2026

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.**

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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

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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

294
60
354
33
387

404

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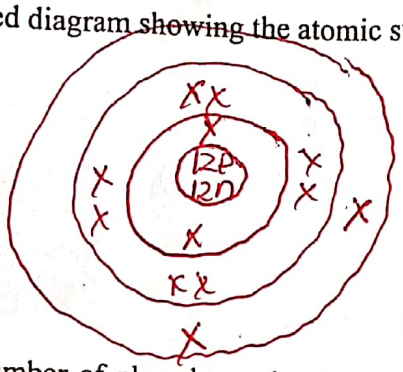
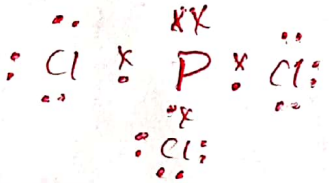
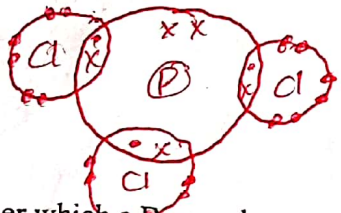
1. (a) Draw a labelled diagram showing the atomic structure of $^{24}_{12}Mg$. (2 marks)



energy levels 1 mk
Nuclear 1 mk
12p ½
12n ½

(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)





NO ½ mark

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

Air hole is closed

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

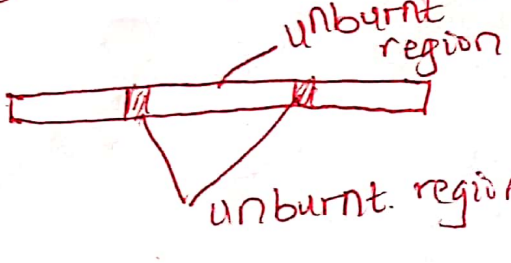
S.S must be correct

$C_4H_{10(g)} + 4O_{2(g)} \rightarrow C_{(s)} + 3CO_{(g)} + 5H_2O_{(l)}$

$C_4H_{10(g)} + 3O_{2(g)} \rightarrow C_{(s)} + CO_{(g)} + 5H_2O_{(g/l)}$

(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)

Slip a wooden splint across the middle part of the flame several times, remove & observe ½
The region at the middle remains unburnt
Indicating the presence of unburnt gases ½



1

unlabelled diagram ½

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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)

Al ½ : Has 3 delocalised e^- while Na & Mg has 1 & 2 e^-s respectively ½

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

Accept correct equations.

Table 1

Compound	Anode	Cathode
Concentrated sodium chloride	Cl_2 ½	H_2 ½
Molten sodium chloride	Cl_2 ½	Na ½

(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)

Metal darts/floats on the surface water
Melts into a silvery ball.
Produces hissing sound/effervescence/bubbles
Beaker feels warm
any 2

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

Tried to correct observation

The solution turns pink, because an alkali is formed. ½ ½

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

Potassium reacts explosively/more vigorously with water. ✓1

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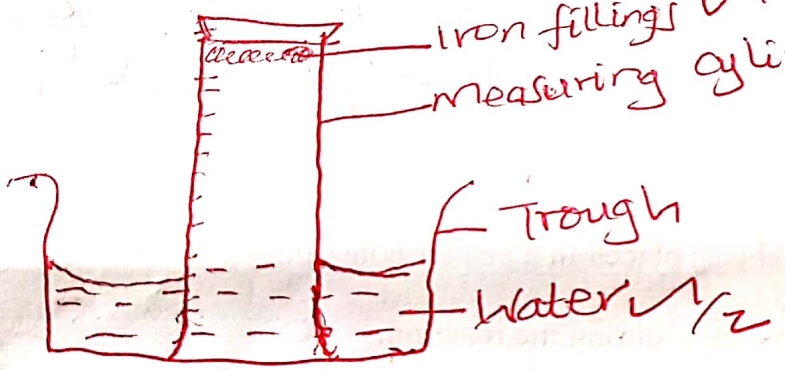
Add excess copper metal to conc. HNO_3 ✓
Add excess copper Metal to 50% HNO_3 ✓

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

Heat the copper wire in air ✓½ to obtain CuO. ✓½
Add CuO to dil HNO_3 to obtain $Cu(NO_3)_2$. Filter ✓½ to remove excess CuO. Heat the filtrate to saturation ✓½ & allow to cool & form crystals ✓½. Dry the crystals ✓½ btn filter papers/Filter to remove the mother liquor. ✓½

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)



workability ½
Slanting measuring cylinder ✓

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

$$\frac{\text{Initial height of air column} - \text{Final height of air column}}{\text{Initial height of air column}} \times 100\%$$

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

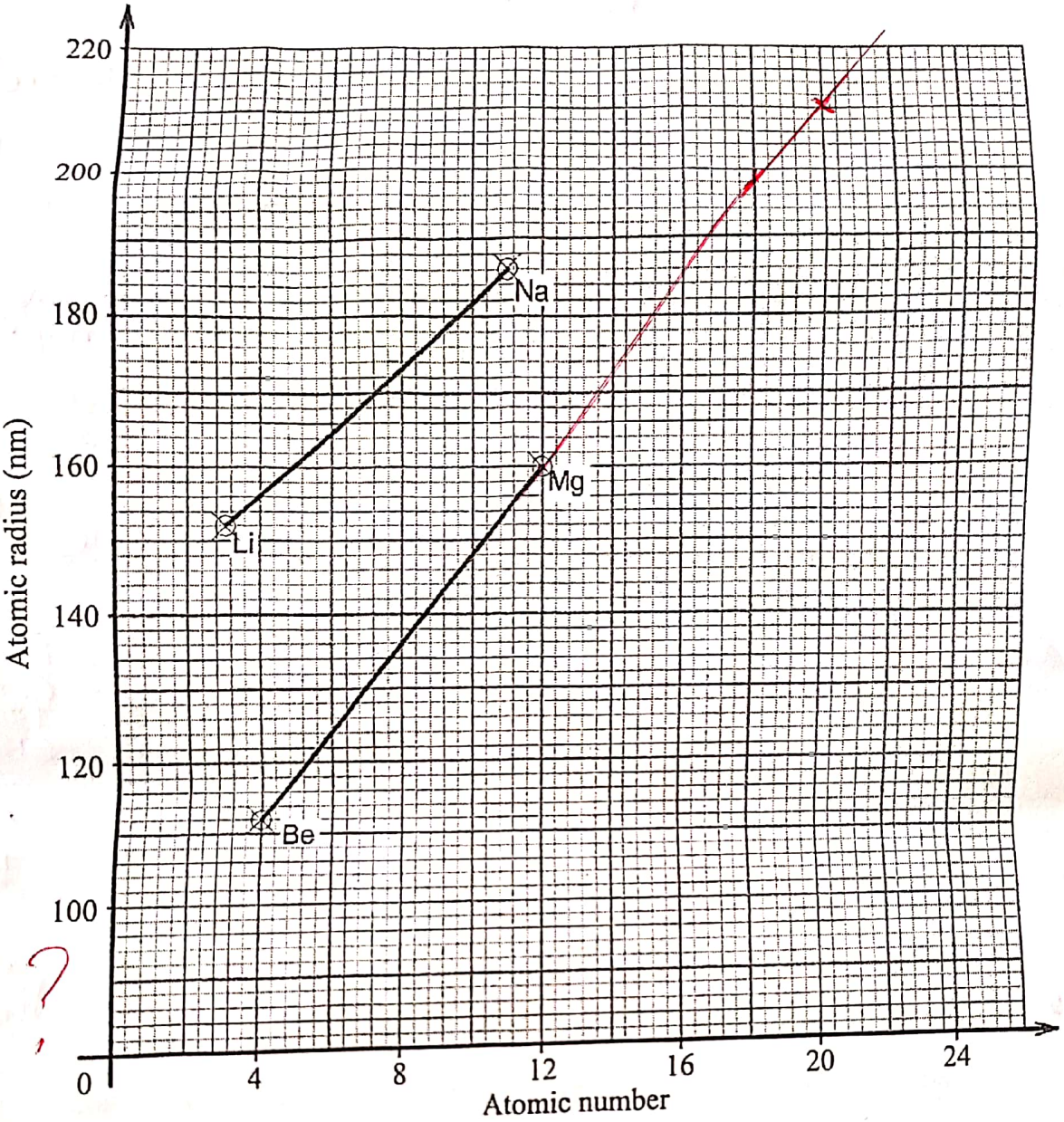

Figure 1

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

(1 mark)

(i) lithium.

Na has 3 energy levels while Li has 2 ✓1

Na 2·8·1 ½

Li 2·1 ½

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(ii) magnesium. Mg 2.8.2 } No mark.
Na 2.8.1 } (1 mark)

Mg has a higher nuclear charge than Na // Mg has more protons than Na

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

208 ~~200~~ ± 2 nm

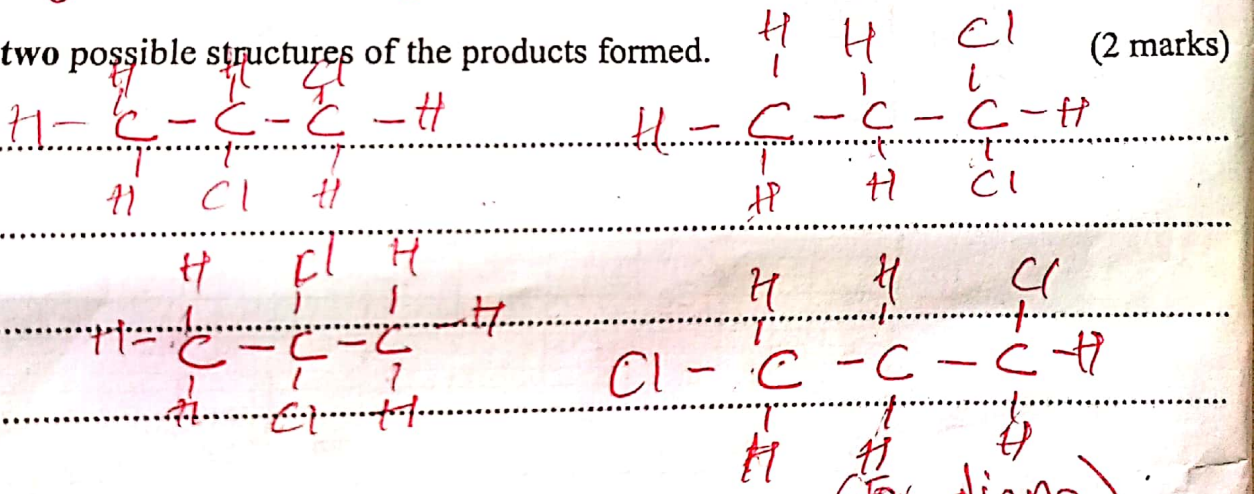
½ for showing on the graph only.

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

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

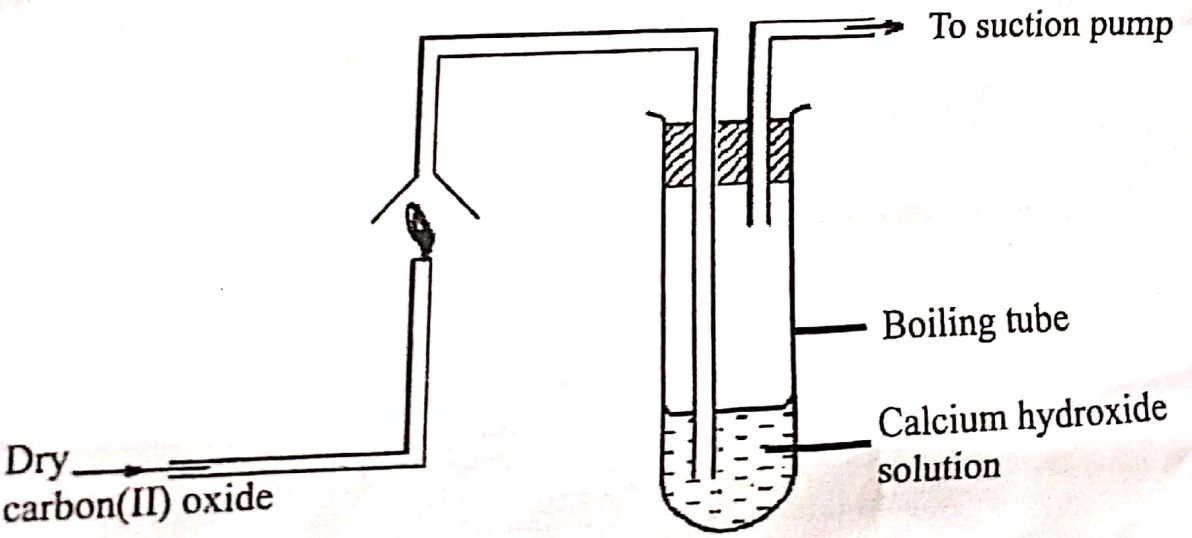
Propyne / prop-1-yne / prop-1,2-diene

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



(for diene)

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



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

carried out in a fume chamber/open air ½
CO is poisonous ½

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

White ppt is initially formed ½ which dissolve to form a colourless solution. 1½

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)

$\frac{-92.4}{2} = -46.2\ kJ\ mol^{-1}$ ✓ Penalize ½ for missing sign.

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

(i) Increase in temperature. (1 mark)

Lowers the yield ½ Toward reaction is exothermic backward reaction is endothermic.
Penalize for backward reaction is favoured

(ii) Finely divided iron. (1 mark)

½ ½
No effect. Catalyst has no effect on position of equillibrium.

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

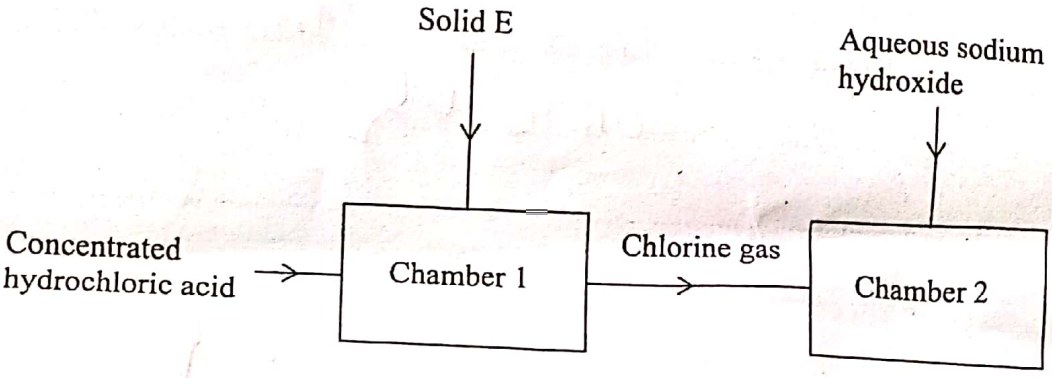


Figure 3

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

Potassium Manganate(VII) / Manganese (IV) oxide / lead (IV) oxide

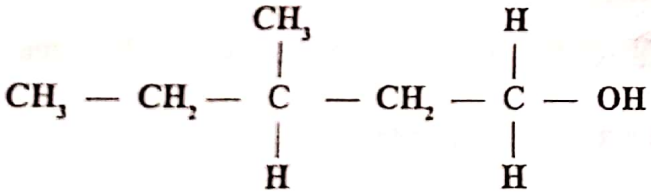
(b) Name the type of reaction that takes place in chamber **1**. (1 mark)

Redox / oxidation

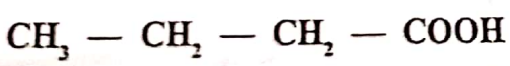
(c) Write an equation for the reaction that takes place in chamber **2**. (1 mark)

$Cl_{2(g)} + 2NaOH_{(aq)} \rightarrow NaCl_{(aq)} + NaOCl_{(aq)} + 2H_2O_{(l)}$

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



Compound **H**



Compound **J**

(a) Give the names of:

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

3-Methylpentan-1-ol

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(ii) Compound J. (1 mark)

Butanoic acid

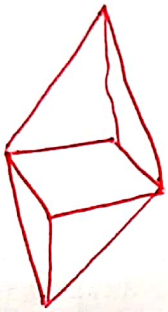
(b) State the conditions necessary for H and J to react. (1 mark)

conc. H_2SO_4 ½

warm/heat (30°-60°C) ½

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) 2

½ ½

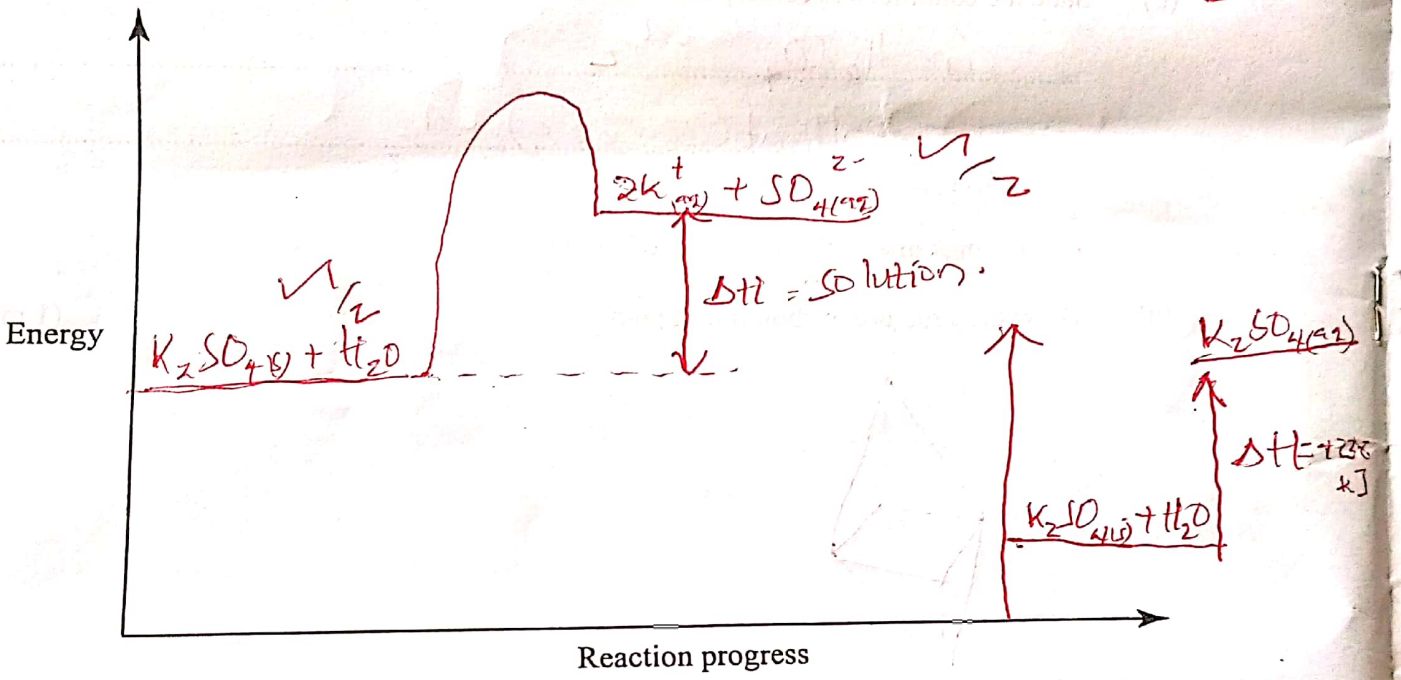
Yellow solid forms amber liquid, as the temp' increases, the liquid darkens & becomes viscous, turns to dark redbrown & less viscous before boiling to give light brown vapour

✓ 2 ✓ 2

2

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. (4 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). (1½ mark)

$K_2SO_4 = 174$

$\frac{5.22}{174} = 0.03$ mol

$\Delta H = 0.03 \times 23.8$ kJ

± 0.714 kJ

penalize ½ for wrong units.

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

When gases react, they do so in volumes that bear simple ratio to one another & products if gaseous temperature & pressure being constant.

(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)

$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$

(ii) Calculate the total volume of the gases at the end of the reaction. (2 marks)

$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$

180 cm^3 400 cm^3 0 cm^3

0 90 cm^3 / 310 cm^3 180 cm^3 400 − 90 = 310

Vol of NO_2 = 180 cm^3

Total = 180 + 310 = 490 cm^3

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16. Describe how the setup in **Figure 4** can be used to distinguish between 50.0 cm³ of 0.2 M hydrochloric acid and 50.0 cm³ of 0.2 M ethanoic acid using pieces of 6 cm length of magnesium ribbon and a stop watch. (3 marks)

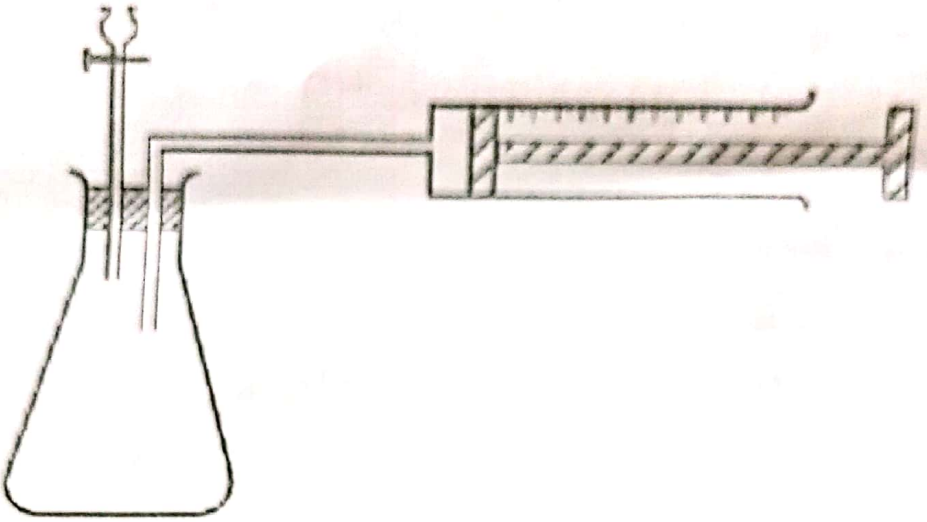

Figure 4

Put 6 cm long Mg ribbon in the conical flask. Add 50cm³ of test sample acid. Using the stopwatch record the volume of gas collected in the syringe at time intervals e.g 15 seconds. (1)
Repeat the experiment with the other test acid
The sample that produces higher volume of the gas within the first 15 seconds is hydrochloric acid (1)

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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)

To two different test tubes containing test samples add dil. HNO_3 ½. Place wet blue litmus paper at the mouth of the test-tubes ½. In both cases the litmus papers turn red ½ thereafter one is bleached. ½. The sample that led to bleaching of a litmus is that of sodium sulphide ✓1

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

Crush the sunflower seeds using mortar & pestle ½ add propanone, stir & decant ✓1; leave the extract in the sunlight for propanone to evaporate leaving the oil behind ½

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

Sodium hydroxide will react with the oil to form soap

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19. 31.5 cm³ of concentrated nitric(V) acid was diluted to 500 cm³. 10.0 cm³ of the dilute acid required 25.0 cm³ of 0.4 M sodium hydroxide for neutralisation.

(a) Calculate concentration of the:

(i) dilute acid. (1 mark)

$HNO_{3(aq)} + NaOH_{(aq)} \rightarrow NaNO_{3(aq)} + H_2O_{(l)}$

1 : 1

$\frac{0.4 \times 25}{1000} = 0.01$ ✓½

$\frac{0.01 \times 1000}{10} = 1\,M$ ✓½

(ii) concentrated acid. (1 mark)

$\frac{1 \times 500}{31.5} = 15.9\,M$ ✓½ ✓½

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

Adding acid to water slowly.

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

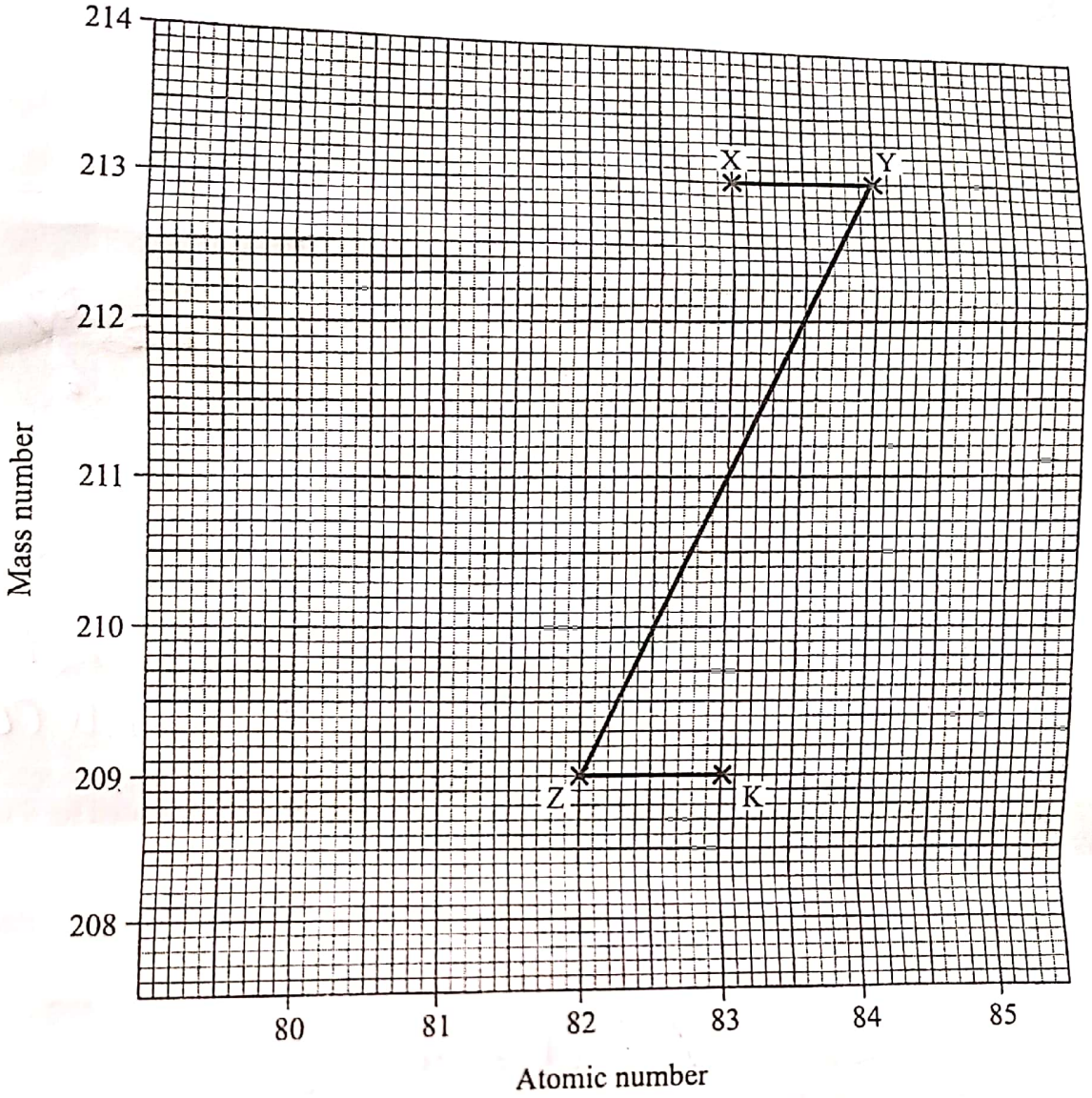

Figure 5

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

$^{213}_{83}X \longrightarrow {}^{209}_{81}K + {}^{4}_{2}He^{2+} + 2\,{}^{0}_{-1}e$

.....

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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)

$\frac{188}{47} = 4$ half-lives ✓1

100% → 50% → 25% → 12.5% → 6.25% ✓1

$\frac{x}{100} = \left(\frac{1}{2}\right)^4$ $x = 100 \times \frac{1}{16} = 6.25\%$

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)

The graphite anode has to be replaced periodically since it is oxidised by air to CO_2

(b) Calculate the mass of aluminium obtained when a current of 20A is used for 5 hours. (1 Faraday = 96500 C; Al = 27.0) ✓½ (2 marks)

$Q = It = 20 \times 5 \times 60 \times 60 = 360,000C$ ✓½

$Al^{3+} + 3e^- \rightarrow Al$ ✓½

$\frac{360,000}{3 \times 96,500} = 1.244$ ✓½

$1.244 \times 27 = 33.588g$ ✓½

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)

Due to formation of Copper (II) carbonate ✓½ copper reacts with atmospheric Carbon(IV) oxide ✓½

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

Due to formation of complex ion tetra ammine copper (II) $[Cu(NH_3)_4]^{2+}$

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

Is the mass of an atom relative to mass of one atom of Carbon-12 whose mass 12.00 atomic mass units.

Is the mass of one atom of an element compared to the mass of 1/12 of carbon-12.

(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)

CX_4	C	X
R.A.M	12	x
%	3.6	96.4
Moles	3.6/12	96.4/x
	0.3	96.4/x
	1	4

$x = 80.33$

R.M.M = x

$\frac{12}{(12+4x)} \times 100 = 3.6$

$1200 = (12+4x)3.6$

$333.33 = 12+4x$

$\frac{333.33}{4} - 12 = \frac{4x}{4}$

$x = 80.33$

$\frac{96.4}{x} = \frac{4}{1}$

$96.4 = 4x$

$x = \frac{96.4}{4} = 24.1$

$\frac{12}{3.6} \times 96.4 = 4x$

$321.33 = 4x$

$x = \frac{321.33}{4} = 80.33$

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)

$H_2C_2O_4 \xrightarrow{H_2SO_4} CO_{(g)} + CO_{2(g)} + H_2O_{(l)}$

Don't penalize for state symbols.

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

Methanoic acid / Sodium methanoate } any 1

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

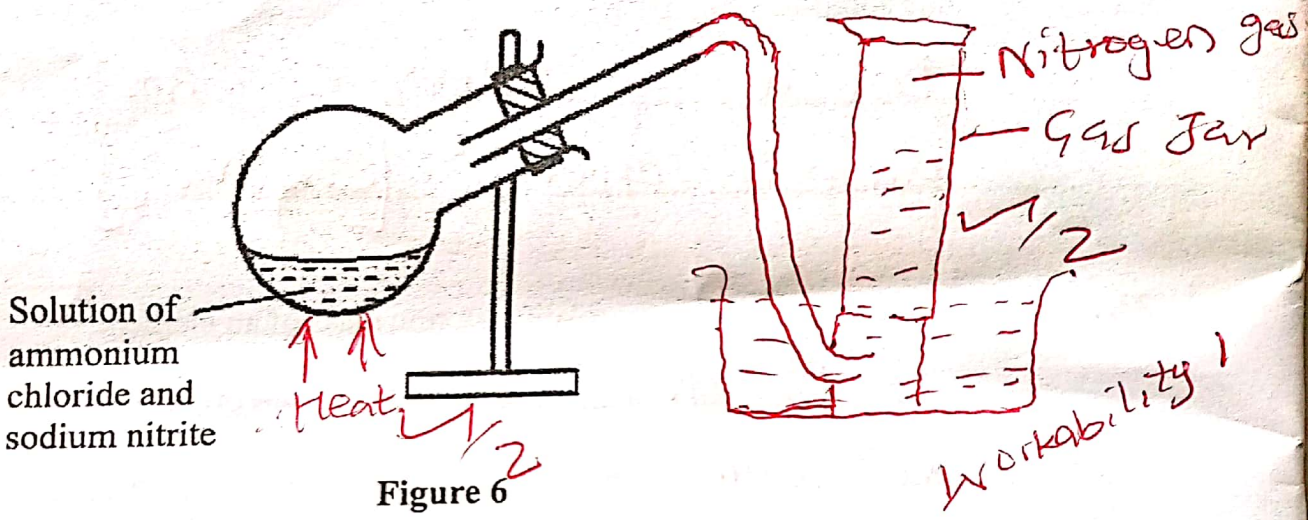

Figure 6

(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)

N2 has impurities e.g noble gases (1)

.....

.....

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26. Hydrazine, $H-\overset{H}{\underset{|}{N}}-\overset{H}{\underset{|}{N}}-H$ 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)

Bonds Broken

$4 \times 388 = 1552$

$1 \times 163 = 163$

$1 \times 496 = 492$

$2211\ kJ$ ✓ (1)

Bonds formed

$1 \times 944 = 944$

$(2 \times 463) \times 2 = 1852$

2796 (1)

$\therefore \Delta H = -2796 + 2211\ kJ = -585\ kJ\ mol^{-1}$ ½ ½

penalize for wrong sign (+)

20 D

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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
$I_2 + 2e \rightarrow 2I^-$	+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)

Award ½ if the table is not used

$Br_{2(g)} + 2I^-_{(aq)} \rightarrow 2Br^-_{(aq)} + I_{2(s)}$ ½ ½

$Br_{2(aq)} + 2Cl^- \rightarrow$ No reaction ½

Bromine will oxidise iodide ions since it has more +ve E^θ

Bromine will not displace chlorine since E^θ for Cl_2 is more +ve.

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

provide iodine ½ Iodine is needed to regulate functioning of thyroid gland ½ prevents goitre ✓

067

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648
45
693

621
45

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