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 ✓1

loss water of crystallization ✓1

2

(ii) Compound B (2 marks)

Solution / Dissolve / colourless liquid ✓1

absorbs water vapour ✓1 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 ($MgSO_4.xH_2O$) (Mg = 24.0; S = 32.0; O = 16.0; H = 1.0). (3 marks)

$MgSO_4 - 1.20g$ ✓½ $xH_2O - 1.26g$ ✓½

$MgSO_4 - 120$ ✓½ $RFM - 18$ ✓½

$MgSO_4$	xH_2O
1.20	1.26 ✓½
120	18
0.01	0.07
0.01	0.01 ✓½
1	7 ✓1

$1.2 \rightarrow 120$ ✓½

$2.46 \rightarrow \frac{2.46 \times 120}{1.2} = 246$

$120 + 18x = 246$ ✓½

$x = 7$

$MgSO_4.7H_2O$

Maximum of 2½ ✓1

$MgSO_4.7H_2O$ (3)

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

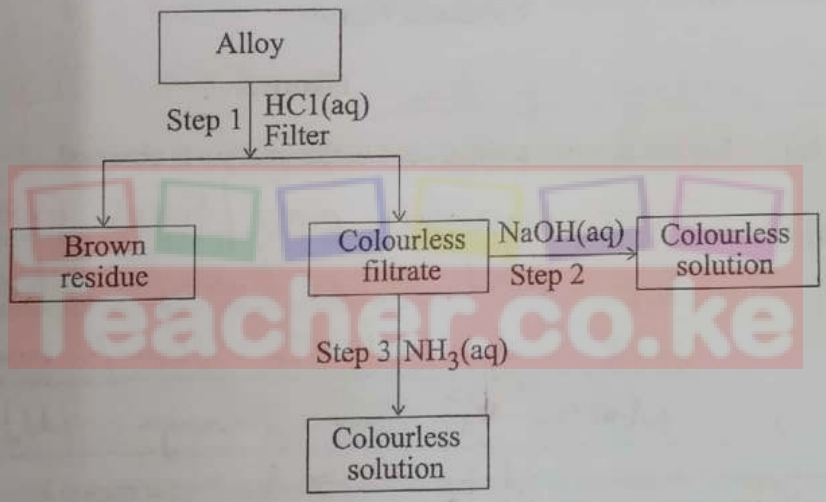


Figure 1

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

Hydrogen gas ✓1 (1)

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

$[Zn(OH_4)]^{2-}$ ✓1 (1)

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

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

Zinc / Zn ✓1 (2)

Copper / Cu ✓1

Correct Symbols.

11

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

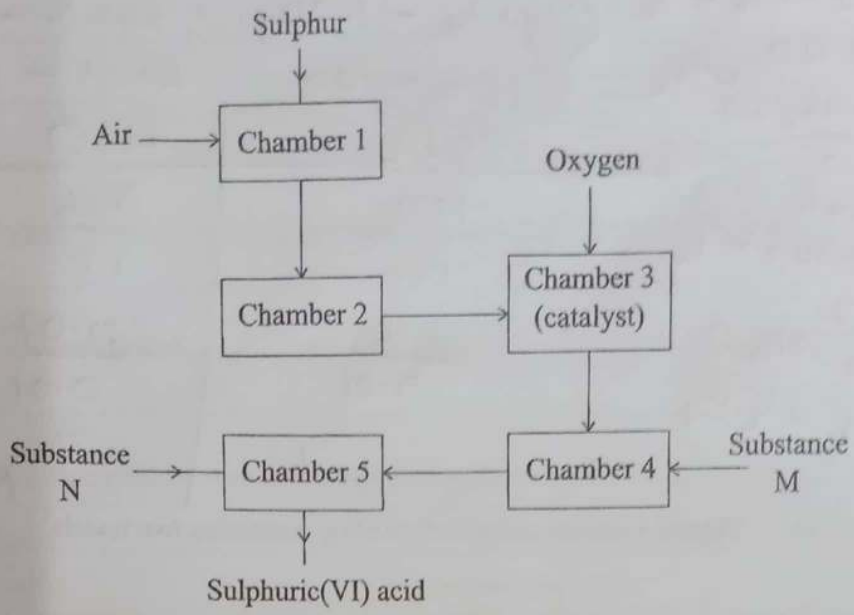
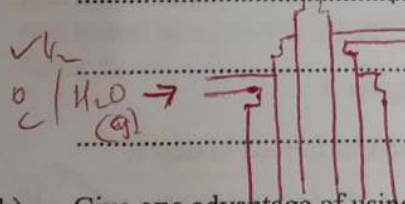


Figure 2

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

Three concentric pipes / Frasch Process ✓½
Superheated water through outer pipe. ✓½
Hot compressed air through inner pipe. ✓½
Molten Sulphur through Middle pipe. ✓½



Frasch ✓½ (2)

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

Air is cheap / Economical / Readily available. ✓ (1)

(c) Identify substances:

(i) M (1 mark)

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

(ii) N (1 mark)

Water / H_2O ✓1 (1)

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

Impurities poisons catalyst / make it ✓1 ineffective (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 ✓½

effective collisions / fruitful ✓½ (1)

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

Preheat SO_2 & O_2 / reactants ✓1

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 (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 ✓1

Stone structure wearing / Chlorosis (1)

Death of aquatic life

Wilting of plants

Respiratory disease

Acid rain lowers pH of soil.

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

Passing through $Ca(OH)_2$ / CaO ✓

Scrabbing / Scrubbing. (1)

11

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

Particles not posses 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 ma

Increase rate of reaction ✓½

More particles are in contact ✓½ (1)

More collision per unit time. /

more particles exposed.

(ii) Pressure. (1 ma

Increase rate of reaction ✓½

Increase Number of collision /

Molecule 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 exces 2M hydrochloric acid. The equation for the reaction is:

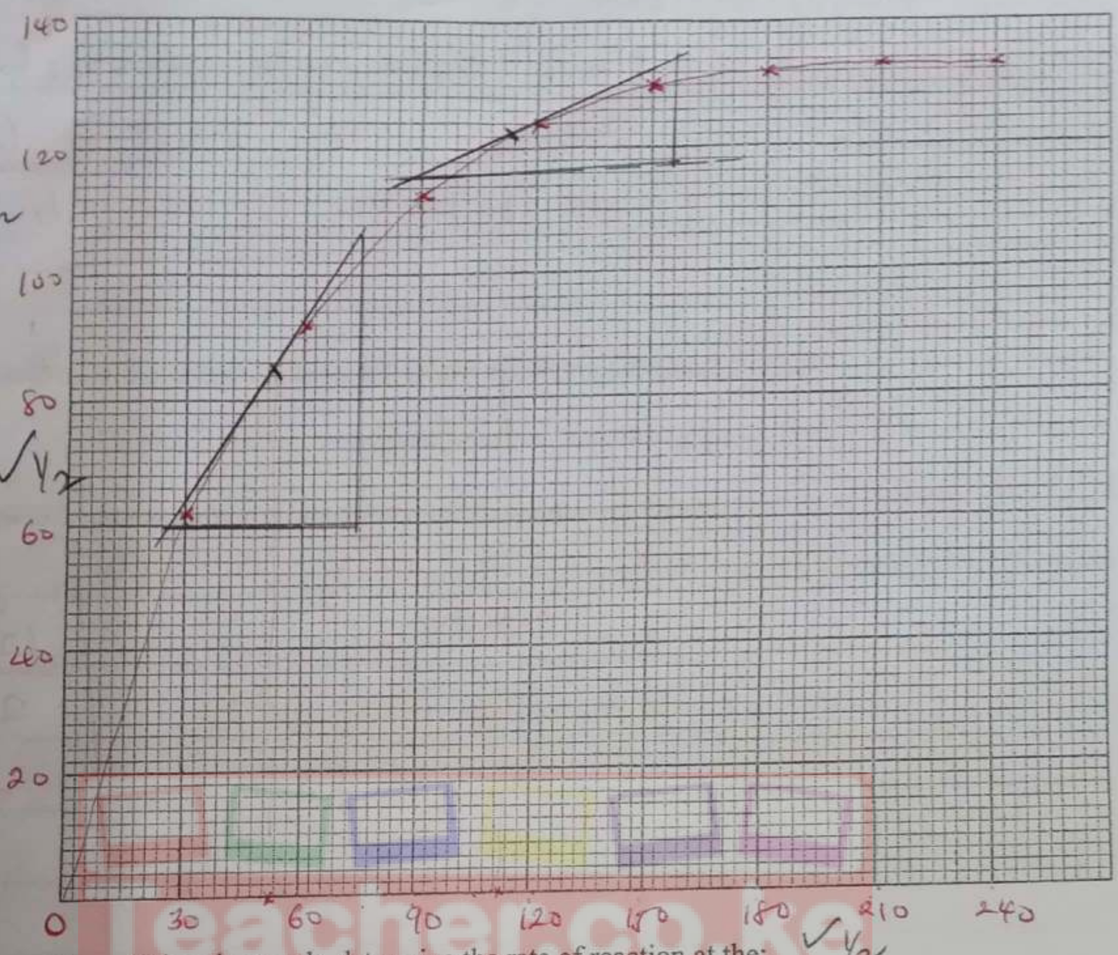
$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

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

(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 (45) ✓½

Calculations from graph ✓½

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

II. 105th second. (1 mark)

Tangent (105) ✓½

Calculations from graph ✓½

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

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

Rate at 45°C is higher than 10°C ✓½
Hence faster rate of reaction / Concentration of reactants is high. ✓½
Rate at 10°C is low; due to reduction in reactants. ✓½

(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).

Moles = 133 / 24000 ✓½ = 0.00554

Mole ratio 1:1 ✓½

1 : $CaCO_3$ 5.54 × 10^{-3}

$5.54 \times 10^{-3} \times 100$ ✓½

0.00554×100

Ans 0.554 g. ✓½

100 × 133 ✓ / 24000 ✓ = 0.554g.

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

Heat / Boil / Evaporate ✓1 to saturation ✓½.
Allow to cool ✓½; Crystals formed ✓½.

or

Sea water trapped in pan / shallow pond ✓1
solid crystallizes out ✓1
Liquor / Mother liquor drained out ✓1

(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 NaCl = 58.5 ✓½

$\frac{36.2 \times 1000}{100}$ = 362. ✓½

$\frac{362}{58.5}$ ✓½

✓½

6.188M or 6.19M.

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

= 6.188M.

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

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

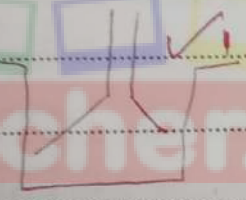
= 6.188M / 6.19M.

(c) Ammonia is highly soluble in water.

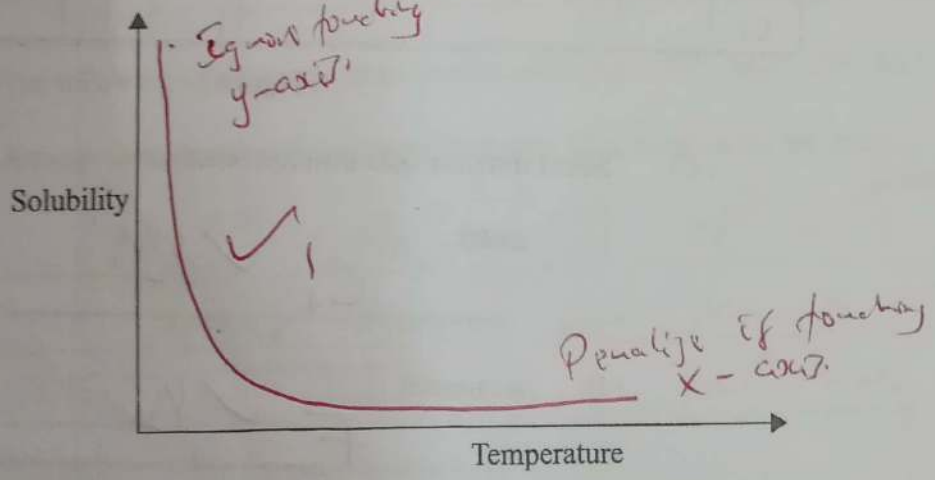
(i) Explain how aqueous ammonia is prepared starting with ammonia gas. (2 marks)

Pass in inverted funnel ✓1

to prevent suck back / funnel increases S.A for dissolution ✓1



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



Ignore touching y-axis.

✓1

Penalize if touching x-axis.

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

Solubility decreases with increase in temperature because particles gain energy and escape

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

Formation of carbonic acid.

reacts with rocks with Ca & Mg salts.

leading to Ca^{2+} and Mg^{2+} ions

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

Li	Be				N	O	F	He / 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. (½ mark)

Cs

II. non-metal. (½ mark)

F

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

He

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

Fractional distillation ✓1

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

Provide inert atmosphere in fluorescent ✓1
Used in fluorescent bulbs/lamps.
Arch welding / Preserving wine / Radioactive dating.

Penalize in manufacture of bulbs.
- High speed printing.
- Dilution of O_2 used by patients with difficulties in breathing.

(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 ✓1 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. (2 marks)

Mg^{2+}; Na^{+}; O^{2-}; N^{3-} ✓1
protons decrease from Mg to Nitrogen ✓1
hence nuclear attraction decrease - Mg - N.

(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; boiling point below room temperature

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

I. H (1 mark)

ions / mobile ions

II. J (1 mark)

electrons / delocalized electrons

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

I. H (1 mark)

electrostatic forces / ionic bonds / electrovalent bonds.

II. K (1 mark)

Van der waals forces / Intermolecular forces.

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

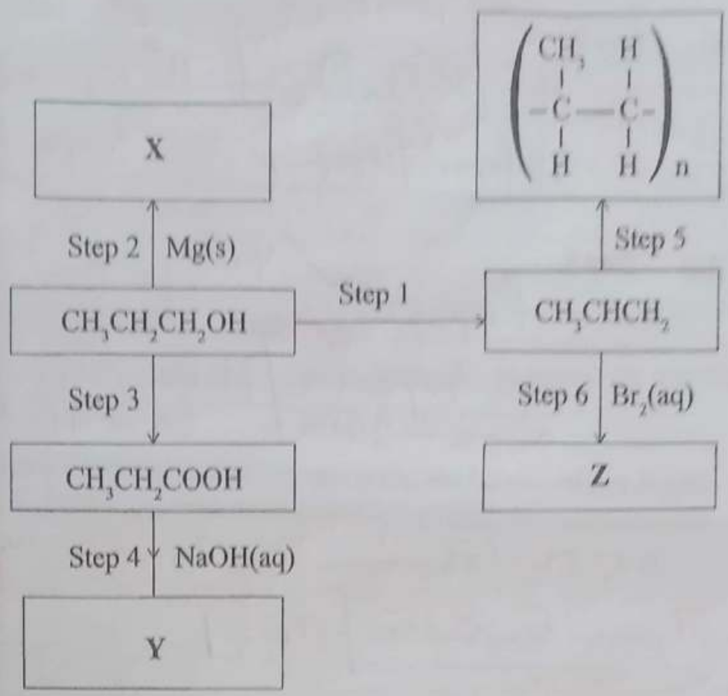


Figure 4

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

(i) X

Name Formula (2 marks)

Magnesium propoxide $(CH_3CH_2CH_2O)_2Mg$.

Not fixed.

(ii) Y

Name Formula (2 marks)

Sodium propanoate CH_3CH_2COONa.

Name underlined merely

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

(i) Step 3. (1 mark)

$H^+ / KMnO_4$ / $H^+ K_2Cr_2O_7$

Warm / Heat / High temperature

(ii) Step 5. (1 mark)

Propene

High temperature 340K – 360K / High pressure 30 – 40 atm / Heat / Catalyst $TiCl_4$ titanium tetrachloride

(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 / Silicon (IV) oxide / phosphoric acid H_3PO_4

High temperature / Heat / 300°C

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

(i) Step 1. (1 mark)

Dehydration

(ii) Step 5. (1 mark)

Addition Polymerization

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

$CH_3CH=CH_2 + Br_2 \rightarrow CH_3CHBrCH_2Br$

$C_3H_6 + Br_2 \rightarrow C_3H_6Br_2$

Equation and symbols

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

Brown decolourized / for

Yellow / orange / brown → fades / decolourized

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)

Ox. No. of Cl in $HClO_3$ from +5 to 0 – Reduction

Ox. No. −1 to 0 – Oxidation

Reduction

$HClO_3$ HCl Cl_2

+5 −1 0

−1 oxidation

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

	Half cell reactions	E^{θ}/V
I	$PbSO_4(s) + 2e \rightarrow Pb(s) + SO_4^{2-}(aq)$	−0.36
II	$PbO_2(s) + 2SO_4^{2-}(aq) + 4H^+(aq) + 2e \rightarrow 2PbSO_4(s) + 2H_2O(l)$	+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)

$PbO_2(s) + 2SO_4^{2-}(aq) + 4H^+(aq) + Pb(s) \rightarrow 2PbSO_4(s) + 2H_2O(l)$

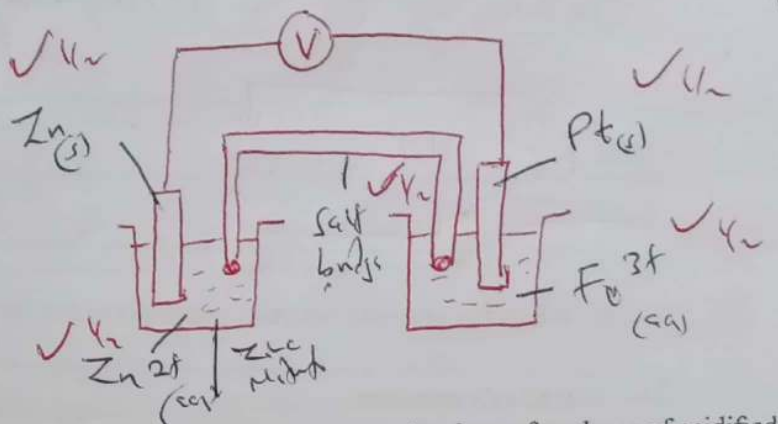
State symbols

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

$+1.69 - 0.36$

$+2.05$ V (Ignore units)

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



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

$H^+ / KMnO_4$ Decolourized / Purple to colourless

Effervescence / Bubbles of a colourless gas.

H_2O_2 oxidized to O_2 gas / Evolution of O_2 gas

Manganate(VII) ions MnO_4^- reduced / change to Manganate(II) ions Mn^{2+}

(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.

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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THE KENYA NATIONAL EXAMINATIONS COUNCIL
Kenya Certificate of Secondary Education

1323
Room 3 – Bolt 2. Room 36.

233/2 **Paper 2**

CHEMISTRY

(Theory)

Mar. 2022 – 2 hours

518

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**	

1124