frasch process/Three Concentric pipes ✓ ½

02

½

Super heated water is pumped through the outermost pipe

Hot compressed air is passed through the innermost pipe ✓ ½

Molten Sulphur passes through the middle pipe to the surface ✓ ½

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(b) Give **one** advantage of using air in chamber **1** instead of using oxygen gas. (1 mark)

Air is cheap source of oxygen gas ✓

OR;

Economical to use air as source of oxygen

Any 1

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(c) Identify substances:

(i) **M**

Concentrated H_2SO_4 ✓ Accept H_2SO_4 (1 mark)

(ii) **N**

Water ✓ (1 mark)

(d) (i) In chamber **2**, drying and purification take place. Give a reason why this is necessary. (1 mark)

Any 1 OR;

Impurities in the gas poison the catalyst ✓

Makes the catalyst inefficient / impairs catalyst

(ii) The reaction in chamber **3** is highly exothermic.

I. Explain why high temperature is required for the reaction in chamber **3**. (1 mark)

It increases rate of reaction ✓ ½

Particles gain kinetic energy resulting to frequent effective collisions ✓ ½ (1)

II. State how the heat produced in chamber **3** can be utilised in this process. (1 mark)

Any 1 OR;

Can be recycled into the system ✓

Used to pre-heat SO_2 and O_2 gases

(e) Give a reason why this method of manufacture is known as '*contact process*'. (1 mark)

SO_2 and O_2 come into contact with each other on the surface of a catalyst ✓

(f) Emission of gases in the sulphuric(VI) acid plant may lead to environmental pollution.

(i) State the evidence that could be used to show that the sulphuric(VI) acid plant causes pollution. (1 mark)

Rusted/Corroded metalic structures near the Plant ✓

or Vegetation turns from green to Yellow/Dries/Wilts

or Respratory diseases

Any 1 or Acid rain lowers pH of soil to acidic

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(ii) Explain how the pollution identified in 2(f)(i) can be controlled. (1 mark)

Scrubbing the gas

or; Passing the gaseous emmisions through alkaline/basic substances eg $Ca(OH)_2$

3. (a) Chemical reactions occur as a result of collisions of particles. Give a reason why **not** all collisions are effective. (1 mark)

Colliding particles may NOT posses the necessary Kinetic energy/Activation energy

or; Particles may not collide in the right/correct orientation

or; Particles may collide in the wrong orientation

(b) State and explain how the following factors affect the rate of reaction:

(i) Surface area of reactants. (1 mark)

Increase in S.A increases the rate of reaction (½) more particles are exposed to the reaction (½) (1)

Accept the reverse

increases no of particles coming into contact

(ii) Pressure. (1 mark)

Increase in pressure brings molecules of gaseous reactants closer to each other (½) (1)

Increases number of collisions/Increases rate of reaction (½)

Accept the reverse

(c) In an experiment to determine the rate of a reaction, marble chips were added to excess 2M hydrochloric acid. The equation for the reaction is:

$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$

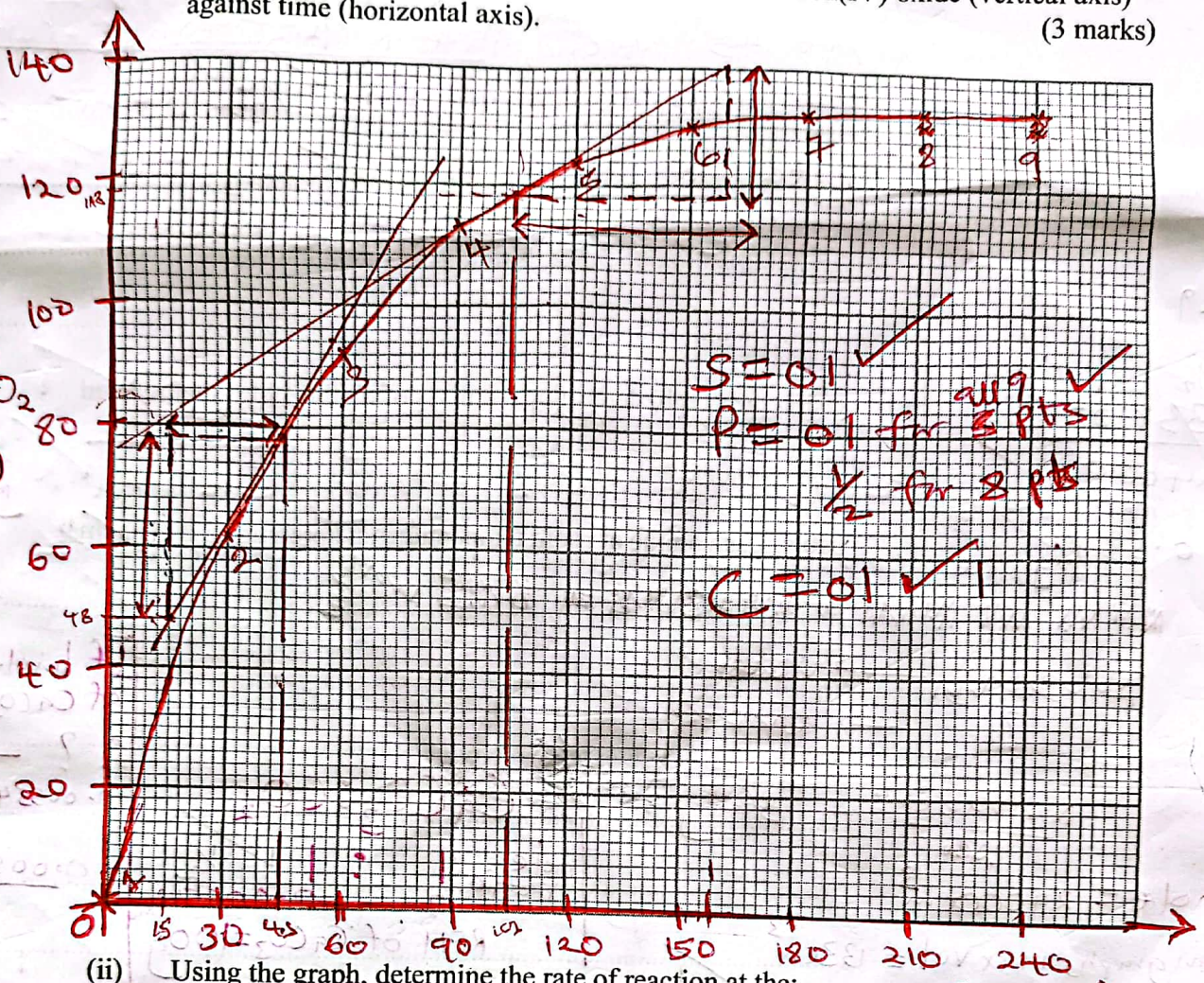
The volume of carbon(IV) oxide produced was measured at 25 °C and recorded after every 30 seconds. **Table 3** shows the results obtained.

Table 3

Time (seconds)	0	30	60	90	120	150	180	210	240
Volume of $CO_2(cm^3)$	0	62	92	113	124	130	132	133	133

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(i) On the grid provided, plot a graph of volume of carbon(IV) oxide (vertical axis) against time (horizontal axis). (3 marks)



(ii) Using the graph, determine the rate of reaction at the:

I. 45th second. (1 mark)

Tangent ✓ ½

Rate = $\frac{\Delta Y}{\Delta X} = \frac{78-48}{45-15} = \frac{30}{30}$ ✓ ½ (01)

$= 1 cm^3/sec$

II. 105th second. (1 mark)

Tangent ✓ ½

Rate = $\frac{\Delta Y}{\Delta X} = \frac{140-118}{159-105} = \frac{22}{54}$ ✓ ½ (07)

$= 0.407 cm^3/sec$

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(iii) Give a reason for the differences in the two rates. (1 mark)

At 45th second, rate is high since concentration of reagents is high ✓ ½ hence faster rate of reaction ✓ ½ (01)

(iv) Using the graph, determine the mass of marble chips that reacted (2 marks)

(Ca = 40.0; C = 12.0; O = 16.0;

Molar gas volume at room temperature and pressure = 24000 cm³).

mass = moles × m.m

0.005542 × 100

1 mole = 24000 cm³

From graph, max vol = 133 cm³ ✓ ½

Moles of gas = V / Mgv = 133 / 24000 = 0.005542 moles ✓ ½

$CaCO_3 : CO_2$

mole ratio 1 : 1 ✓ ½

0.005542 : ?

RFM of $CaCO_3$ = 100g

If 1 mole → 100g of $CaCO_3$

? ← 0.005542

0.005542 × 100 / 1 ✓ ½

= 0.5542g ✓ ½

Moles of $CaCO_3$ reacted 0.005542

4. (a) Sea water contains approximately 3% sodium chloride. Describe how sodium chloride is obtained from sea water. (3 marks)

Put sea water in a beaker

Heat/Boil/Evaporate the solution to saturation ✓ ½ point

Allow solution to cool ✓ ½ for crystals ✓ 1 to form (03)

OR;

Sea water is tapped in a pan/shallow pond ✓ 1 and allowed to undergo solar evaporation ✓ 1 until solid crystalises out. Liquor is allowed to drain out ✓ 1 and solid left is washed and dried.

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Moles = mass / m.m = 36.2 / 58.5 = 0.6188 mole

OR) RMM of Cl_2 = 58.5

If 0.6188 moles → 1000 cm^3

? → 1000 cm^3

$= \frac{1000 \times 0.6188}{100}$ = 6.188M

6.19M

6.2M

(b) The solubility of sodium chloride is 36.2 g in 100 g of water at room temperature. Determine the concentration in moles per litre of a saturated aqueous sodium chloride at room temperature (Na = 23.0; Cl = 35.5; density of water = 1.0 gcm^{-3}). (2 marks)

RFM of NaCl = 23 + 35.5 = 58.5

If 36.2g → 100 cm^3

? → 1000 cm^3

$= \frac{1000 \times 36.2}{100} = 362$ g/litre

$M = \frac{\text{Concn in g/l}}{RFM} = \frac{362}{58.5}$

6.188M or 6.19M

02

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(c) Ammonia is highly soluble in water.

(i) Explain how aqueous ammonia is prepared starting with ammonia gas. (2 marks)

Ammonia gas is passed through Inverted funnel dipped in water in a beaker, to prevent suck back

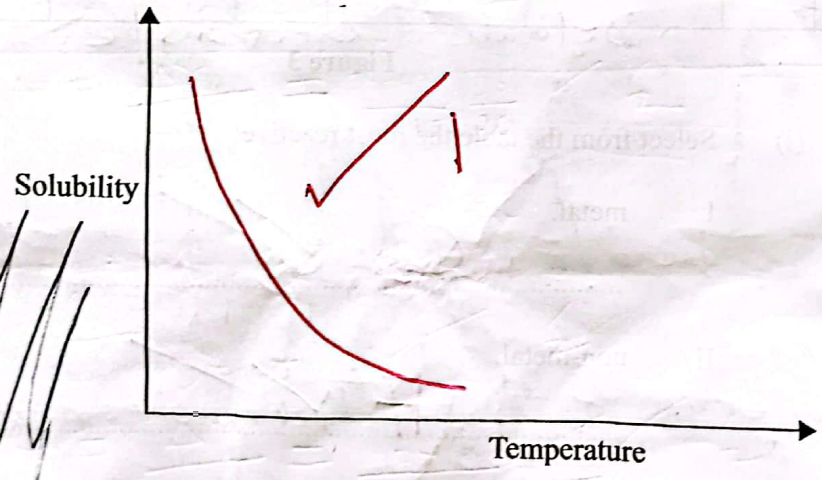
increase S.A over which ammonia gas dissolves

Accept correct diagram for 1 mk

Explanation 1 mk

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(ii) On the axes provided, sketch a curve showing how solubility of ammonia gas varies with temperature. (1 mark)



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(iii) Give a reason for the shape of the curve. (1 mark)

Solubility of Ammonia decreases with increase in temperature ✓ ½ CO2 gaseous particles gain kinetic energy ✓ ½ and escape from the solution.

(d) Water hardness is due to the presence of magnesium and calcium ions. Explain how these ions get into sources of water. (2 marks)

CO_2 dissolves in rain water forming H_2CO_3 ✓ 1
H_2CO_3 reacts with rocks containing Ca and Mg ✓ ½ salts Hence leaving Ca^{2+} and Mg^{2+} in water ✓ ½

5. (a) **Figure 3** shows part of a Periodic Table.

Li	Be						He
Na	Mg			N	O	F	Ne
K	Ca	Al	Si			Cl	Ar
Rb						Br	
Cs						I	

Figure 3

(i) Select from the table the most reactive:

I. metal. Cs ✓ ½ (½ mark)

II. non-metal. F ✓ ½ (½ mark)

(ii) Select an element with the highest first ionisation energy. He ✓ 1 (1 mark)

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(iii) I. Name the method used to obtain argon from its source. (1 mark)

Fractional distillation/Fractional distillation of liquid air/Fractional distillation of liquified air

II. Give one industrial use of argon. (1 mark)

Arch welding/Used in flouresient bulbs (lamps)/Dilution of O_2 used by patients with difficulty in breathing/Used in forensic medicine/Used in high speed printing

radioactive dating

(iv) Explain each of the following observations:

I. The melting point of lithium is higher than that of potassium. (1 mark)

Li has stronger metallic bonds than K hence more energy required to break the metallic bonds in Li than K

Li has stronger electrostatic forces

II. The melting point of chlorine is lower than that of iodine. (1 mark)

I_2 has more stronger van der waals intermolecular forces than Cl_2

(v) The following ions have the same number of electrons: N^{3-}, Mg^{2+}, O^{2-}, Na^{+}

Arrange them in order of increasing ionic size. Give a reason for the order. (2 marks)

Mg^{2+}, Na^{+}, O^{2-}, N^{3-} → increasing ionic size

O^{2-}

Number of protons decrease from Mg to N hence nuclear attraction decreases from Mg to N

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(b) Use **Table 4** to answer the questions that follow.

Table 4

Property	Substance			
	H	I	J	K
Melting point (°C)	993	113	–38.9	–85
Boiling point (°C)	1695	183	357	–60
Electrical conductivity at room temperature	Does not conduct	Does not conduct	Conducts	Does not conduct
Electrical conductivity in molten state	Conducts	Does not conduct	Conducts	Does not conduct

(i) Identify the substance which is a gas at room temperature.

Give a reason. (1 mark)

K ✓ ½ ½

It's boiling point of −60°c ✓ is below the RT

(ii) Name the particles responsible for electrical conductivity in substance:

I. **H**

Mobile ions / Ions / Free ions ✓ (1 mark)

II. **J**

Delocalised electrons / electrons / Free electrons ✓ (1 mark)

(iii) Identify the type of forces that hold the particles together in:

I. **H**

Ionic bond / Electrovalent bond / Electrostatic forces ✓ (1 mark)

II. **K**

Vanderwaals forces / Intermolecular forces ✓ (1 mark)

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6. **Figure 4** shows a flow chart involving reactions of some organic compounds.

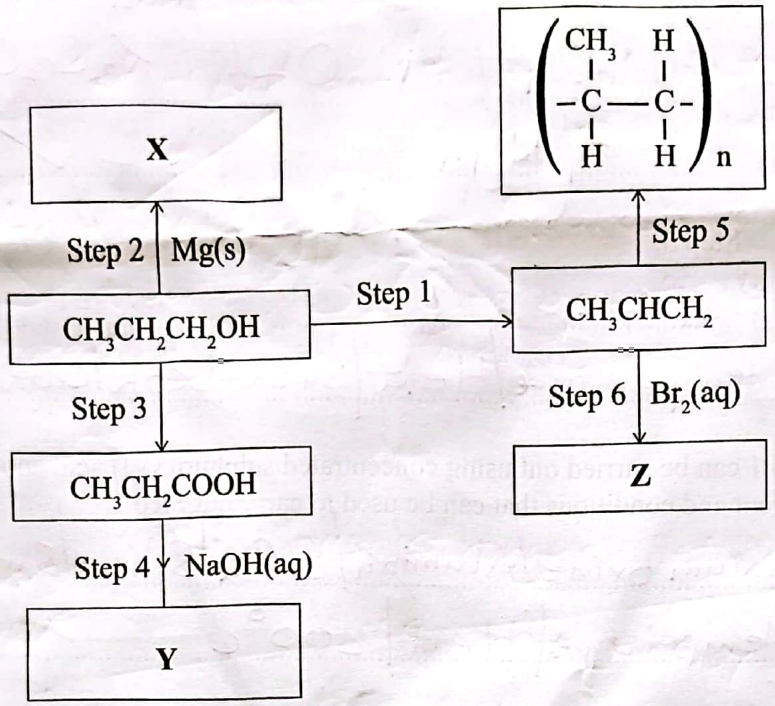


Figure 4

(a) Write the formula and give the names of compounds:

(i) **X**

Name Magnesium propoxide 1 Formula $(CH_3CH_2CH_2O)_2Mg$ or $(C_3H_7O)_2Mg$ 1 (2 marks) 2

Independent

(ii) **Y**

Name Sodium propanoate Formula CH_3CH_2COONa or C_2H_5COONa or $C_2H_5COO^-$ (2 marks) 2

Independent

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(b) Give the reagents and conditions necessary for carrying out:

(i) Step 3. (1 mark)

Acidified $KMnO_4$ / $KMnO_4$ / Acidified $K_2Cr_2O_7$ ✓ ½

Warm / Heat / High temperature ✓ ½

(ii) Step 5. (1 mark)

Propene

High pressure / High temperature / Heat / 340K-360K / Catalyst / $TiCl_4$

(c) Step 1 can be carried out using concentrated sulphuric(VI) acid and heat. Name another reagent and conditions that can be used to carry out Step 1. (1 mark)

Aluminium oxide / Alumina / SiO_2 / Silica / Sand / Phosphoric acid / phosphoric(V) acid

High temperature / Heat / 300°C

(d) Give the name of the type of reaction that takes place in:

(i) Step 1. (1 mark)

Dehydration / Elimination ✓ 1

(ii) Step 5. (1 mark)

Polymerization ✓ 1

(e) (i) Write an equation for the reaction in step 6. (1 mark)

$C_3H_6 + Br_2 \longrightarrow C_3H_6Br_2$

$CH_3CHCH_2 + Br_2 \longrightarrow CH_3CHBrCH_2Br$

(ii) State the observations made in step 6. (1 mark)

Bromine is decolourised / turns to colourless ✓ 1

brown bromine turns to colourless / fades

or, Yellow bromine turns to colourless

or, Orange bromine turns to colourless

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7. (a) Using the oxidation numbers of chlorine, explain why the following is a redox reaction.

$HClO_3(aq) + 5HCl(aq) \rightarrow 3Cl_2(g) + 3H_2O(l)$ (2 marks)

Oxidation no of Cl in HCl increases from −1 to 0 hence oxidized

Oxidation no of Cl in $HClO_3$ reduces from +5 to 0 hence Reduction

(b) Use the following standard reduction potentials to answer the questions that follow:

	Half cell reactions	E^0/V
I	$PbSO_4(s) + 2e \rightarrow Pb(s) + SO_4^{2-}(aq)$	−0.36
II	$PbO_2(s) + SO_4^{2-}(aq) + 4H^+(aq) + 2e \rightarrow PbSO_4(s) + 2H_2O(l)$	+1.69
III	$Fe^{3+}(aq) + e \rightarrow Fe^{2+}(aq)$	+0.77
IV	$Zn^{2+}(aq) + 2e \rightarrow Zn(s)$	−0.76
V	$MnO_4^{2-}(aq) + 8H^+(aq) + 5e \rightarrow Mn^{2+}(aq) + 4H_2O(l)$	+1.51
VI	$O_2(g) + 2H^+(aq) + 2e \rightarrow H_2O_2(aq)$	+0.68
VII	$Fe^{2+}(aq) + 2e \rightarrow Fe(s)$	−0.44
VIII	$Cu^{2+}(aq) + 2e \rightarrow Cu(s)$	+0.34

(i) The half cells **I** and **II** are combined to form an electrochemical cell.

I. Write an equation for the cell reaction. (1 mark)

$PbO_{2(s)} + 2SO_4^{2-} + 4H^+_{(aq)} + Pb_{(s)} \rightarrow 2PbSO_{4(s)} + 2H_2O_{(l)}$

II. Calculate the e.m.f of the cell. (1 mark)

$E^\circ_{cell} = E_{RHS} - E_{LHS}$

$= +1.69 - (-0.36)$

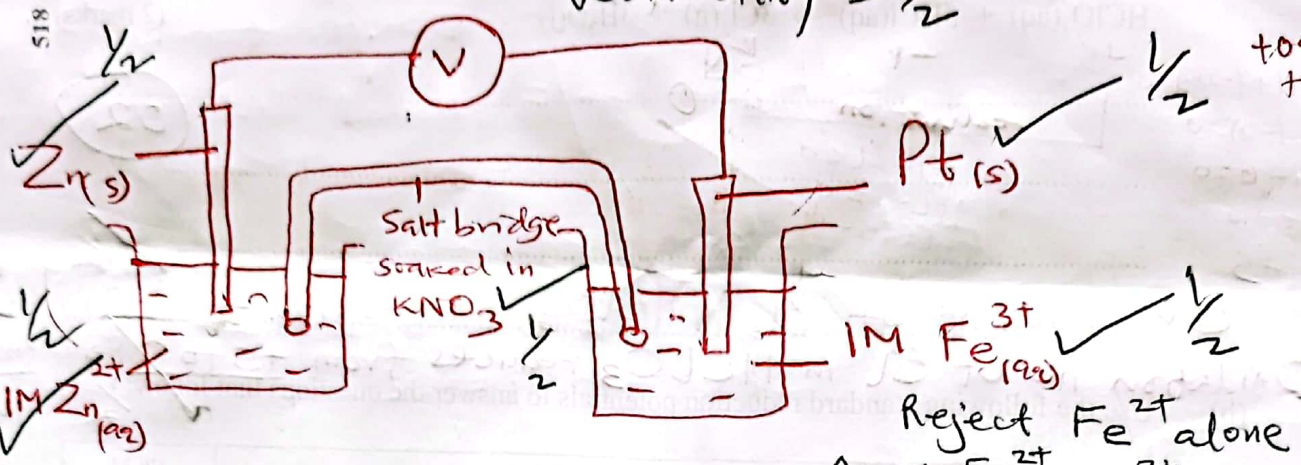
$= +2.05\,V$

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Award if interchanged but Penalise 1mk for Workability

(ii) Draw a labelled diagram for the electrochemical cell formed using half cells **III** and **IV**. (3 marks)

Workability = ½ ✓



½ ✓ ½ ✓ ½ ✓ ½ ✓ ½ ✓

+0.83 rxn will take place

Reject Fe^{2+} alone

Accept $Fe^{2+} + Fe^{3+}$

(iii) State and explain the observations made when a few drops of acidified potassium manganate(VII) are added to hydrogen peroxide. (3 marks)

$KMnO_4/H^+$ changes from Purple ✓ to colourless / is decolourised ✓1 3

Effervescence / Bubbles of a colourless gass ✓1 / Fizzing / Fizzing

manganate (VII) ion / MnO_4^- is reduced to Mn^{2+} ✓½

H_2O_2 is oxidised to O_2 ✓½

(iv) Coating iron with zinc is a more effective way of corrosion prevention than coating it with copper. Explain. (2 marks)

Zinc is more reactive than Iron ✓1 2

Iron is more reactive than Copper /

Copper is less reactive than iron

30 x 8 = 240

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