

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 (2 marks)

Powder ✓

lose water of crystallization ✓

(2)

- (ii) Compound B (2 marks)

Solution / Dissolve / colourless liquid ✓

absorbs water vapour of crystallization ✓

(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.

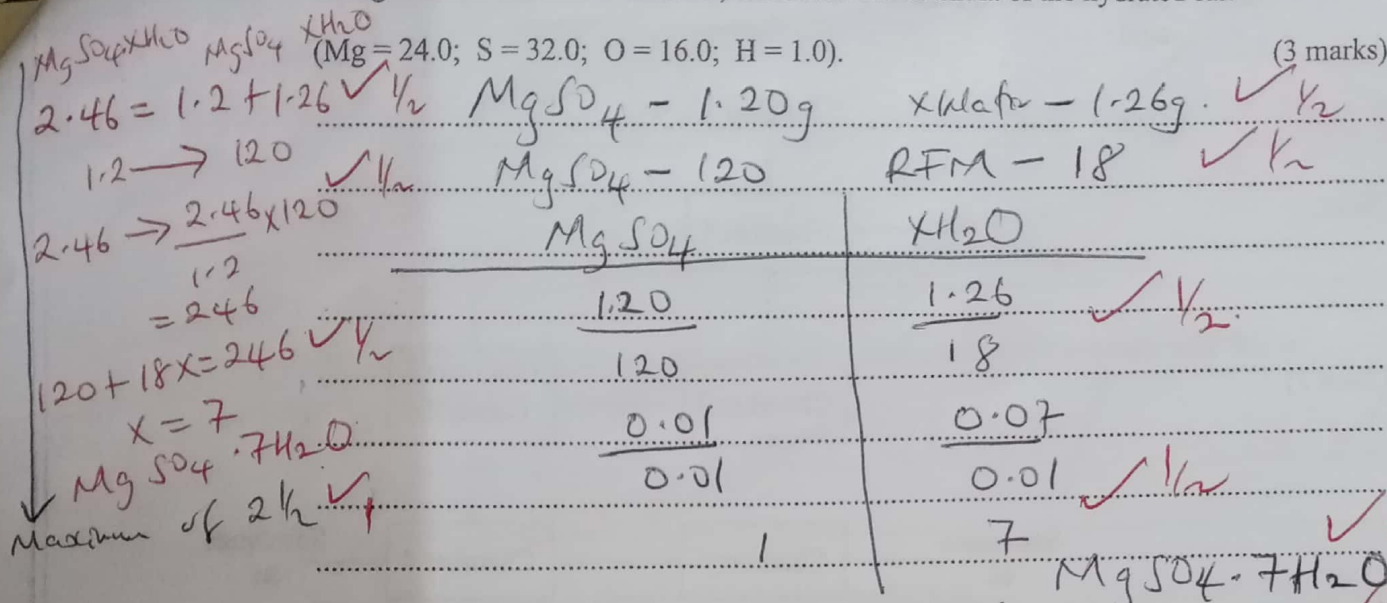
Table 2

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

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)



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

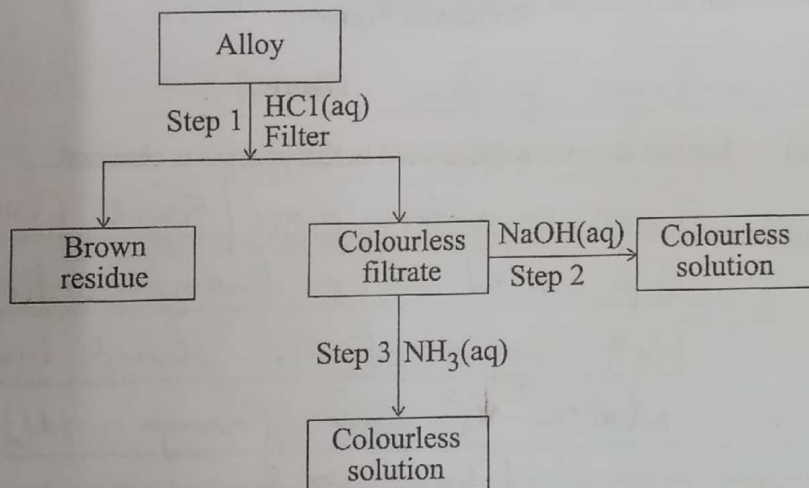


Figure 1

(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)

$[Zn(OH)_4]^{2-}$
 $Zn(OH)_4^{2-}$

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

Zinc / Zn

Copper / Cu

Correct symbols

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

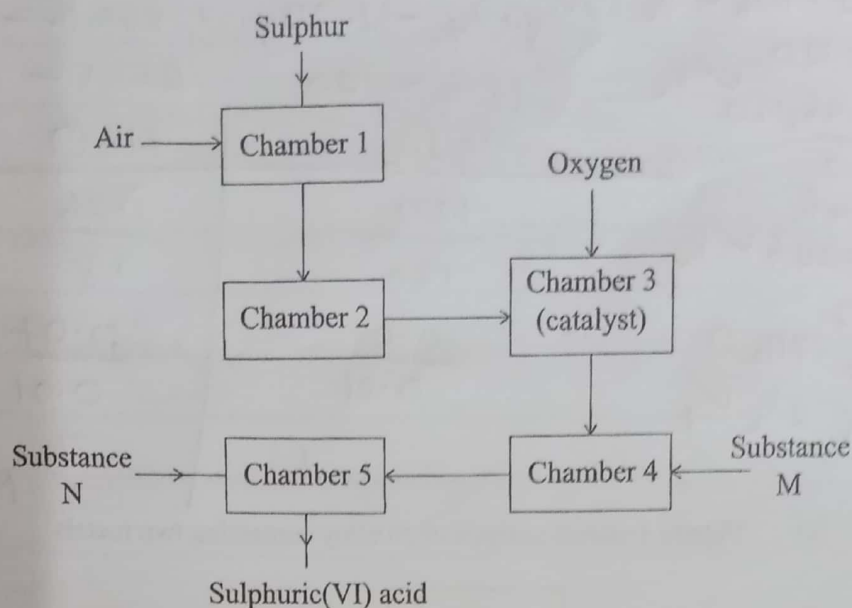
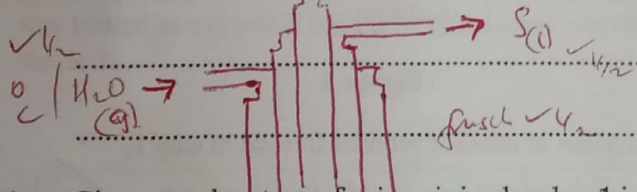


Figure 2

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

Three concentric pipes / Frasch Process ✓ $\frac{1}{2}$
 Superheated water through outer pipe. ✓ $\frac{1}{2}$
 Hot compressed air through inner pipe. ✓ $\frac{1}{2}$
 Molten sulphur through middle pipe. ✓ $\frac{1}{2}$



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

Air is cheap / Economical / Readily available! ✓

(c) Identify substances:

(i) M

Concentrated Sulphuric(VI) acid / H_2SO_4 (1 mark) ✓

(ii) N

Water / H_2O (1 mark) ✓

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

Impurities poison catalyst / make it inefficient ✓ (1)

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

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

Increase rate of reaction ✓ $\frac{1}{2}$
effective collisions / faster ✓ $\frac{1}{2}$ (1)

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

Preheat SO_2 & O_2 / reactants ✓ $\frac{1}{2}$
Recycling of heat (1)

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

Reactants come in contact with catalyst ✓ (1)

(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)

Rusting of metallic structure ✓ $\frac{1}{2}$
Stone structure wearing / crumbling ✓ $\frac{1}{2}$ (1)
Death of aquatic life
Kilning of plants
Respiratory diseases
Acid rain lowers pH of soil.

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Turn over

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

Passing through Ca(OH)_2 / CaO ✓
 Scrubbing / Scurbbing. (1)

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

Particles not possess necessary kinetic energy /
 activation energy ✓
 Particles collide in wrong orientation (1)

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

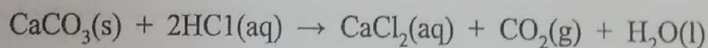
- (i) Surface area of reactants. (1 mark)

Increase rate of reaction ✓ ✓
 More particles are in contact ✓
 More collision per unit time ✓
 More particles exposed (1)

- (ii) Pressure. (1 mark)

Increase rate of reaction ✓ ✓
 Increase number of collision ✓ ✓
 Molecules of gaseous reactants closer ✓
 Decrease volume / Frequency of collision (1)

- (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:

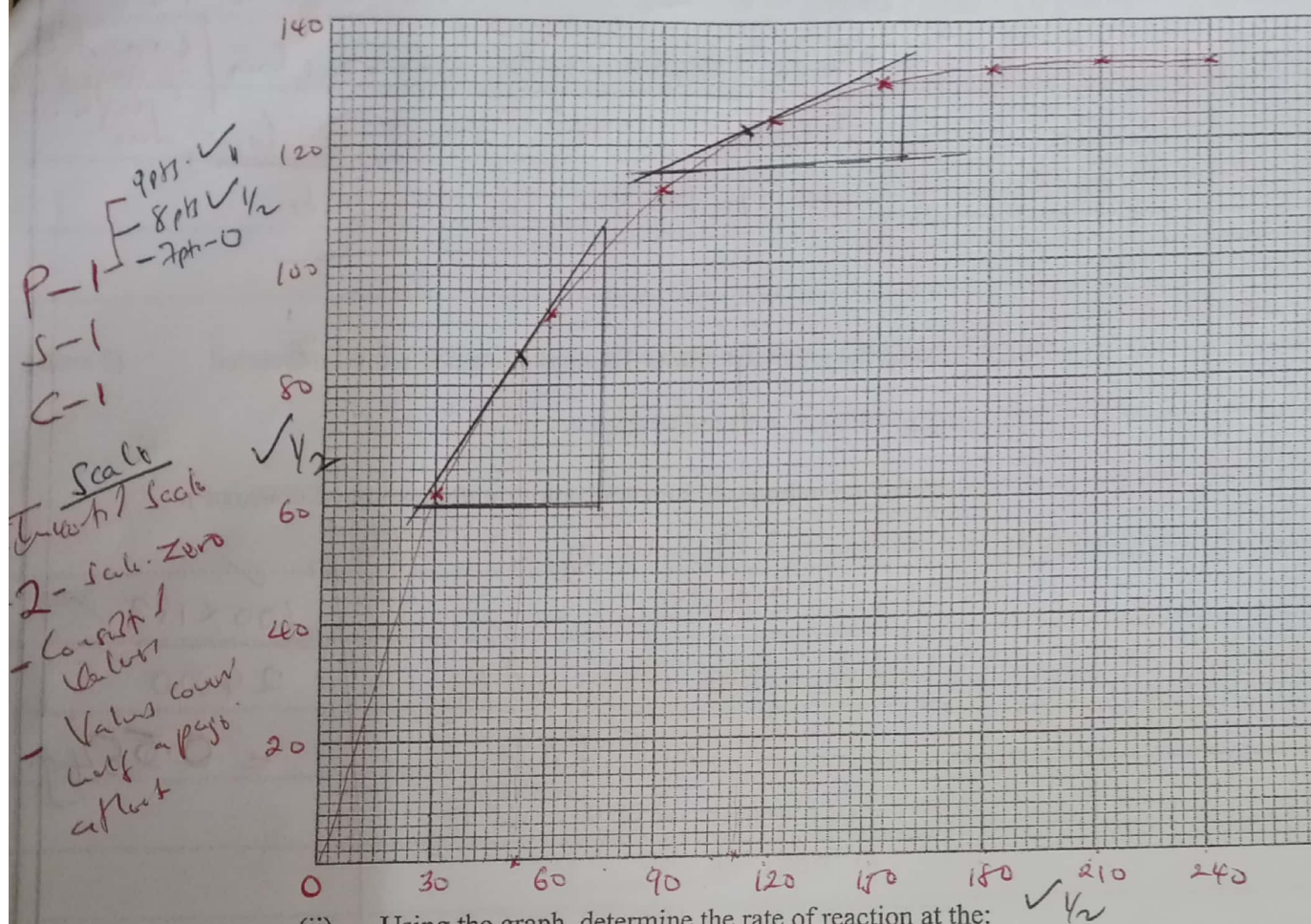


The volume of carbon(IV) oxide produced was measured at 25 °C and recorded after every 30 seconds. Table 3 shows the results obtained.

Table 3

Time (seconds)	0	30	60	90	120	150	180	210	240
Volume of $\text{CO}_2(\text{cm}^3)$	0	62	92	113	124	130	132	133	133

- (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 at 45 ✓

Calculations from graph ✓

$$\frac{dy_2 - dy_1}{dx_2 - dx_1} \quad \text{Ans} = \text{cm}^3/\text{sec}$$

II. 105th second.

(1 mark)

Tangent at 105 ✓

Calculations from graph ✓

$$\frac{dy_2 - dy_1}{dx_2 - dx_1} \quad \text{Ans} = \text{cm}^3/\text{sec}$$

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

Rate at 45°C is ^{Higher} greater than 105°C
 Hence faster rate of reaction / concentration of reactants
 Rate at 105°C is low; due to reduction in reactants

- (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).

$$\begin{aligned} \text{Moles} &= \frac{133}{24000} \quad \checkmark \frac{1}{2} \quad 0.00554 \\ \text{Mole ratio } 1:1 \quad \checkmark \frac{1}{2} \\ \therefore \text{CaCO}_3 &= 5.54 \times 10^{-3} \\ 5.54 \times 10^{-3} \times 100 \text{ RFM} \quad \checkmark \frac{1}{2} \\ 0.00554 \times 100 \\ \text{Ans } 0.554 \text{ g.} \quad \checkmark \frac{1}{2} \end{aligned}$$

$$\begin{aligned} &100 \times 133 \quad \checkmark \\ &24000 \quad \checkmark \\ &= 0.554 \text{ g.} \quad \checkmark \end{aligned}$$

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

Heat / Boil / Evaporate to saturation.
 Allow to cool. Crystals formed.

or

Sea water tapped in pan / shallow pond
 Solid crystallises out
 liquor / Mother liquor drawn out

- (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 ($\text{Na} = 23.0$; $\text{Cl} = 35.5$; density of water = 1.0 g cm^{-3}). (2 marks)

$$\text{RFM NaCl} = 58.5 \quad \checkmark \frac{1}{2}$$

$$\frac{36.2 \times 1000}{100} = 362 \quad \checkmark \frac{1}{2}$$

$$\frac{362}{58.5} \quad \checkmark \frac{1}{2}$$

$$6.188\text{M} \text{ or } 6.19\text{M}.$$

$$\frac{36.2 \times 1000}{58.5 \times 100}$$

$$= 6.188\text{M}.$$

$$\frac{36.2}{58.5} = 0.6188\text{M}.$$

$$\times 1000$$

$$\frac{100}{100}$$

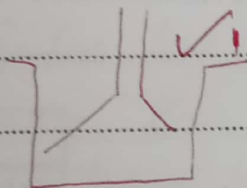
$$= 6.188\text{M} / 6.19\text{M}.$$

- (c) Ammonia is highly soluble in water.

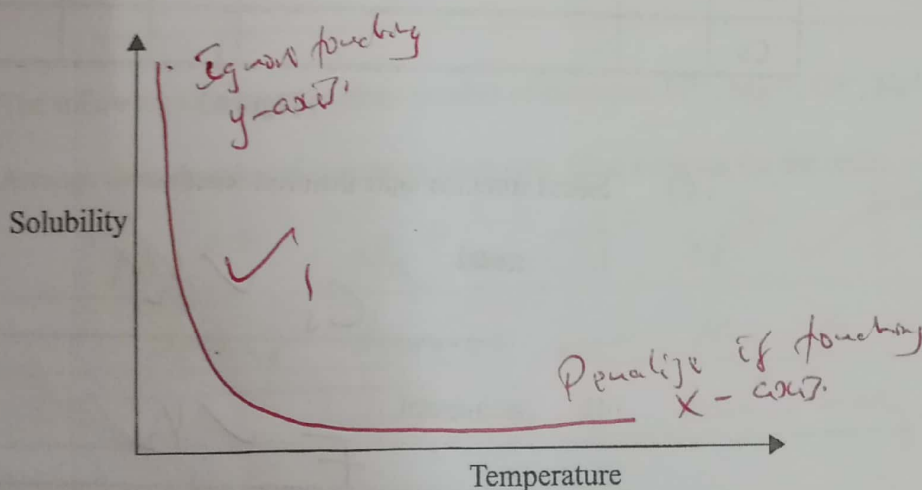
- (i) Explain how aqueous ammonia is prepared starting with ammonia gas. (2 marks)

Pass an inverted funnel \checkmark

to prevent suck back / funnel inverts S.A. for dissolution \checkmark



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



- (iii) Give a reason for the shape of the curve. ✓ 1/2

(1 mark)

Solubility decreases with increase in temperature
because particles gain energy and escape. ✓ 1/2

- (d) Water hardness is due to the presence of magnesium and calcium ions. Explain how these ions get into sources of water. CO_2 reacts with water ✓ 1/2 (2 marks)

Formation of carbonic acid. ✓ 1/2
reacts with water with Ca & Mg salts. ✓ 1/2
leading to Ca^{2+} and Mg^{2+} ions. ✓ 1/2

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

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

Figure 3

- (i) Select from the table the most reactive:

I. metal.

(1/2 mark)

Cs ✓ 1/2

II. non-metal.

(1/2 mark)

F ✓ 1/2

- (ii) Select an element with the highest first ionisation energy.

(1 mark)

He ✓ 1

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

Fractional distillation ✓

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

Preserves inert atmosphere in fluorescent ✓

Used in fluorescent tubes / lamps

arc welding / preserving wire / radioactive dating.

- (iv) Explain each of the following observations:

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

Lithium has stronger metallic bonds than potassium.

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

Iodine has stronger ^{more} Van der Waals forces than chlorine.

Iodine - stronger / more intermolecular forces.

- (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.

Mg^{2+} , Na^{+} , O^{2-} , N^{3-} ✓

Proper decrease from Mg to Nitrogen.

hence nuclear attraction decreases - Mg - N.

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

Table 4

Property	Substance			
	H	I	J	K
Melting point ($^{\circ}\text{C}$)	993	113	-38.9	-85
Boiling point ($^{\circ}\text{C}$)	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.

K; boiling point below room temperature (1 mark)

K; boiling point below room temperature

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

I. H

ions / mobile ions

(1 mark)

II. J

electrons / delocalized electrons

(1 mark)

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

I. H

electrostatic forces / ionic bonds

(1 mark)

II. K

Van der Waals forces / intermolecular forces

(1 mark)

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

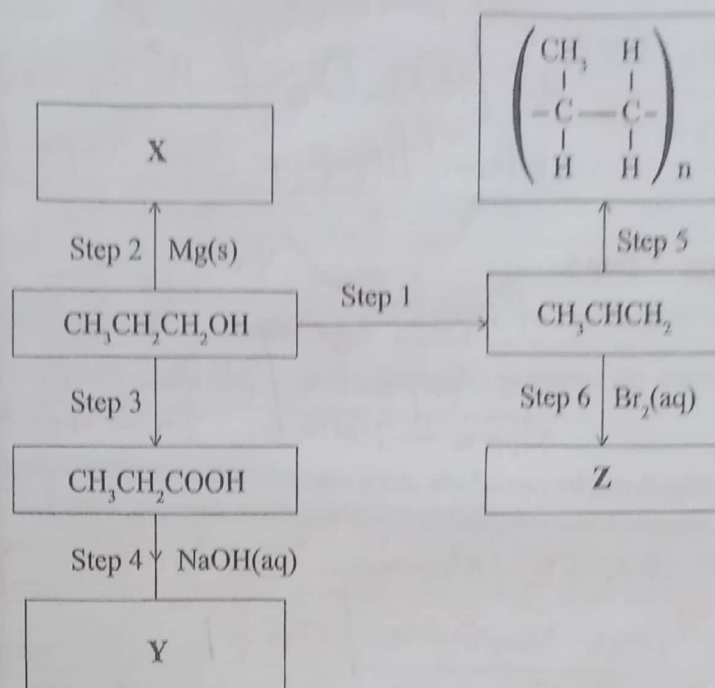


Figure 4

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

(i) X

Name: Magnesium propoxide ✓
 Formula: $(\text{CH}_3\text{CH}_2\text{CH}_2\text{O})_2\text{Mg}$ ✓ (2 marks)
 Not fixed.

(ii) Y

Name: Sodium propanoate ✓
 Formula: $\text{CH}_3\text{CH}_2\text{COONa}$ ✓ (2 marks)
 Name independent marking

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

(i) Step 3.

$\text{H}^+ | \text{K.MnO}_4 | \text{H}^+ \text{K}_2\text{Cr}_2\text{O}_7$
 alarm \downarrow must + high temperature

(1 mark)

(ii) Step 5.

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(1 mark)

High temperature 340K - 360K	High pressure 30 - 40 atm	Catalyst $TiCl_4$ + AlR_3
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- (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)

Al_2O_3 / Aluminium Oxide / Alumina / silica / sand /
 High Temperature / Heat /
 3000°C

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

(i) Step 1.

Daley Loafers ✓✓

(1 mark)

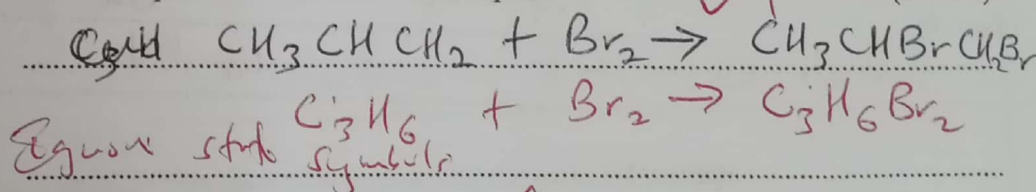
(ii) Step 5.

Addition Polymerization ✓

(1 mark)

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

(1 mark)

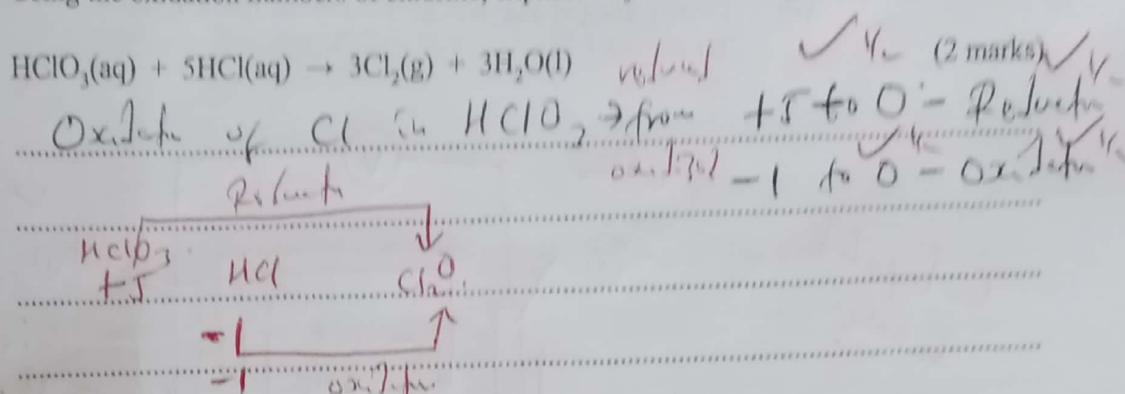
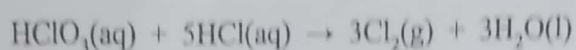


- (ii) State the observations made in step 6. ✓ /

(1 mark)

Brown decolorized, (for
yellow / orange / brown → fuchs / decolorized)

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

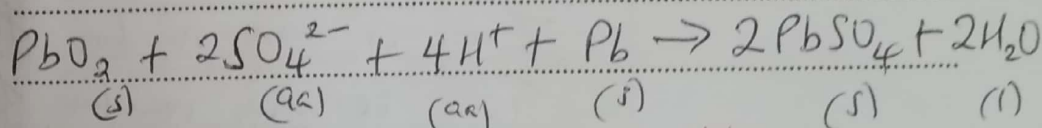


- (b) Use the following standard reduction potentials to answer the questions that follow:

	Half cell reactions	E°/V
I	$\text{PbSO}_4(\text{s}) + 2\text{e}^- \rightarrow \text{Pb}(\text{s}) + \text{SO}_4^{2-}(\text{aq})$	-0.36
II	$\text{PbO}_2(\text{s}) + 2\text{SO}_4^{2-}(\text{aq}) + 4\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow 2\text{PbSO}_4(\text{s}) + 2\text{H}_2\text{O}(\text{l})$	+1.69
III	$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Fe}^{2+}(\text{aq})$	+0.77
IV	$\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Zn}(\text{s})$	-0.76
V	$\text{MnO}_4^{2-}(\text{aq}) + 8\text{H}^+(\text{aq}) + 5\text{e}^- \rightarrow \text{Mn}^{2+}(\text{aq}) + 4\text{H}_2\text{O}(\text{l})$	+1.51
VI	$\text{O}_2(\text{g}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2\text{O}_2(\text{aq})$	+0.68
VII	$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Fe}(\text{s})$	-0.44
VIII	$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$	+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)



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

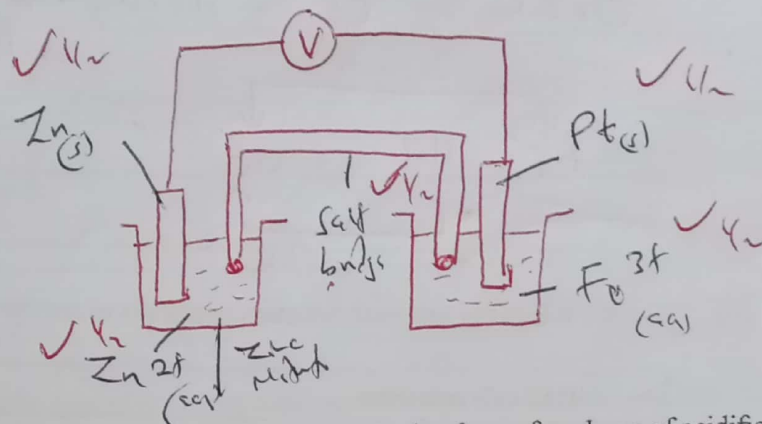
$$+1.69 - (-0.36) = 2.05 \text{ V}$$

$$+2.05 \text{ V}$$

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

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

$H^+ / KMnO_4$ Decolorizes / Purple to colorless.
Effervescent / Bubbles of a colorless gas.
 H_2O_2 oxidized to O_2 gas / evolution of O_2 gas.
Manganate(VII) MnO_4^- reduced / changes to
Manganate(II) Mn^{2+}

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

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Zinc is more reactive than Iron.

Iron is more reactive than Copper.

Copper is less reactive than Iron.

Zinc is higher in electrochemical series than Iron.

Iron is higher than Copper.



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CHEMISTRY

(Theory)

Mar. 2022 – 2 hours

Paper 2



Name Index Number

Candidate's Signature Date

Instructions to candidates

- (a) Write your name and index number in the spaces provided above.
- (b) Sign and write the date of examination in the spaces provided above.
- (c) Answer **all** the questions in the spaces provided in the question paper.
- (d) **Non-programmable** silent electronic calculators and KNEC mathematical tables may be used.
- (e) All working **must** be clearly shown where necessary.
- (f) **This paper consists of 16 printed pages.**
- (g) **Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.**
- (h) **Candidates should answer the questions in English.**

For Examiner's Use Only

Question	Maximum Score	Candidate's Score
1	11	
2	11	
3	11	
4	11	
5	13	
6	11	
7	12	
Total Score	80	

