THE KENYA NATIONAL EXAMINATIONS COUNCIL
Kenya Certificate of Secondary Education

233/1 **Paper 1**

CHEMISTRY – (Theory)

Mar. 2022 – 2 hours

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 20 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

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

17	18	19	20	21	22	23	24	25	26	27	Grand Total	

1. (a) Draw a labelled diagram showing the atomic structure of $^{24}_{12}\mathbf{Mg}$. (2 marks)

(b) The atomic number of phosphorus is 15. Draw a dot (•) and cross (x) diagram for the compound formed when phosphorus reacts with chlorine, atomic number 17. (1 mark)

2. (a) State the condition under which a Bunsen burner produces a luminous flame. (1 mark)

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(b) Write an equation for the reaction that takes place in a luminous flame assuming the laboratory gas is butane. (1 mark)

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(c) One of the regions in the non-luminous flame is the unburnt gas region. Describe how the presence of this region can be shown using a wooden splint. (1 mark)

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3. (a) The elements sodium, magnesium and aluminium belong to group I, II and III respectively. Select the element with the highest electrical conductivity and give a reason. (1 mark)

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(b) Complete **Table 1** to show the products of electrolysis for concentrated sodium chloride and molten sodium chloride.

Table 1

Compound	Anode	Cathode
Concentrated sodium chloride		
Molten sodium chloride		

(2 marks)

4. A small piece of sodium metal was placed in a beaker containing pure water.

(a) State **two** observations made during the reaction. (1 mark)

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(b) State and explain another observation made when a drop of phenolphthalein is added to the mixture in the beaker. (1 mark)

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(c) Explain why it is **not** advisable to carry out this experiment using potassium metal. (1 mark)

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5. Describe how a pure sample of copper(II) nitrate crystals can be prepared using recycled copper wire. (3 marks)

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6. The following apparatus and chemicals are used to investigate the percentage of air used when iron rusts: iron filings, 100 ml measuring cylinder, trough and water.

(a) Draw a setup of the experiment. (2 marks)

(b) Write an expression to show how the percentage of air used is calculated at the end of the experiment. (1 mark)

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7. **Figure 1** shows a graph of atomic radius of some group I and group II elements.

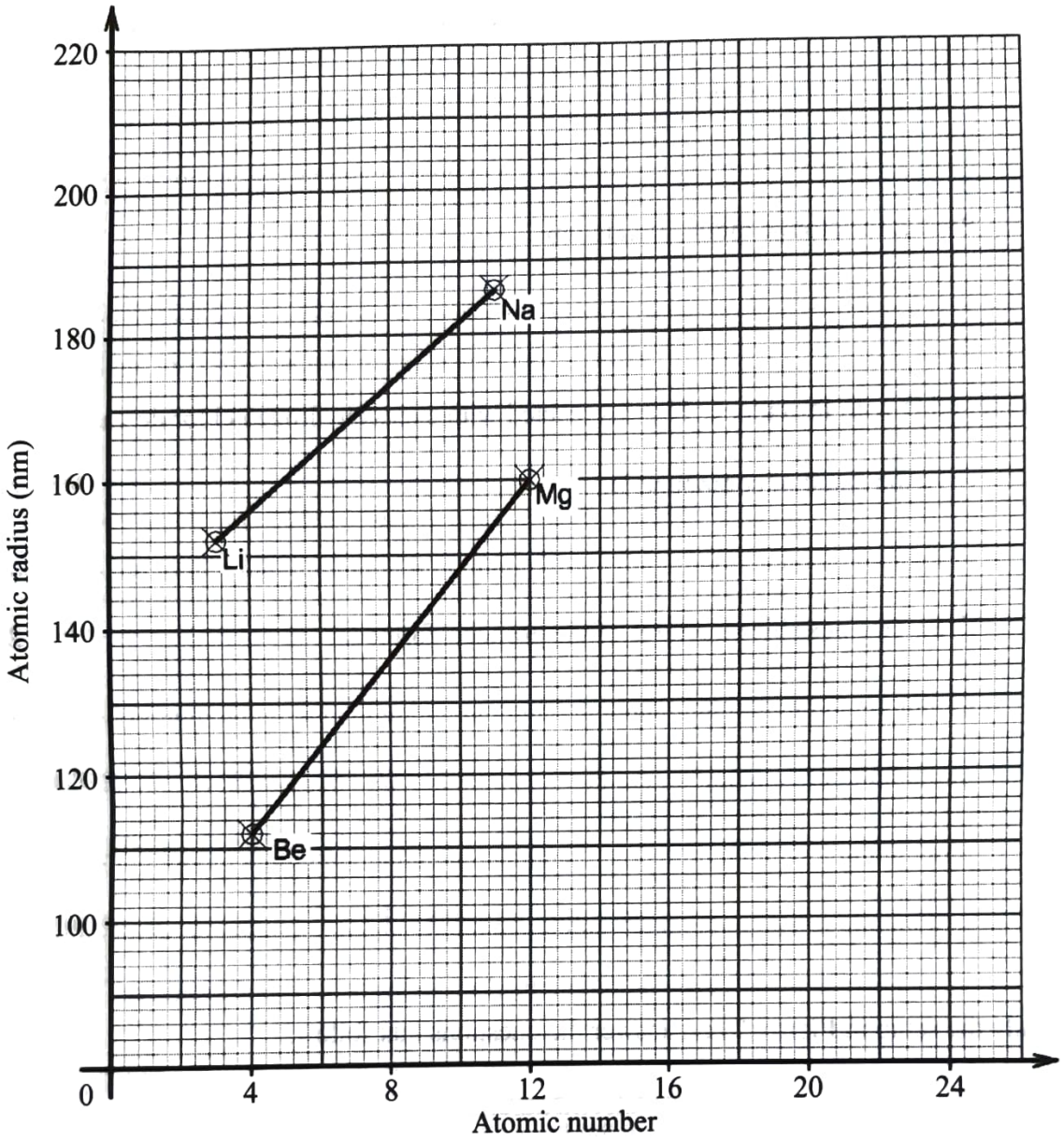

Figure 1

(a) Explain why the atomic radius of sodium is higher than that of:

(i) lithium. (1 mark)

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(ii) magnesium. (1 mark)

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(b) Predict the atomic radius of calcium. (1 mark)

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8. Compound **D** with formula, C_3H_4, was reacted with excess hydrogen chloride gas.

(a) Give the name of compound **D**. (1 mark)

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(b) Draw **two** possible structures of the products formed. (2 marks)

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9. Study the setup in **Figure 2** and answer the questions that follow.

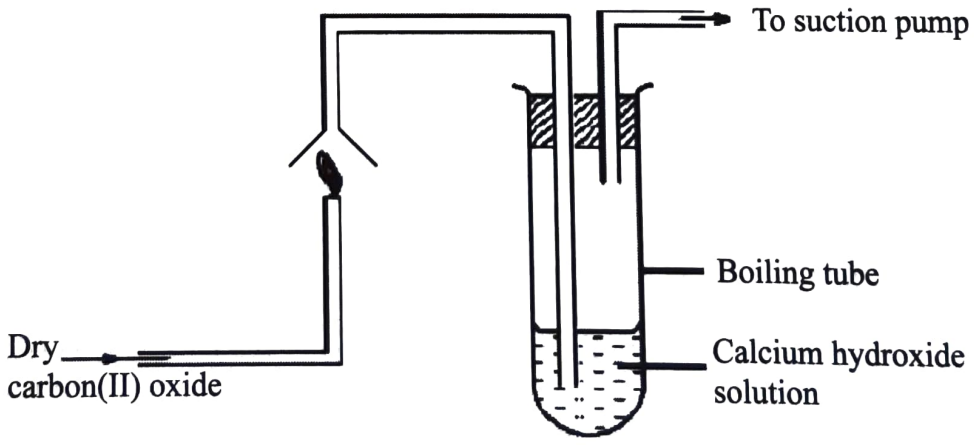

Figure 2

(a) State the precaution that should be taken in carrying out the experiment. Give a reason. (1 mark)

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(b) State the observations made in the boiling tube. (2 marks)

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10. Consider the following reaction:

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

The enthalpy change is **–92.4 kJ** per mole of nitrogen.

(a) Give the enthalpy change per mole of ammonia. (1 mark)

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(b) State and explain how each of the following affects the yield of ammonia:

(i) Increase in temperature. (1 mark)

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(ii) Finely divided iron. (1 mark)

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11. Study the flow chart in **Figure 3** and answer the questions that follow.

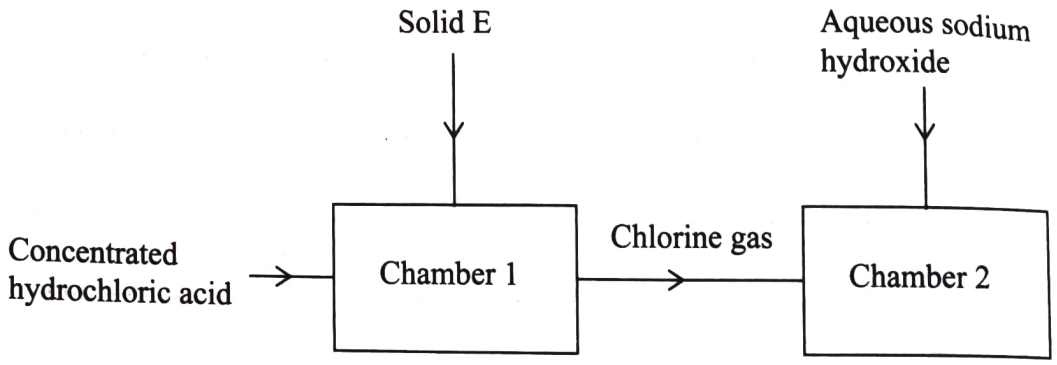

Figure 3

(a) Identify solid **E**. (1 mark)

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(b) Name the type of reaction that takes place in chamber **1**. (1 mark)

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(c) Write an equation for the reaction that takes place in chamber **2**. (1 mark)

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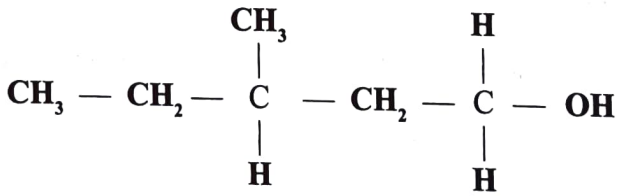
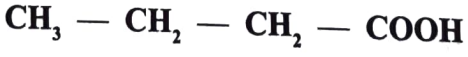
12. Compounds **H** and **J** have the following structures.



Compound **H**



Compound **J**

(a) Give the names of:

(i) Compound **H**. (1 mark)

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(ii) Compound **J**. (1 mark)

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(b) State the conditions necessary for **H** and **J** to react. (1 mark)

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13. Rhombic sulphur is **one** of the allotropes of sulphur.

(a) Draw the structure of rhombic sulphur. (1 mark)

(b) Describe the observations made when rhombic sulphur is heated from room temperature until it boils. (1 mark)

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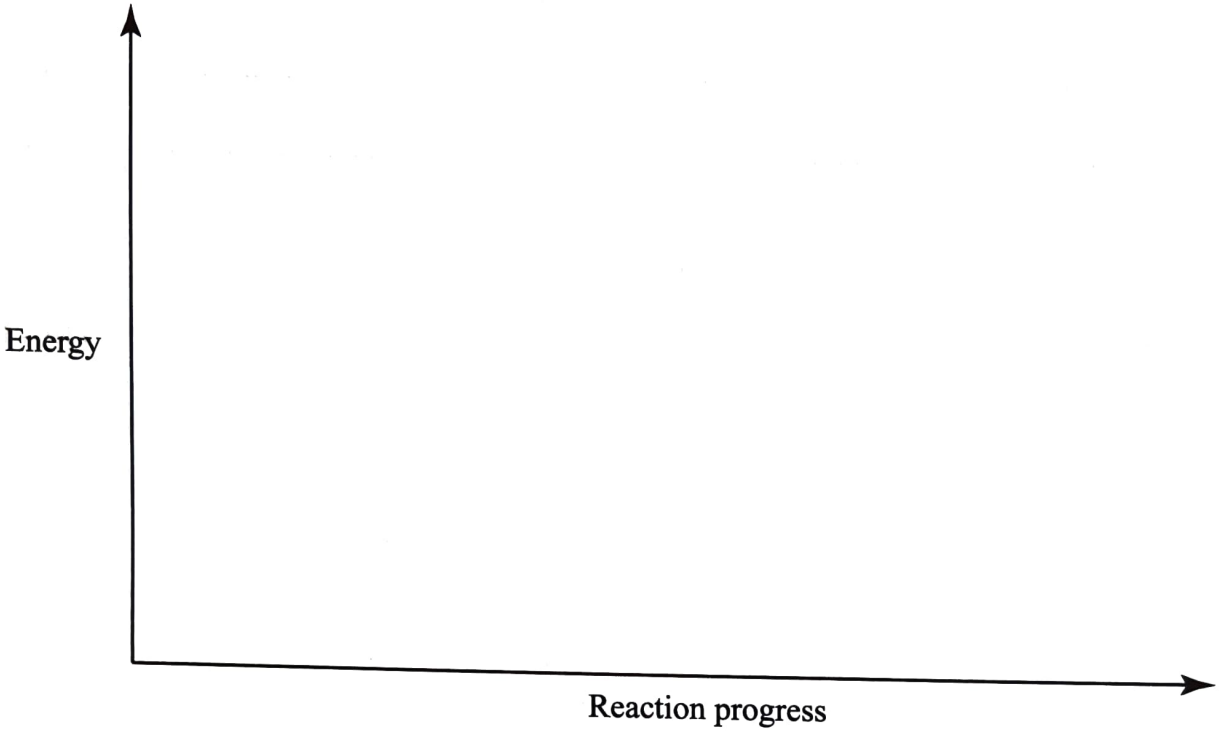
14. The molar enthalpy of solution for potassium sulphate (K_2SO_4) is **+23.8 kJ**.

(a) On the axes provided, draw a labelled energy level diagram for the dissolution process of potassium sulphate in water. (2 marks)



(b) Calculate the enthalpy change when 5.22 g of potassium sulphate is completely dissolved in water (K = 39.0; S = 32.0; O = 16.0). (1 mark)

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15. (a) State Gay–Lussac's law. (1 mark)

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(b) 180 cm^3 of nitrogen(II) oxide gas was reacted with 400 cm^3 of oxygen gas.

(i) Write an equation for the reaction. (1 mark)

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(ii) Calculate the total volume of the gases at the end of the reaction. (3 marks)

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16. Describe how the setup in **Figure 4** can be used to distinguish between 50.0 cm^3 of 0.2 M hydrochloric acid and 50.0 cm^3 of 0.2 M ethanoic acid using pieces of 6 m length of magnesium ribbon and a stop watch. (3 marks)

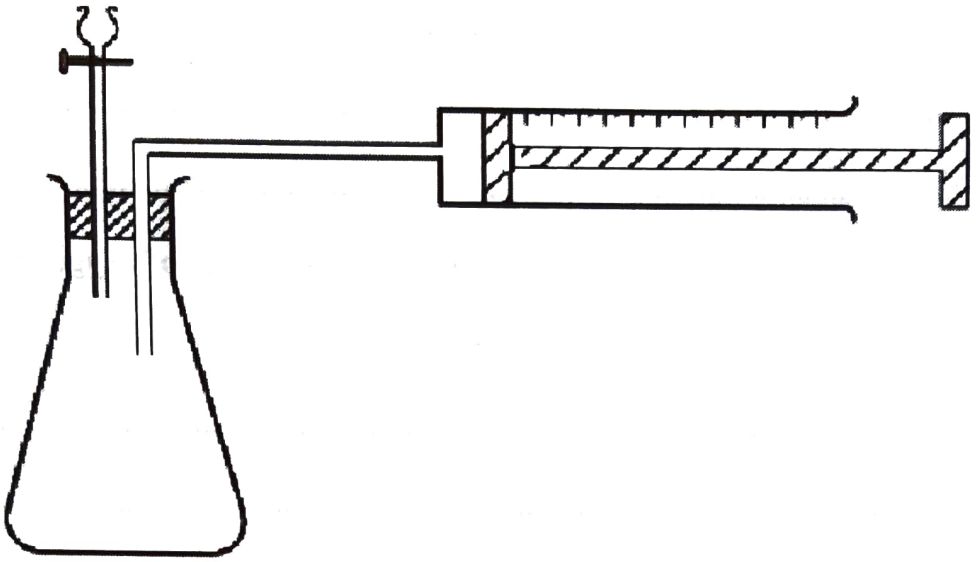

Figure 4

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17. Describe how dilute nitric(V) acid and blue litmus papers can be used to distinguish between solid samples of sodium carbonate and sodium sulphite. (3 marks)

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18. (a) Describe how propanone can be used to extract a pure sample of sunflower oil. (2 marks)

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(b) State why sodium hydroxide solution is **not** suitable for the extraction of sunflower oil. (1 mark)

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19. 31.5 cm^3 of concentrated nitric(V) acid was diluted to 500 cm^3. 10.0 cm^3 of the dilute acid required 25.0 cm^3 of 0.4 M sodium hydroxide for neutralisation.

(a) Calculate concentration of the:

(i) dilute acid. (1 mark)

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(ii) concentrated acid. (1 mark)

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(b) State the correct method for diluting the concentrated nitric(V) acid. (1 mark)

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20. **Figure 5** shows part of a radioactive decay series.

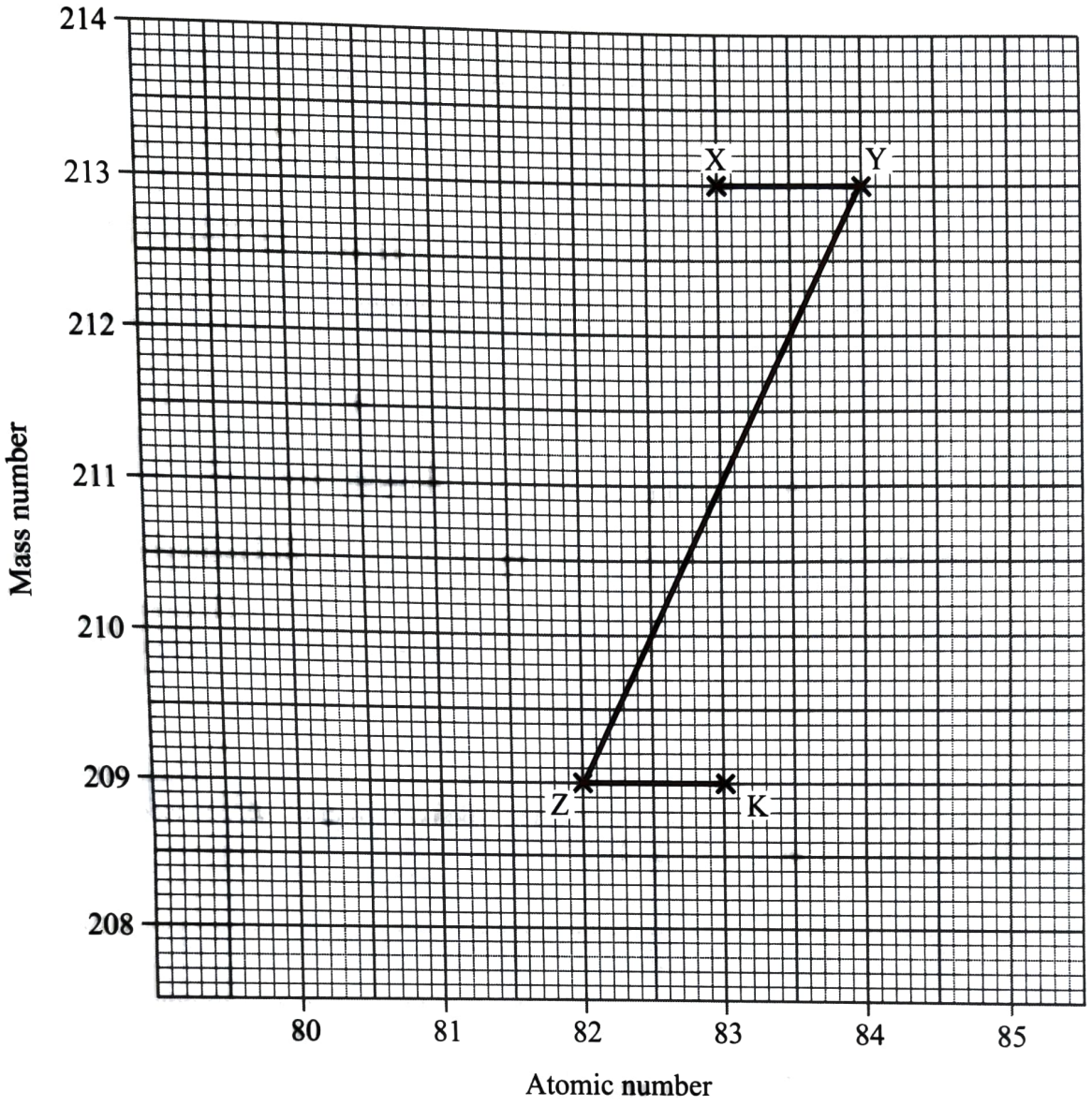

Figure 5

(a) **Write a nuclear equation for the formation of nuclide K from nuclide X.** (1 mark)

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(b) The half-life of nuclide **X** is 47 minutes. Determine the percentage of nuclide **X** that remains after 188 minutes. (2 marks)

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21. Aluminium is extracted from aluminium oxide by electrolysis.

(a) Other than the cost of electricity, give another reason why this method is expensive. (1 mark)

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(b) Calculate the mass of aluminium obtained when a current of 20A is used for 5 hours. (1 Faraday = 96500 C; Al = 27.0) (2 marks)

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22. Explain each of the following observations:

(a) Articles made of copper turn green when left exposed in air over a long period of time. (1 mark)

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(b) Addition of aqueous ammonia to a solution containing copper(II) ions produces a deep blue solution. (1 mark)

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23. (a) State what is meant by relative atomic mass of an element. (1 mark)

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(b) A compound of carbon and element **X** with formula, CX_4 contains 3.6% carbon by mass. Calculate the relative atomic mass of **X**. (2 marks)

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24. Carbon(II) oxide can be prepared by dehydration of ethanedioic acid.

(a) Complete the following equation to show the reaction that takes place. (1 mark)

$H_2C_2O_4 \rightarrow$

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(b) Name another reagent that can be used to prepare carbon(II) oxide by dehydration. (1 mark)

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25. **Figure 6** shows an incomplete diagram of a setup for laboratory preparation of nitrogen gas.

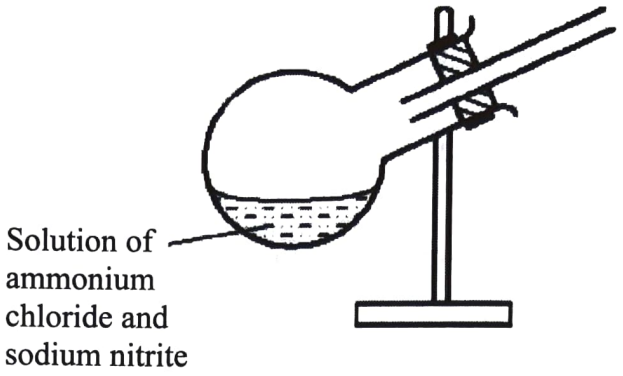

Figure 6

(a) Complete the setup in **Figure 6** to show how nitrogen gas can be collected. (2 marks)

(b) The nitrogen prepared using this setup is purer than that obtained from air. Give a reason. (1 mark)

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26. Hydrazine, $\mathbf{H-N-N-H}$ (with H bonded to each N) is used as a fuel in rockets. Using the bond energies in **Table 2**, calculate the enthalpy change for combustion of hydrazine.

$N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(g)$

Table 2

Bond	Bond Energy kJ/mol
N — H	388
N — N	163
O = O	496
N ≡ N	944
O — H	463

(3 marks)

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27. (a) **Table 3** gives the standard reduction potentials of some group VII elements.

Table 3

Reduction equations	E°/V
$Cl_2 + 2e \rightarrow 2Cl^-$	+1.36
$Br_2 + 2e \rightarrow 2Br^-$	+1.07
$I_2 + 2e \rightarrow 21^-$	+0.54

State and explain the reactions that take place when aqueous bromine is added to a sample of sea water containing both chloride and iodide ions. (2 marks)

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(b) Give a reason why potassium iodide is added to table salt. (1 mark)

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THE KENYA NATIONAL EXAMINATIONS COUNCIL
Kenya Certificate of Secondary Education

233/2 **Paper 2**

CHEMISTRY

(Theory)

Mar. 2022 – 2 hours

248

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	

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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)

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(ii) Compound **B** (2 marks)

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(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)

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

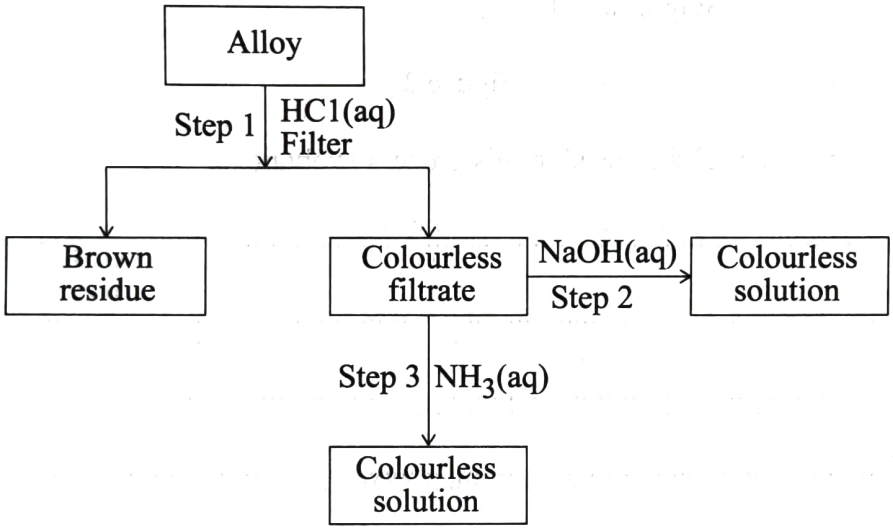

Figure 1

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

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

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

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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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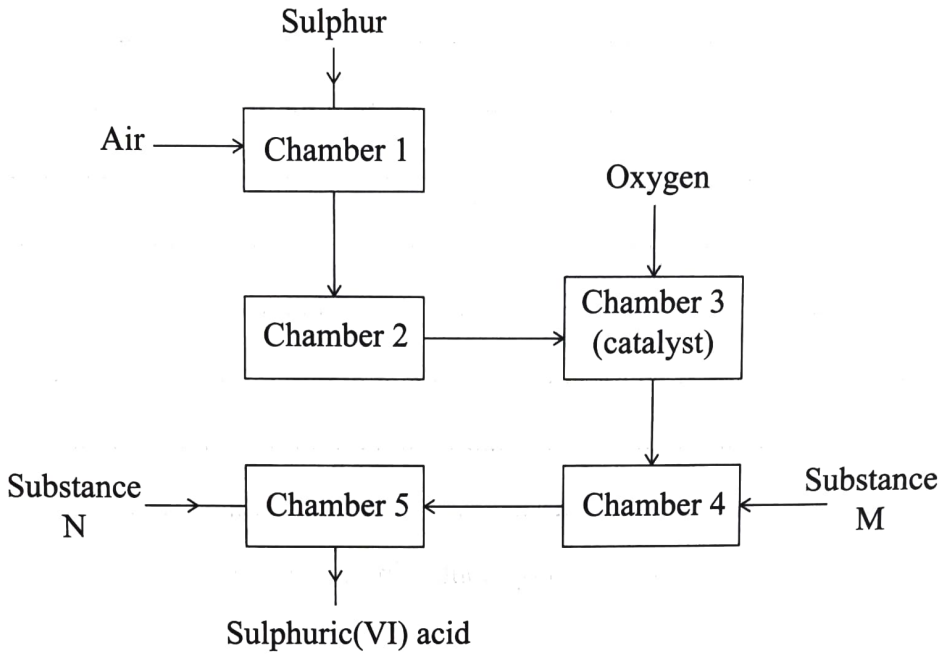

Figure 2

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

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

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(c) Identify substances:

(i) **M** (1 mark)

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(ii) **N** (1 mark)

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

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

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

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

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

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(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)

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

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

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

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

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(ii) Pressure. (1 mark)

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(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:

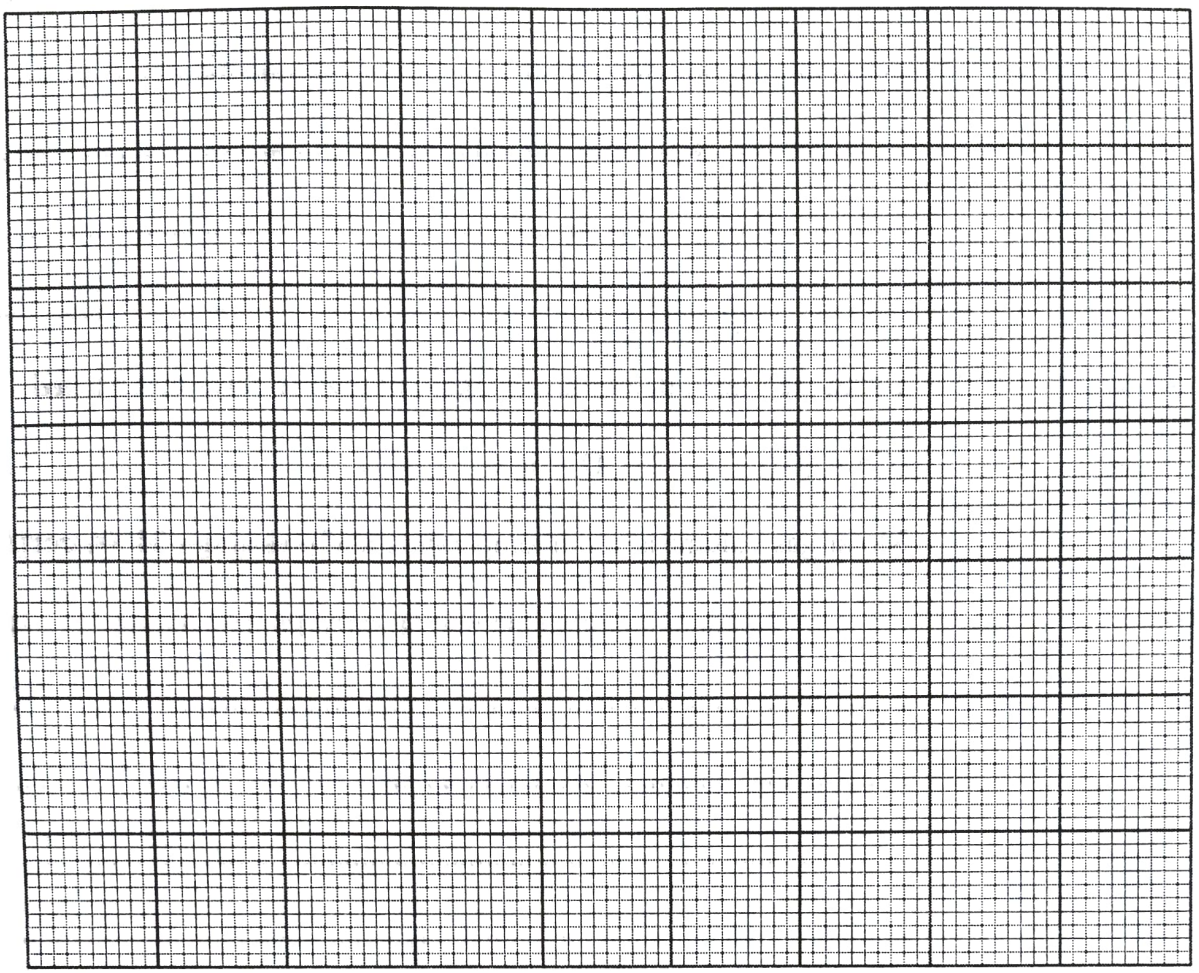
$CaCO_3(s) + 2HC1(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$

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)

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II. 105th second. (1 mark)

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

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(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 cm^3).

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

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(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)

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(c) Ammonia is highly soluble in water.

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

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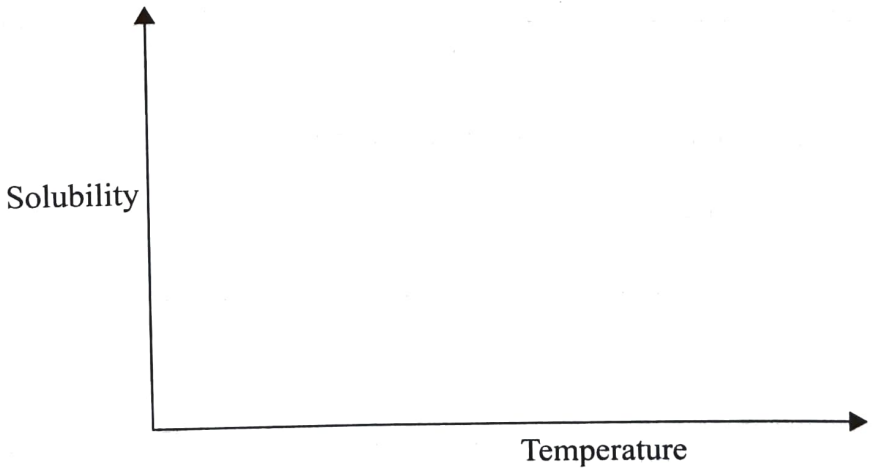
(ii) On the axes provided, sketch a curve showing how solubility of ammonia gas varies with temperature. (1 mark)



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

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

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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. (½ mark)

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II. non-metal. (½ mark)

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

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

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

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(iv) Explain each of the following observations:

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

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

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(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)

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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)

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

I. **H** (1 mark)

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II. **J** (1 mark)

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

I. **H** (1 mark)

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II. **K** (1 mark)

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

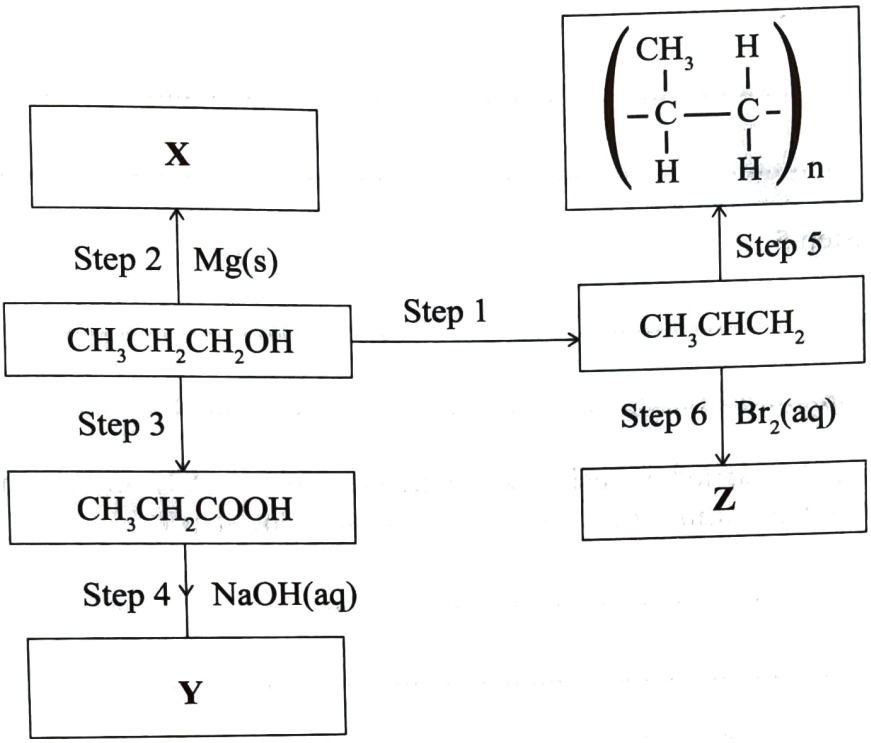

Figure 4

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

(i) **X**

Name Formula (2 marks)

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(ii) **Y**

Name Formula (2 marks)

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

(i) Step **3**. (1 mark)

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(ii) Step **5**. (1 mark)

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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)

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

(i) Step **1**. (1 mark)

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(ii) Step **5**. (1 mark)

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

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

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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)

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(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)

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

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(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)

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(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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THE KENYA NATIONAL EXAMINATIONS COUNCIL
Kenya Certificate of Secondary Education

233/3

Paper 3

CHEMISTRY – (Practical)

Mar. 2022 – 2¼ hours

490

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) You are **not** allowed to start working with the apparatus for the first 15 minutes of the 2¼ hours allowed for this paper. This time is to enable you to read the question paper and make sure you have all the chemicals and apparatus that you may need.
(e) All working **must** be clearly shown where necessary.
(f) **Non-programmable** silent electronic calculators and KNEC mathematical tables may be used.
(g) **This paper consists of 8 printed pages.**
(h) **Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.**
(i) **Candidates should answer the questions in English.**

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For Examiner's Use Only

Question	Maximum Score	Candidate's Score
1	15	
2	8	
3	17	
Total Score	40	

1. You are provided with:

- **Solution A:** 0.10 M solution of a monobasic acid A;
- **Solution B:** Sodium hydroxide solution;
- **Solution C:** containing 10.0 g of acid C per litre of solution.

You are required to:

- Standardise **solution B** using **solution A**;
- Determine the number of moles of sodium hydroxide that react with one mole of acid C.

PROCEDURE I

Fill the burette with **solution A**. Using a pipette and pipette filler, place 25.0 cm^3 of **solution B** into 250 ml conical flask. Titrate **solution B** with **solution A** using phenolphthalein indicator and record your results in **Table 1**. Repeat the titration and complete **Table 1**.

(a) **Table 1**

	I	II	III
Final burette reading			
Initial burette reading			
Volume of solution **A** used, cm^3			

(3 marks)

(b) Calculate the:

(i) average volume of **solution A** used. (1 mark)

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(ii) number of moles of **solution A** in the average volume used. (1 mark)

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(iii) number of moles of sodium hydroxide (**N**) in 25.0 cm^3 of **solution B**. (1 mark)

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(iv) concentration of sodium hydroxide in moles per litre. (1 mark)

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PROCEDURE II

Clean the burette and fill it with **solution C**. Using a pipette and pipette filler, place 25.0 cm^3 of **solution B** into a 250 ml conical flask.

Titrate **solution B** with **solution C** using phenolphthalein indicator and record your results in **Table 2**. Repeat the titration and complete **Table 2.**

(c) **Table 2**

	I	II	III
Final burette reading			
Initial burette reading			
Volume of solution **C** used, cm^3			

(3 marks)

(d) Calculate the:

(i) average volume of **solution C** used. (1 mark)

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(ii) concentration in moles per litre, of **solution C**, given that the relative formula mass of **acid C** is 210.0. (1 mark)

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(iii) number of moles of **acid C** in the average volume used. (1 mark)

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(e) (i) Write the ratio of moles of **acid C** to moles of sodium hydroxide **(N)** in the 25.0 cm^3 of **solution B**. (1 mark)

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(ii) Determine the number of moles of sodium hydroxide that react with one mole of **acid C**. (1 mark)

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2. You are provided with **solid D**.

You are required to determine the freezing point of **solid D**.

PROCEDURE

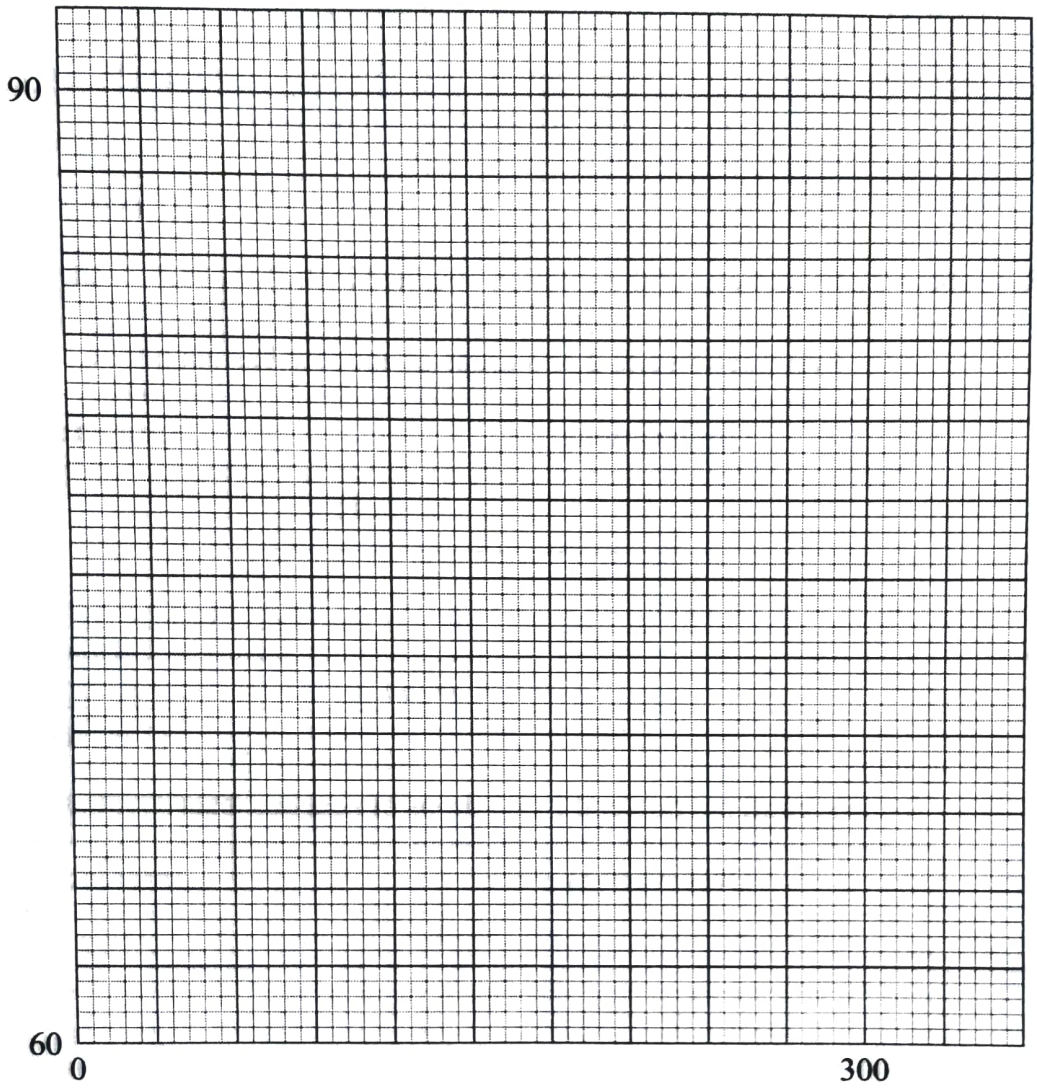
(i) Fill a 250 ml beaker with about 200 cm^3 of tap water and heat the water until it boils.
(ii) Place all **solid D** provided in a **dry** test tube and insert a thermometer into the solid.
(iii) Place the test tube in the boiling water and allow the solid to heat until it all melts.
(iv) When the temperature of the melted solid is approximately 90 °C, remove the test tube, wipe the sides with tissue paper and then place the test tube into an empty 250 ml beaker.
(v) Start the stop watch or clock when the temperature of the melted solid is 85.0 °C.
(vi) As the solid cools, measure and record its temperature every 30 seconds and complete **Table 3.**

(a) **Table 3**

Time, s	0	30	60	90	120	150	180	210	240	270	300
Temperature, °C											

(4 marks)

(b) On the grid provided, plot a graph of temperature (vertical axis) against time.



(3 marks)

(c) Using the graph in (b), determine the freezing point of **solid D**. (1 mark)

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3. You are provided with **solid E**. Carry out the following tests and record your observations and inferences in the spaces provided.

(a) Place **all** the **solid E** in a boiling tube. Add about 10 cm^3 of dilute nitric(V) acid, warm the mixture and then allow to stand until all the solid dissolves. Add about 10 cm^3 of distilled water to the solution and shake. Retain the solution for tests **(b)** and **(c)**.

Observations	Inferences

(2 marks) (1 mark)

(b) Use about 2 cm^3 portions of the solution obtained in 3(a) for each of the following tests.

(i) To the **first portion** add 2 or 3 drops of aqueous barium nitrate.

Observations	Inferences

(1 mark) (1 mark)

(ii) To the **second portion** add 2 or 3 drops of aqueous lead(II) nitrate.

Observations	Inferences

(1 mark) (1 mark)

(iii) To the **third portion** add aqueous sodium hydroxide dropwise until in excess.

Observations	Inferences

(1 mark) (1 mark)

(iv) Place about 3 cm^3 of aqueous ammonia in a test tube. To the **fourth portion**, add all the aqueous ammonia from the test tube dropwise.

Observations	Inferences

(1 mark) (1 mark)

(c) To the remaining solution of **solid E** in the boiling tube, add all the **solid G** provided. Shake the mixture for about 2 minutes. Filter the mixture into a boiling tube. Retain the filtrate for tests (i) and (ii) below.

Observations	Inferences

(1 mark) (1 mark)

(i) To about 2 cm^3 portion of the filtrate, add aqueous ammonia dropwise until in excess.

Observations	Inferences

(1 mark) (1 mark)

(ii) To about 2 cm^3 portion of the filtrate add 2 or 3 drops of dilute hydrogen peroxide solution.

Observations	Inferences

(1 mark) (1 mark)

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