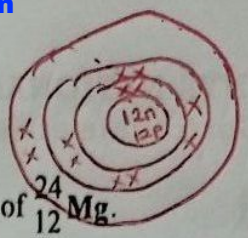
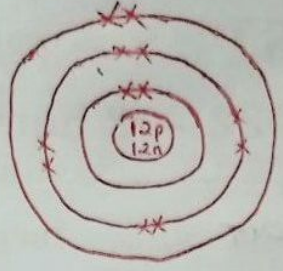


1. (a) Draw a labelled diagram showing the atomic structure of $^{24}_{12}Mg$. (2 marks)

Nuclear composition
12p ✓½
12n ✓½
Electrons ✓1

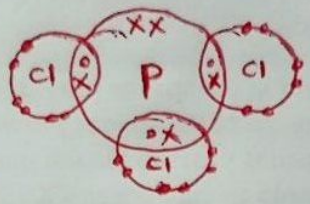


OR

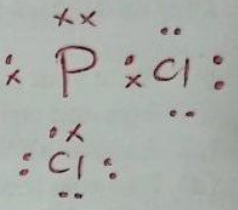
3 energy levels ✓1
Nuclear with occupied protons and neutrons ✓1

(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)

- 1 or 0 mark
- use of only dots or crosses penalise fully



✓1



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

When airhole/collar is closed ✓1 or fully closed.

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

Wrong state symbols penalised ½

$CH_4(g) + 4O_2(g) \rightarrow C(s) + 3CO(g) + 5H_2O$ (1)

OR

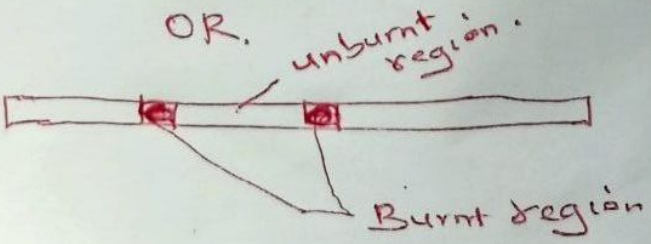
$CH_4(g) + 4O_2(g) \rightarrow 3C(s) + CO(g) + 5H_2O$ (1)

(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 ✓

The central part remains unburnt/uncharred while the outer part burns.

OR.



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)

Aluminium ✓½

It has 3 delocalised ✓½ electrons while Sodium and magnesium has one and two respectively.

(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	Chlorine or Cl_2	Hydrogen H_2
Molten sodium chloride	Chlorine Cl_2	Sodium Na

- Use of equation to show correct product Award'

(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)

Any two correct ½ each.

- The piece of metal darts/floats
- melts into silvery ball.
- production of effervescence/hissing sound
- The beaker becomes warm

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

(marks tied)

Solution turns ✓½ pink because sodium hydroxide/alkaline ✓½ solution is formed.

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

Potassium reacts explosively with water/more vigorously/more violent.

- Add excess copper (II) oxide
- Filter to remove unreacted copper
- Heat the solution to saturation
- Allow to cool
- Dry the crystals

4

Concentrated nitric (V) acid or nitric (V) acid 50% nitric (V) acid

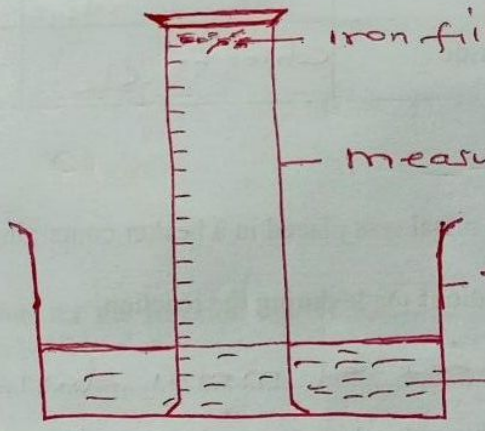
5. Describe how a pure sample of copper(II) nitrate crystals can be prepared using recycled copper wire. (3 marks)

- Heat the copper wire in air to form copper (II) oxide ✓½
- Add excess copper (II) oxide to dilute nitric acid ✓½
- Filter to remove unreacted copper (II) oxide ✓½
- Heat the resulting solution to saturation ✓½
- Allow it to cool to form crystals ✓½
- Dry/filter the crystals ✓½

- Stop marking where the candidate goes wrong.
- Use equations accepted partially.

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
✓ Slanting measuring cylinder
✓ Uncalibrated measuring cylinder

Workability ✓½

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

$$\frac{\text{Initial height of air column} - \text{Final height of air column}}{\text{Initial height of air column}} \times 100$$ ✓1

Or Volume instead of height

OR

$$\frac{\text{Initial height of water} - \text{Final height of water}}{\text{Initial height of water}} \times 100$$

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

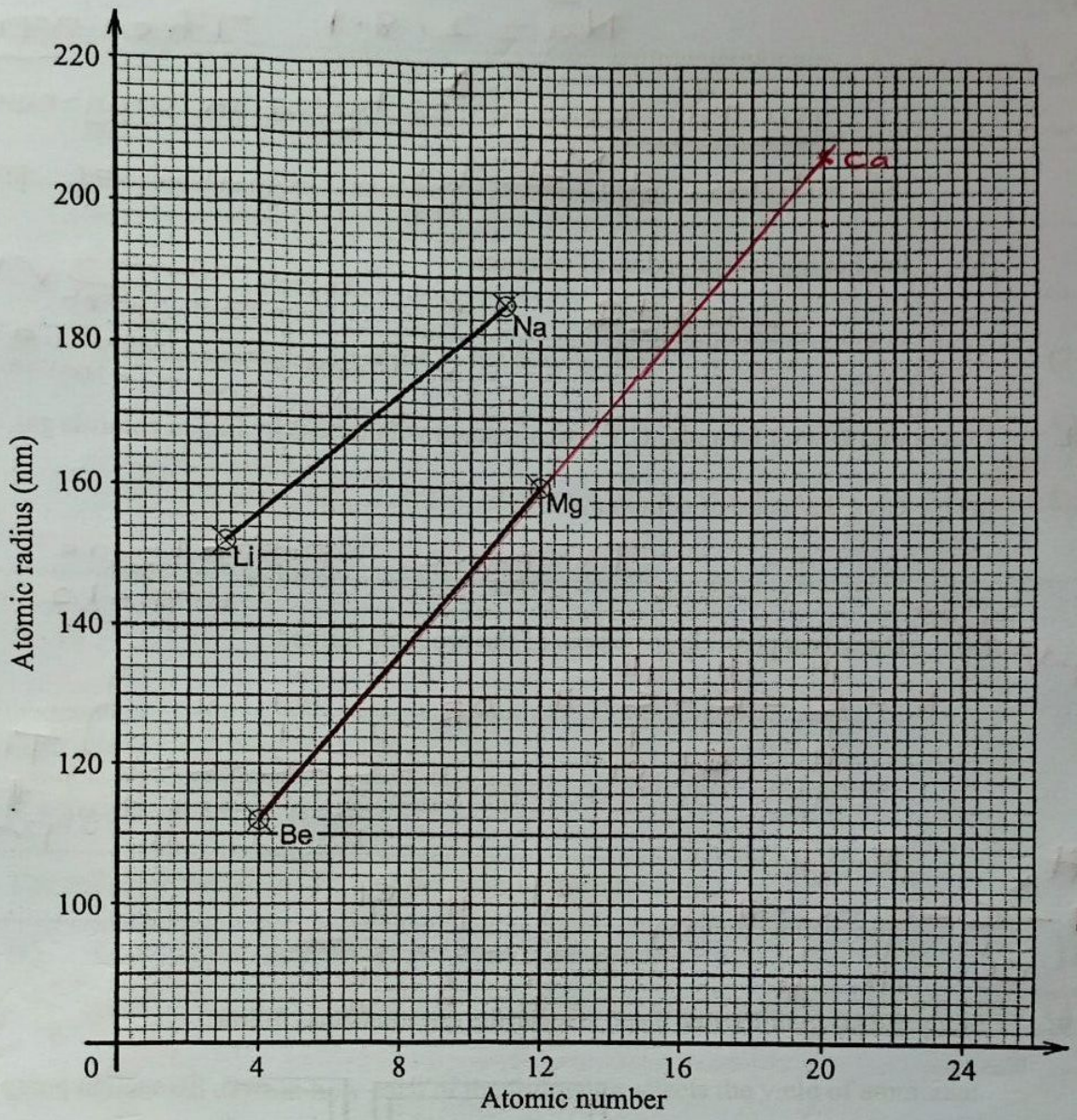


Figure 1

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

(i) lithium. (1 mark)

Na = 2.8.1
Li = 2.1
Sodium has 3 energy levels while Lithium has two ✓1 or Li = 2.1 Na = 2.8.1 ✓½

(ii) magnesium. (1 mark)

Mg = 2.8.2
Na = 2.8.1
The effective nuclear charge ✓1 is higher in magnesium than Sodium. Mg has higher number of protons ✓1

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

208 ± 2, ✓ without showing on the graph ✓1
✓ Extrapolate to 20 on x-ax and mark the value ✓½.

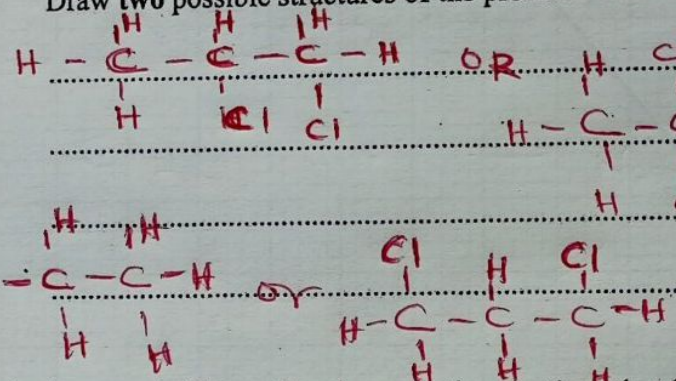
8. Compound **D** with formula, C_3H_4, was reacted with excess hydrogen chloride gas.

(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)

prop-1,2-diene
Tied



Tied to Propyne.

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

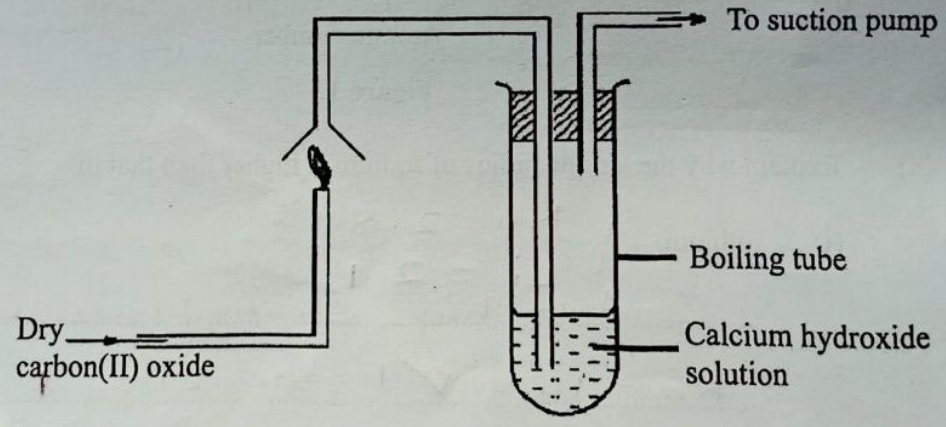


Figure 2

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

The experiment should be carried out in a fume chamber ✓½ / out in open ✓½ Since Carbon (II) oxide is poisonous ✓½

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

A white precipitate ✓1 is formed which dissolves ✓1 to form a colourless solution.

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)

$\frac{-92.4}{2} \Rightarrow -46.2\ kJmol^{-1}$ ✓1

(missing -ve sign penalise ½)

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

(i) Increase in temperature. (1 mark)

It lowers ✓½ the yield of ammonia since the forward reaction is exothermic ✓½, or backward reaction is endothermic.

(ii) Finely divided iron. (1 mark)

No effect ✓½ A catalyst has no effect on the position of the equilibrium ✓½.

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

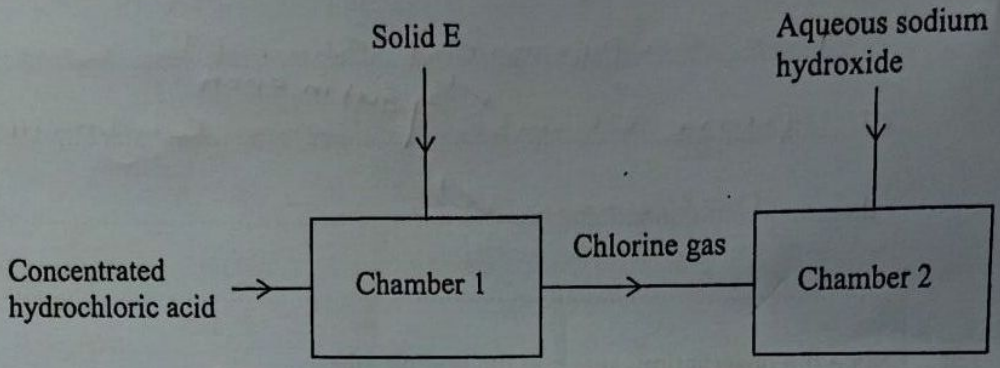


Figure 3

(a) Identify solid **E**. $KMnO_4$ / MnO_4 or PbO_2. (1 mark)

Potassium manganate VII or Manganese (IV) oxide
Lead (IV) oxide

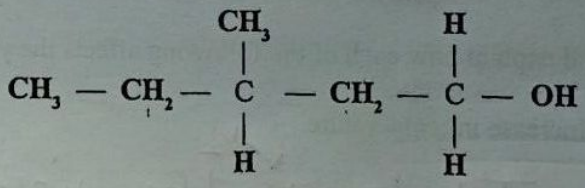
(b) Name the type of reaction that takes place in chamber **1**. (1 mark)

Redox / oxidation

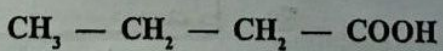
(c) Write an equation for the reaction that takes place in chamber **2**. (1 mark)

$Cl_{2(g)} + 2NaOH \longrightarrow NaCl_{(aq)} + NaOCl_{(aq)} + H_2O$

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



Compound **H**



Compound **J**

(a) Give the names of:

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

3-methylpentanol / 3-methylpentan-1-ol

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

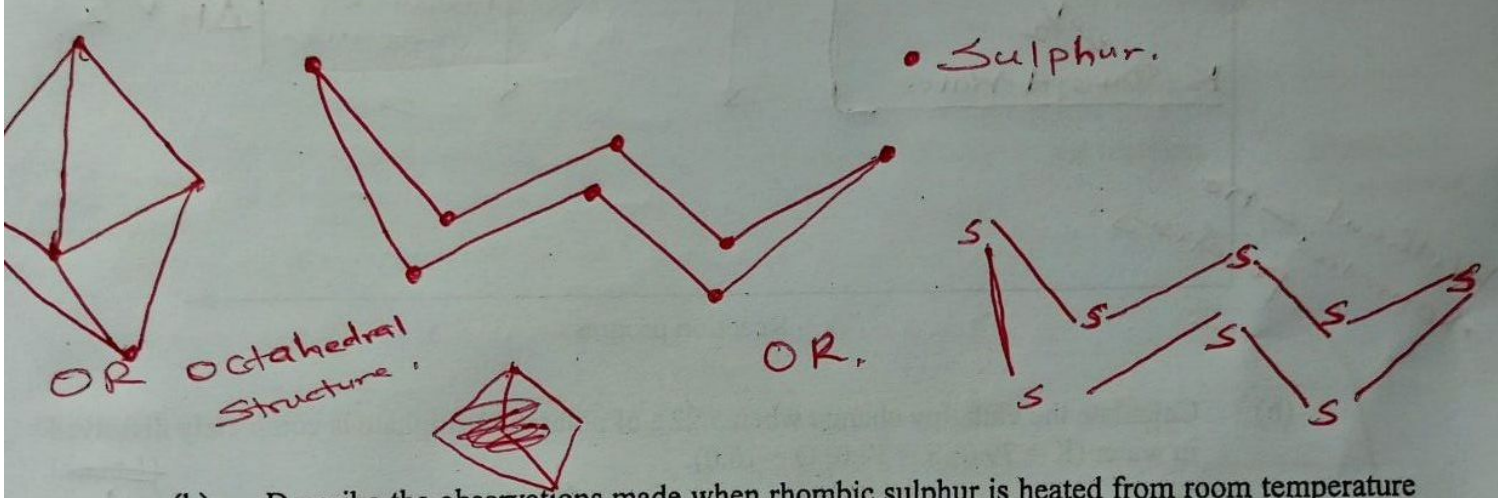
Butanoic acid.

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

- Concentrated Sulphuric VI acid ✓½ | Sulphuric VI acid
- Warm | Heat ✓½ | Temperature between 30-60°c

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 marks)

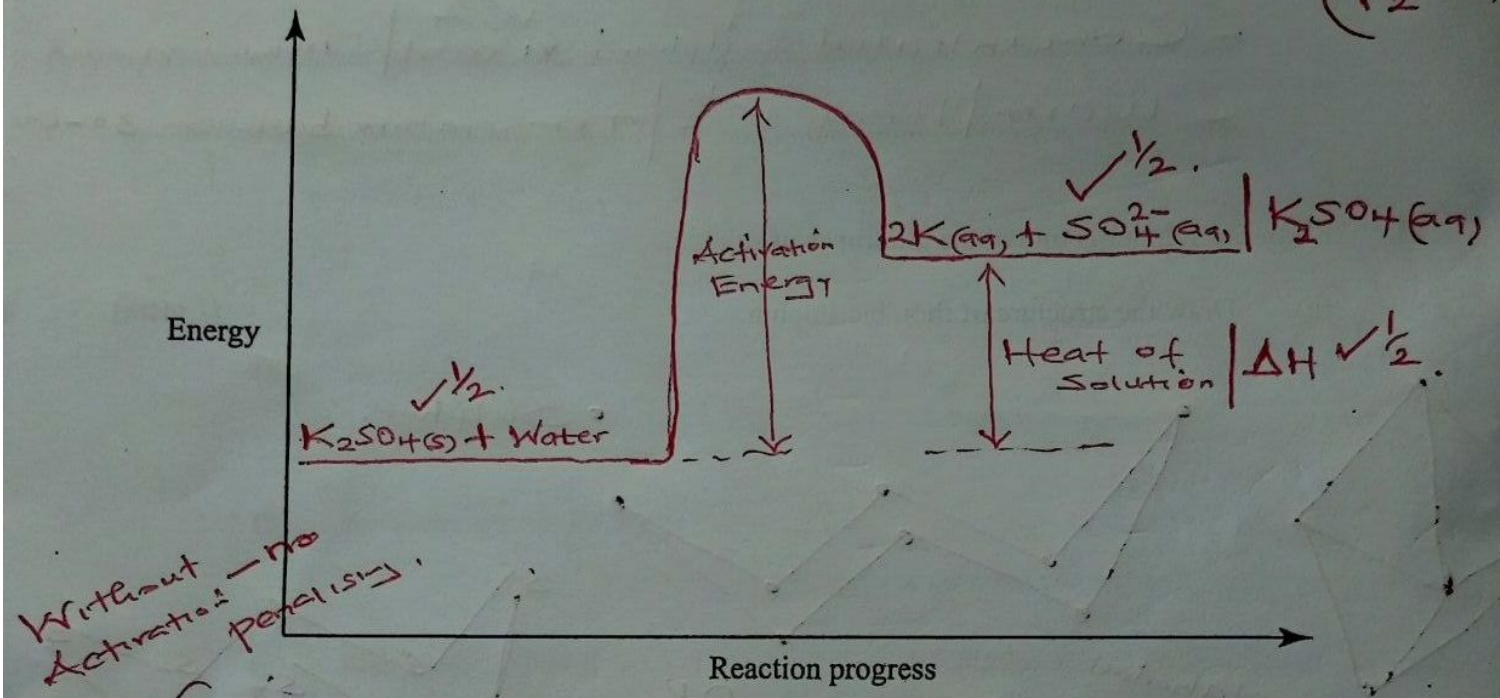
Yellow solid ✓½ forms amber liquid ✓½.

As the temp increases, the liquid becomes darker and viscous ✓½.

Then it turns dark red/brown and less viscous ✓½.

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)~~ (1½ marks)



Without Activation – no penalty.

(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)~~ (1½ marks)

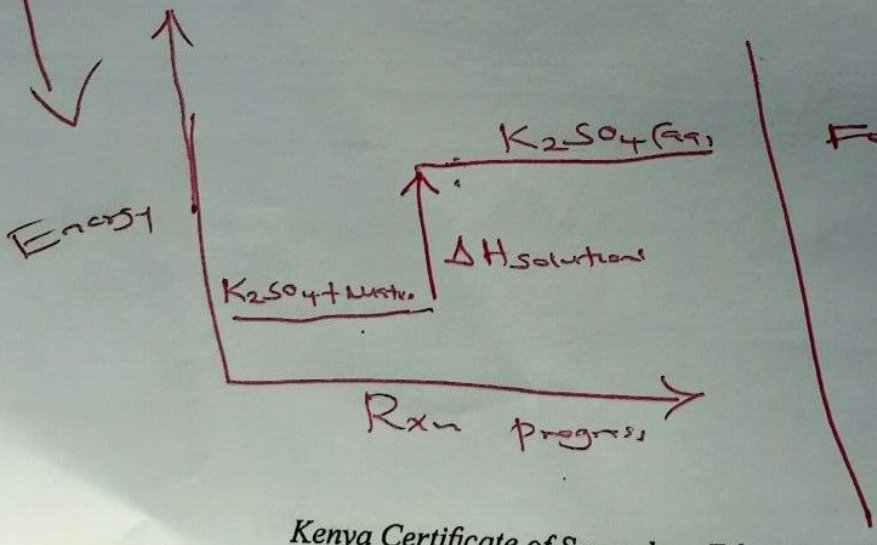
RFM of K_2SO_4 = ~~157~~ 174 ✓½

moles of K_2SO_4 = $\frac{5.22}{174}$ = 0.03 ✓½

$\Delta H = 0.03 \times 23.8 = 0.714\,KJ$ ✓½.

Wrong unit – p

OR



For exothermic rxn – penalise fully.

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

When gases react, they do so in volumes that bear simple ratios to one another and to the products if gaseous at constant temperature and pressure. ✓1

(b) 180 cm³ of nitrogen(II) oxide gas was reacted with 400 cm³ of oxygen gas.

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

$2NO_{(g)} + O_{2(g)} \longrightarrow 2NO_{2(g)}$ ✓1

(ii) Calculate the total volume of the gases at the end of the reaction. ~~(3 marks)~~ 2marks

$2NO + O_2 \longrightarrow 2NO_2$

Using ratio

Volume of oxygen = $\frac{180 \times 1}{2}$ ✓½

= 90 cm³ ✓½

Volume of oxygen unreacted = 400 − 90

= 310 ✓½

Volume of NO_2 = 180 cm³ ✓½

Total volume = 310 + 180 ✓½

= 490 cm³

½

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 m length of magnesium ribbon and a stop watch. (3 marks)

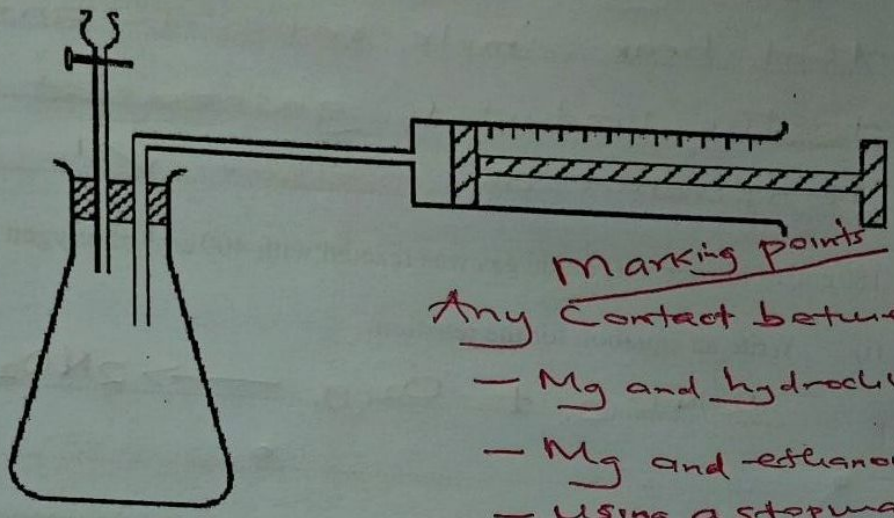


Figure 4

Marking points.

Any Contact between

- Mg and hydrochloric acid ✓½
- Mg and ethanoic acid ✓½
- Using a stopwatch to show the difference ✓1
- Conclusion - HCl takes a shorter time ✓1

- Put a 6cm Mg ribbon in conical flask and add 50cm³ of HCl. Using a stopwatch, record the volume of gases collected at a time interval eg 15 cm³
- Repeat the experiment using 50 cm³ of ethanoic acid
- More/Higher volume of gas will be collected when HCl is used than ethanoic acid at same interval of time

OR

- The reaction will take a shorter time to completion when HCl is used than when ethanoic acid is used.

2023

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 the samples add dil. nitric(V) acid ✓½
— Place wet blue litmus at the mouth of test tubes ✓½
— Both turns red ✓½
— Thereafter one of them is bleached ✓½
— The sample that produces bleaching on the litmus is Sodium Sulphite ✓1

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

✓½ Crush the sunflower seeds using mortar and pestle
— Add propanone ✓½ and stir
— Decant ✓½
— Leave the extract on sunlight for propanone to evaporate leaving oil behind.

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

✓1 It will react with oil to form soap

2023

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)

$C_1V_1 = C_2V_2$.

$0.4 \times 25 = C_2 \times 10$

$C_2 = \frac{0.4 \times 25}{10}$

$= 1M$

Moles of $NaOH = \frac{0.4 \times 25}{1000} = 0.01$

Moles of $HNO_3 = 0.01$

Molarity of $HNO_3 = \frac{0.01 \times 1000}{10} = 1M$

(ii) concentrated acid. (1 mark)

$C_1V_1 = C_2V_2$ ✓1

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

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

Add acid to water ✓1

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

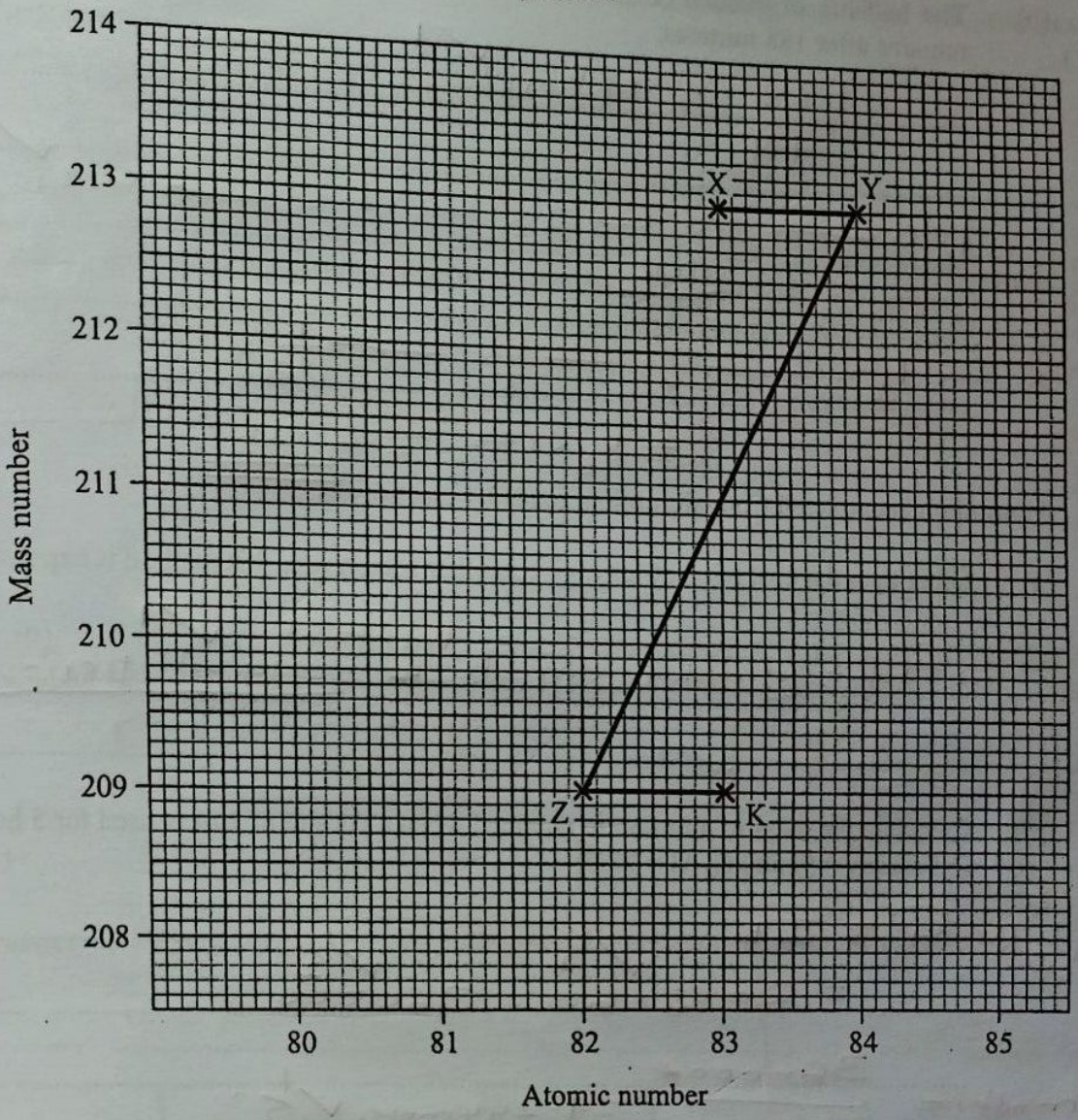


Figure 5

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

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

(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

OR

$X - \frac{1}{2}x - \frac{1}{4}x - \frac{1}{8}x - \frac{1}{16}x$

$\% = \frac{1}{16} \times 100 = 6.25\%$

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 ✓1

(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)

$Al^{3+} + 3e \rightarrow Al$ ✓½

$Q = It$ ✓½

$= 20 \times 5 \times 60 = 360000$

$\text{moles} = \frac{360000}{3 \times 96500} = 1.244 \text{ moles}$ ✓½

$\text{mass} = 1.244 \times 27$

$= 33.588\text{g}$ ✓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

Since copper reacts with Carbon (IV) oxide CO_2. ✓½

(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 of ✓½
tetraamine Copper (II) ions ✓½
OR due to formation of tetraamine copper (II) ions $[Cu(NH_3)_4]^{2+}$ ✓1

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

Is the mass of one atom relative to mass 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)

Let R.Atm of X be n

	C	X
R.Atm	12	n
% mass	3.6	96.4 ✓½
No. of moles	$\frac{3.6}{12}$	$\frac{96.4}{n}$ ✓½
	0.3	$\frac{96.4}{n}$
Ratio	1	4 ✓½

$\frac{96.4}{n} = 4$

$\frac{96.4}{n} = 4 \times 0.3$

$n = \frac{96.4}{1.2}$

$= 80.3$

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)

$H_2C_2O_4 \xrightarrow{H_2SO_4(l)} CO(g) + CO_2(g) + H_2O(l)$ ✓1

State Symbols not must

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

- Methanoic
- Sodium methanoate.

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

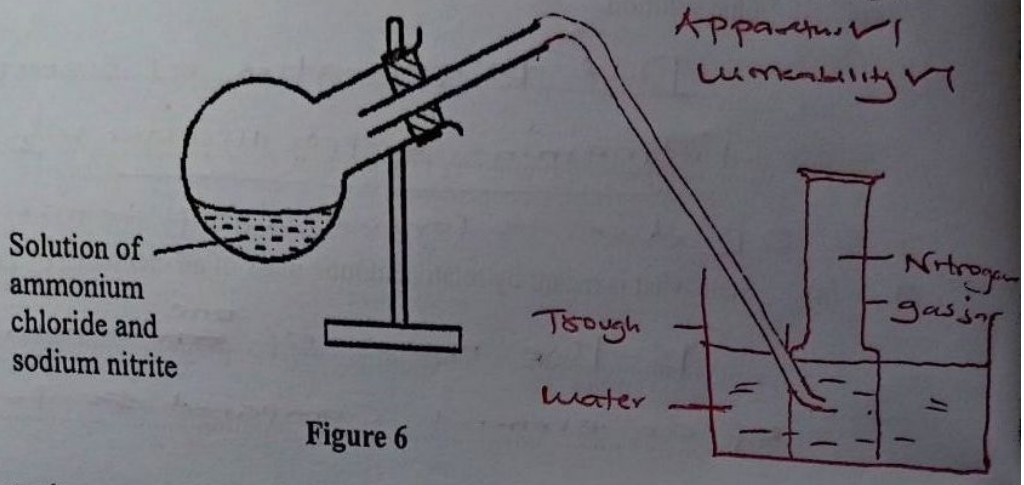


Figure 6

(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)

It has impurities such as noble gases

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

$N_2H_4 + O_2 \longrightarrow N_2 + H_2O$

Bonds broken

$4 \times 388 = 1552$

$1 \times 163 = 163$

$1 \times 496 = 496$

2211 ✓

Bonds formed

$1 \times 944 = 944$

$2 \times 463 = 1852$

-2796 ✓

Enthalpy of combustion $= -2796 + 2211$ ✓

$= -585\ kJ/mol$ ✓

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)

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

$Br_{2(aq)} + 2Cl^- \longrightarrow$ No reaction. Bromine will oxidize iodide ions to iodine since it has more positive E^θ ✓1

Bromine will not displace chlorine since E^θ for Cl^- is more positive ✓1

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

Potassium iodide is a source of iodine. Iodine is needed to regulated functioning of thyroid gland ✓1

THIS IS THE LAST PRINTED PAGE.