SUCCESS PATH JOINT EXAMINATION

Kenya Certificate of Secondary Education

233/2 – CHEMISTRY (Theory) – Paper 2 **FORM FOUR**

121 / 2 - Chemistry Paper 2
March/April 2026
Time: 11.00 a.m – 1.00 p.m

Name ..... Ms. ..... Index Number.....

Class ..... School .....Signature.....

Instructions to candidates

(i) Write your name, adm number and class in the spaces provided above.
(ii) Sign and write the date of examination in the spaces provided above.
(iii) Answer all the questions in in the spaces provided in the question paper.
(iv) Non – programmable silent electronic calculators and KNEC Mathematical tables may be used.
(v) All workings must be clearly shown where necessary
(vi) This paper consists of 12 printed pages.
(vii) Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.
(viii) Candidates should answer the questions in English.

For Examiner's Use Only

Questions	Maximum Score	Candidates' Score
1	10	
2	14	
3	12	
4	10	
5	11	
6	11	
7	12	
TOTAL	80	

1 Study the information in the **Table 1** which shows the periodic properties of certain elements. The letters do not represent the actual symbols of the elements.

Table 1

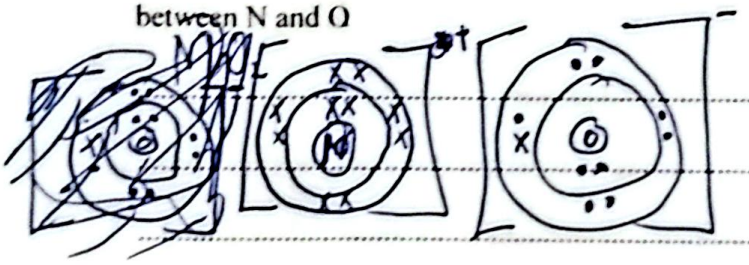
Element	Ion	Electron arrangement of ion	Atomic radius	Ionic radius
M	M^+	2.8	1.97	0.88
N	N^+	2.8.8	1.99	0.89
O	O^-	2.8	0.72	1.36
P	P^{2-}	2.8.8	0.99	1.46

(a) Give the period and group to which element P belongs:

Period 3 (1 mark)

Group VII (1 mark)

(b) Using dots (•) and crosses (×) to represent electrons show the bonding in a compound formed between N and O (2 marks)



(c) Compare and explain the reactivity of element M and N with water. (2 marks)

N is more reactive than M. ✓ N has a larger atomic radius than M, hence lower ionization energy. ✓ N loses its valence electron more readily.

(d) Explain why the atomic radius of O is smaller than its ionic radius. (1 mark)

O gains one electron to form O^-. This increases inter-electron repulsion.

(e) Element M react with chlorine according to the equation: $M_{(s)} + Cl_{2(g)} \longrightarrow MCl_{2(s)}$

Determine the mass of solid MCl_2 formed when 0.002 moles of M is reacted with excess chlorine. (R.A.M of M = 25, Cl = 35.5) (3 marks)

Molar mass of MCl_2 = 25 + (35.5 × 2)
= 96 g/mol.

Mass = MM × MM =
= 0.002 × 96
= 0.192 g.

96
1/2

2 (a) Carbon (IV) oxide is present in soft drinks. State two roles of carbon (IV) oxide in soft drinks. (2 marks)

- Preservative. ✓1
- Provides fizz // enhance taste. ✓1

(b) The flow chart in **Figure 1** summarises the steps involved in the production of sodium carbonate. Use it to answer the questions that follow.

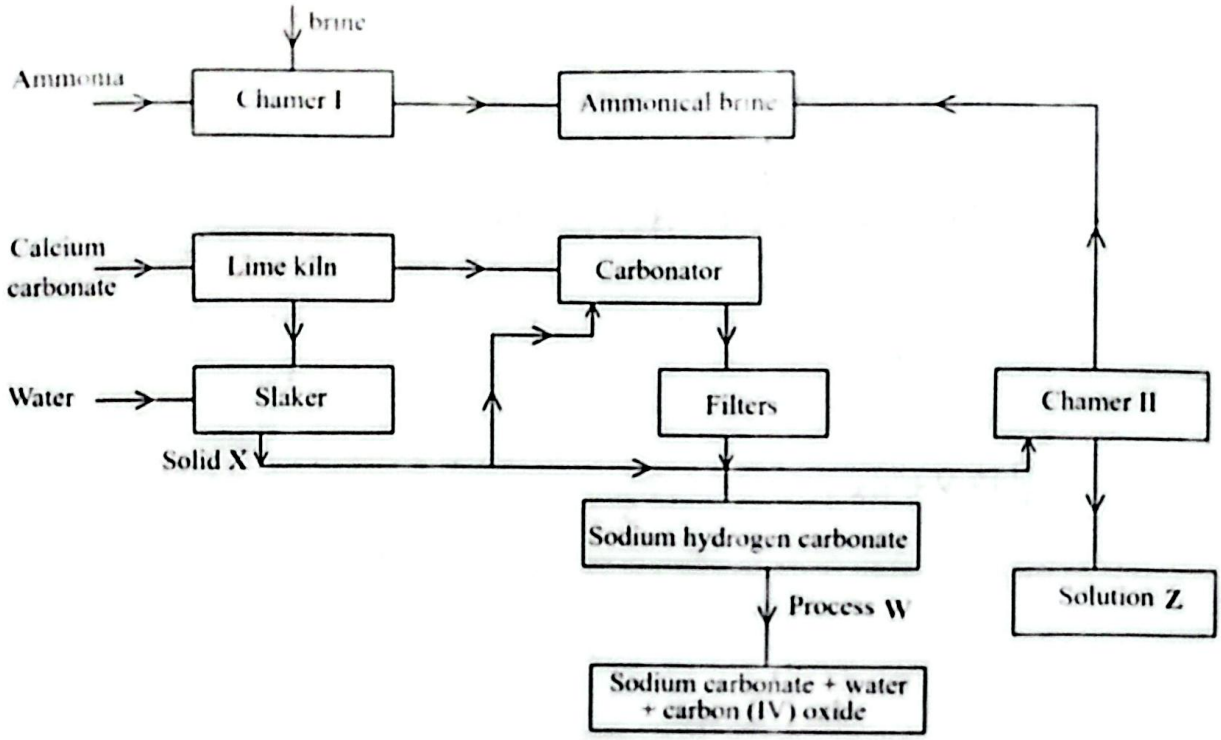


Figure 1

(i) Name the process illustrated in **Figure 1**. (1 mark)

Solvay process.

(ii) Identify the starting materials required in the production of sodium carbonate. (2 marks)

- Brine (Concentrated sodium chloride)
- Ammonia.
- Limestone / Calcium Carbonate. Any 2.

(iii) Write equations for the two reactions that occur in the carbonator. (2 marks)

$NH_3(g) + H_2O(l) + CO_2(g) \longrightarrow NH_4HCO_3(aq)$ ✓1

$NH_4HCO_3(aq) + NaCl(aq) \longrightarrow NaHCO_3(s) + NH_4Cl(aq)$ ✓1

(iv) Name *two* substances that are recycled in the process shown in Figure 1. (2 marks)

- Ammonia. ✓
- Carbon (IV) oxide ✓

(v) Identify:

Solid X. Calcium oxide // CaO (1 mark)

Process W Heating // Thermal decomposition. (1 mark)

(vi) Write an equation for the reaction that produces solution Z. (1 mark)

$Ca(OH)_{2(aq)} + 2NH_4Cl_{(aq)} \longrightarrow CaCl_{2(aq)} + 2H_2O_{(l)} + 2NH_{3(g)}$

(vii) Apart from softening hard water, state *two* other uses of sodium carbonate. (2 marks)

- Manufacture of Glass ✓1
- Paper industry. ✓1
- Manufacture of detergents ✓

3 (a) Name the compounds below.

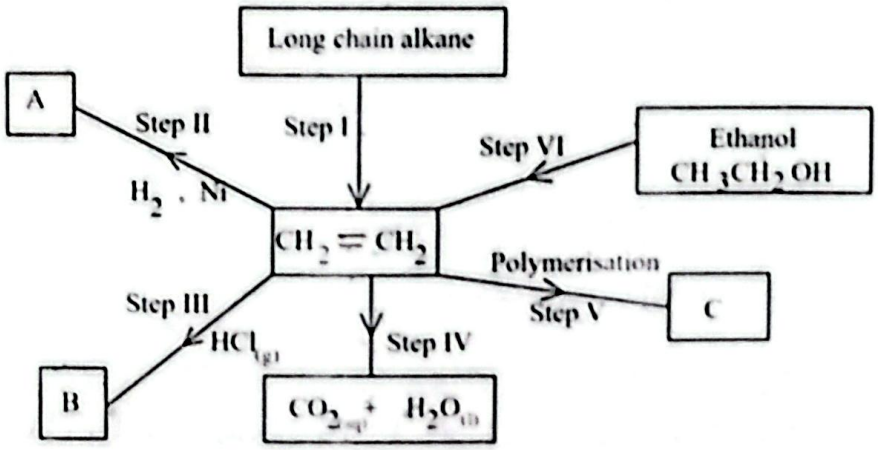
(i) C_6H_{10} (1 mark)

Hexyne ✓

(ii) CH_3CHCH_2 (1 mark)

Propene ✓

(b) Study the flow chart below and answer the questions that follow:



(i) Name the process taking place in Step I (1 mark)

Catalytic Cracking // Thermal Cracking

(ii) Describe a chemical test that can be used to distinguish between compound A and $CH_2 = CH_2$ (2 marks)

*Add Bromine water to a test tube containing compound A and another one containing $CH_2=CH_2$. ✓2 Yellow colour of Bromine remains in test tube with compound A but it is decolourised in compound $CH_2 = CH_2$ ✓

- Acidified $KMnO_4$ is decolourised in $CH_2C=CH_2$ but remains purple in Compound A.

Reject $K_2Cr_2O_7$ etc

(iii) Give the name of the following compounds

(I) A Ethane (1 mark)

(II) B Chloroethane. (1 mark)

(iv) Give the structural formula of substance C (1 mark)

$$\left[CH_2-CH_2\right]_n.$$

(v) Name the type of reaction that occurs in:

I) Step IV Combustion (1 mark)

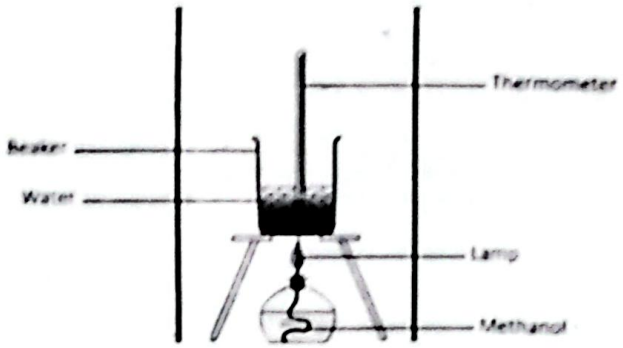
II) Step VI Dehydration (1 mark)

(vi) Give the reagents and the conditions necessary for Step VI (2 marks)

Reagents: Conc. H_2SO_4 / Al_2O_3

Conditions: temperature at 170°C / 300°C

4 In an experiment to determine the heat of combustion of methenol, CH_3OH, a student used a set-up like the one shown in the diagram below.



- Volume of water = 50 cm^3
- Final temperature of water = 27.0°C
- Initial temperature of water = 20.0°C
- Final mass of lamp + Methanol = 22.11g
- Initial mass of lamp + Methanol = 22.9

(a) Calculate:

(i) The number of moles of methanol used in this experiment (C = 12, O = 16, H = 1) (1 mark)

Mass of CH_3OH = 22.9 − 22.1
= 0.795

moles = $\frac{0.79}{32}$ = 0.0247 mol.

(ii) The heat of combustion per mole of methanol (Specific heat capacity of solution = 4.2 kJ/kg/K. Density of solution = 1g/ cm^3) (2 marks)

$\Delta H = mc\Delta T$
= 0.05 kg × 4.2 × 7
= 1.47 kJ
Molar heat = $\frac{1.47}{0.0247}$
= 59.51 kJ/mol. ✓
−59.51 kJ/mol. ✓
(Sign is a must)

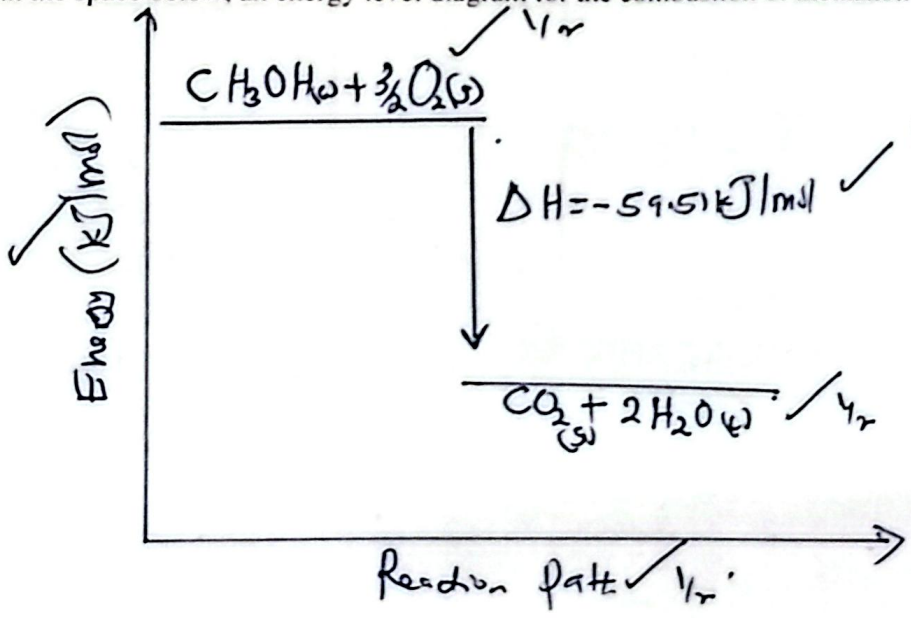
(b) Write the thermochemical equation for the combustion of methanol. (1 mark)

$CH_3OH(l) + \frac{3}{2}O_2(g) \longrightarrow CO_2(g) + 2H_2O(l); \Delta H = -59.51\ kJ/mol$

(c) Explain why the value of the molar heat of combustion for methanol obtained in this experiment is different from the theorical value. (2 marks)

- Heat absorbed by the apparatus/beaker.
- Incomplete combustion of Methanol.
- Experiment was not carried out under standard conditions. (Any one point explained)

(a) Sketch, in the space below, an energy level diagram for the combustion of methanol. (2 marks)



(b) Using the thermochemical data given in the table below, calculate the enthalpy for the reaction:

$CH_4(g) + 2Cl_2(g) \rightarrow CH_2Cl_2(g) + 2HCl(g)$ (2 marks)

Bond	Bond energy (kJ/mol)
C – H	414
Cl – Cl	244
C – Cl	326
H – Cl	431

ΔH = Energy used in bond breaking − Energy absorbed during the reaction for bond formation

$[4(C-H)+2(Cl-Cl)] - [2(C-H)+2(C-Cl)+2(H-Cl)]$

$[4(414)+2(244)] - [2(326)+2(414)+2(431)]$

$(1656kJ + 488kJ) - [652+828+862]$

$2,144kJ - 2342kJ$

$= -198kJ/mol.$

5 **Figure 4** is a flow chart showing preparation of and reactions of ammonia gas. Use it to answer the questions that follows.

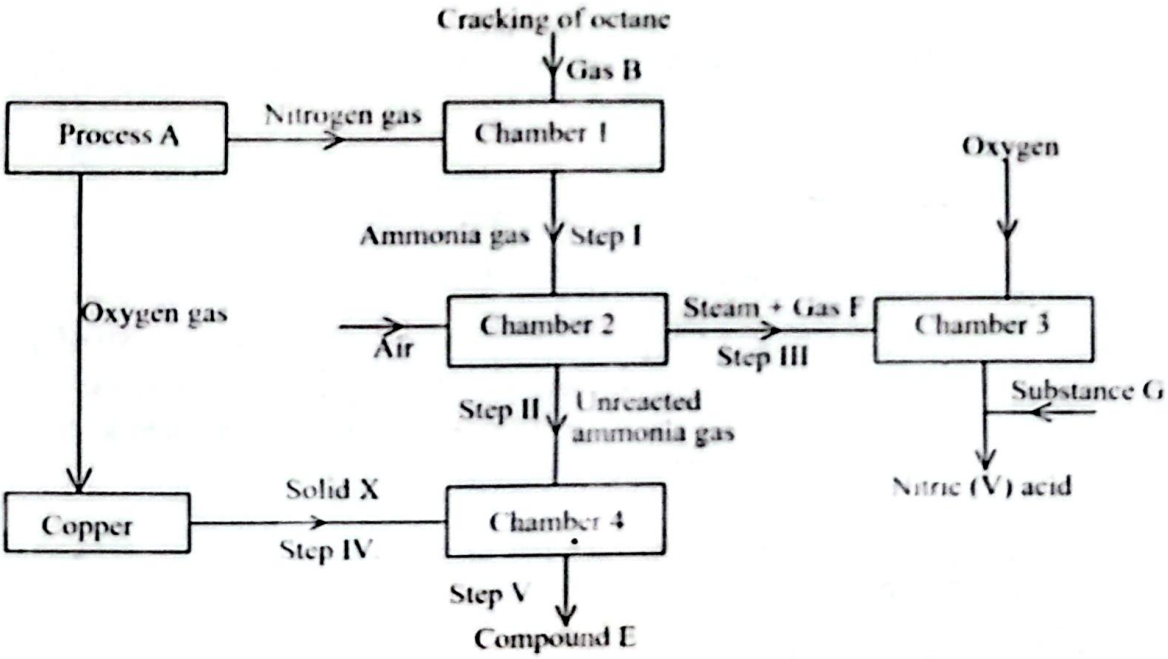


Figure 4

(a) Give the name of;

(i) Gas B; (1 mark)

Hydrogen gas

(ii) Process A; (1 mark)

Fractional distillation of Liquefied air.

(iii) Substance G. (1 mark)

Water.

(b) Name the catalyst used in;

(i) Chamber 1: (1 mark)

Finely divided iron

(ii) Chamber 2. (1 mark)

platinum-Rhodium.

(c) State the observation made during the reaction taking place in step IV. (1 mark)

* Black solid (CO) turns into a brown solid (Cu).
* Colourless droplets form on the cooler part of the container.

(d) Write equation for the reaction taking place in chamber 2. (1 mark)

$4NH_{3(g)} + 5O_{2(g)} \xrightarrow{Pt/Rh} 4NO_{(g)} + 6H_2O_{(g)}$

(e) State and explain observations made in chamber 4. (2 marks)

- Effervescence/Bubbling of a brown gas.
- The solution turns blue:

Conc HNO_3 is a strong oxidizing agent, it oxidizes copper metal to $Cu(NO_3)_2$ which is a blue solution and it itself is reduced to NO_2 gas brown. (Accept the equation)

(f) Give *two* use of nitric (V) acid. (2 marks)

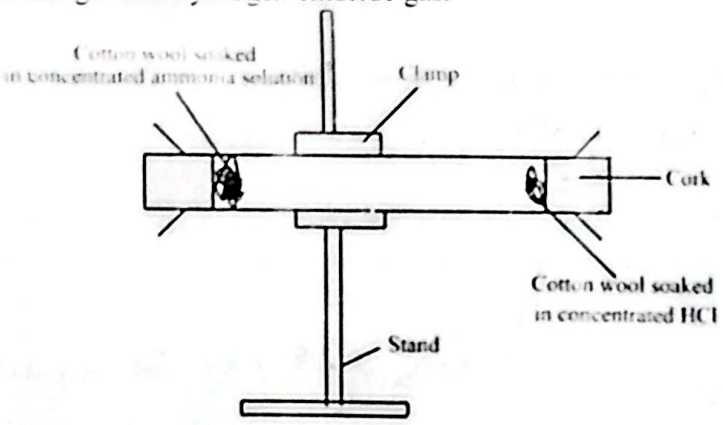
- Manufacture of fertilizers
- Manufacture of explosives.
- Manufacture of dyes and drugs.

Any 2 correct.

6 (a) State Graham's law of diffusion. (1 mark)

The rate of diffusion of a gas is inversely proportional to the square root of it density at constant temperature and pressure.

(b) The figure below shows an experiment that was used to investigate the rate of diffusion of ammonia gas and hydrogen chloride gas.



(i) Define the term diffusion. (1 mark)

Process by which particles move from a region of higher concentration to a region of lower concentration.

(ii) State and explain the observation made during the experiment after few minutes. (3 marks)

Observation.

A white dense fume forming.

Explanation.

Ammonia gas has a lower molecular mass than hydrogen chloride gas; its molecules faster and cover a longer distance than HCl molecules in the same amount of time.

(iii) Determine the molecular masses of ammonia (NH_3) and Hydrogen chloride (HCl). (N = 14.0, H = 1.0, Cl = 35.5). (2 marks)

$NH_3 = 14 + (1 \times 3)$

$= 17$

$HCl: 1 + 35.5$

$= 36.5$.

(iv) Which gas covered a longer distance? Explain. (2 marks)

NH_3 gas; It has ~~larger~~ smaller molecular mass hence lighter than HCl, therefore faster.

(c) If it takes 20 seconds for 200 cm^3 of oxygen gas to diffuse across a porous plug. How long will it take an equal volume of sulphur (IV) oxide to diffuse across the same plug? (O = 16.0, S = 32.0) (2 marks)

$\frac{T_1}{T_2} = \sqrt{\frac{M_1}{M_2}}$

$\frac{20}{T_{SO_2}} = \sqrt{\frac{32}{64}}$

$\frac{20}{T_{SO_2}} = \sqrt{0.5}$

$T_{SO_2} = \frac{20}{0.707}$

$T_{SO_2} = 28.28$ seconds.

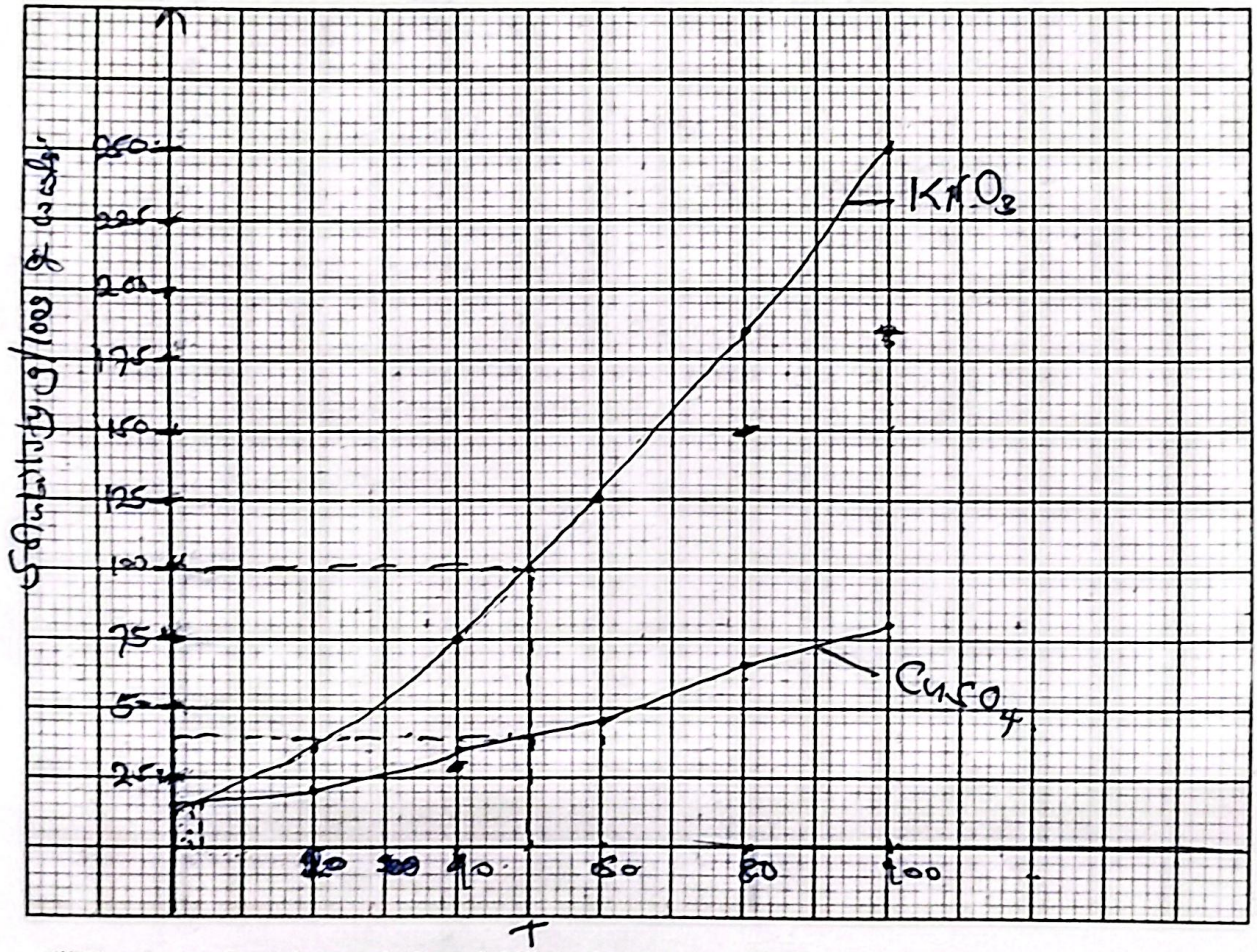
7. Solubility of potassium nitrate and copper (II) sulphate were determined at different temperatures. The following data was obtained.

Temperature(°C)		0	20	40	60	80	100
Solubility g / 100g of water	KNO_3	12	30	75	125	185	250
	$CuSO_4$	15	20	35	45	65	80

(a) Define the term solubility as used in salts. (1 mark)

The maximum mass of solute in grams that dissolve 100g of water at a specified temperature.

(i) On the grid below, plot solubility curves for both salts: where solubility (vertical axis) is plotted against temperature (horizontal axis) (4 marks)



(ii)Determine from the graph the solubility of each salt at 50°C.

I) KNO_3 (1 mark)

100g / 100g of water

II) $CuSO_4$ (1 mark)

40g/100g of water

(iii) At what temperature was the solubility of both salts equal? (1 mark)

12°c ± 2°c

(iv) If a hot solution containing 80g of KNO_3 in 100g of water was cooled from 70°C to 25°C what mass of crystals would be formed? (1 mark)

80g − 38g

= 42g.

(c) (i) What is meant by the permanent hardness of water? (1 mark)

Water hardness that cannot be removed by boiling. // Water that contains dissolve $MgSO_4$ / $CaSO_4$ r

(ii) State one chemicals substance that can be used to remove permanent hardness. (1 mark)

- Sodium carbonate // Washing soda.
- Ammonia solution.

(iii) State one advantage of hard water. (1 mark)

- It contains Ca^{2+} which is good for bone and teeth.
- ~~Has a better taste than soft water~~
- It help in formation of lead carbonate coating pipe, Preventing lead poisoning.

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