THE KENYA NATIONAL EXAMINATIONS COUNCIL
Kenya Certificate of Secondary Education

233/1 **Paper 1**

CHEMISTRY – (Theory)

Dec. 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 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

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

17	18	19	20	21	22	23	24	Grand Total

1. (a) State **one** property that can be used to distinguish between a proton and a neutron. (1 mark)

Charge - Proton has Positive Charge While Neutron has no charge (1) (OR)

Mass - Neutron is slightly heavier than Proton

(b) An ion of element Y has the formula:

$^{40}_{20}Y^{2+}$

(i) Write the electron arrangement of the ion. (1 mark)

2.8.8 OR 2,8,8 (1)

(ii) Identify the group and period in the Periodic Table to which the element belongs.

Group ..... (½ mark)

Period 4 ½ ..... (½ mark)

2. (a) Complete **Table 1** by writing the formula and naming the structure of the chlorides of the elements.

Table 1

Element	Sodium	Magnesium	Silicon	Phosphorus
Formula of chloride	NaCl	$MgCl_2$	$SiCl_4$	PCl_3 / PCl_5
Name of the Structure of chloride	Giant ionic	Giant ionic	Simple Molecular	Simple Molecular

(2 marks)

(b) Select from **Table 1** an acidic chloride and write the equation for its reaction with water. (1 mark)

$PCl_{3(l)} + 3H_2O_{(l)} \rightarrow H_3PO_{3(aq)} + 3HCl_{(aq)}$

OR

$PCl_{5(l)} + 4H_2O_{(l)} \rightarrow H_3PO_{4(aq)} + 5HCl_{(aq)}$

OR

$SiCl_{4(l)} + 2H_2O_{(l)} \rightarrow SiO_{2(s)} + 4HCl_{(aq)}$

3. (a) Write a thermochemical equation for the formation of carbon(II) oxide. (1 mark)

$C_{(s)} + \frac{1}{2}O_{2(g)} \rightarrow CO_{(g)}$; $(\Delta H^\circ f)$ Accept without this ✓0

(b) Use the energy level diagram in **Figure 1** to answer the questions that follow.

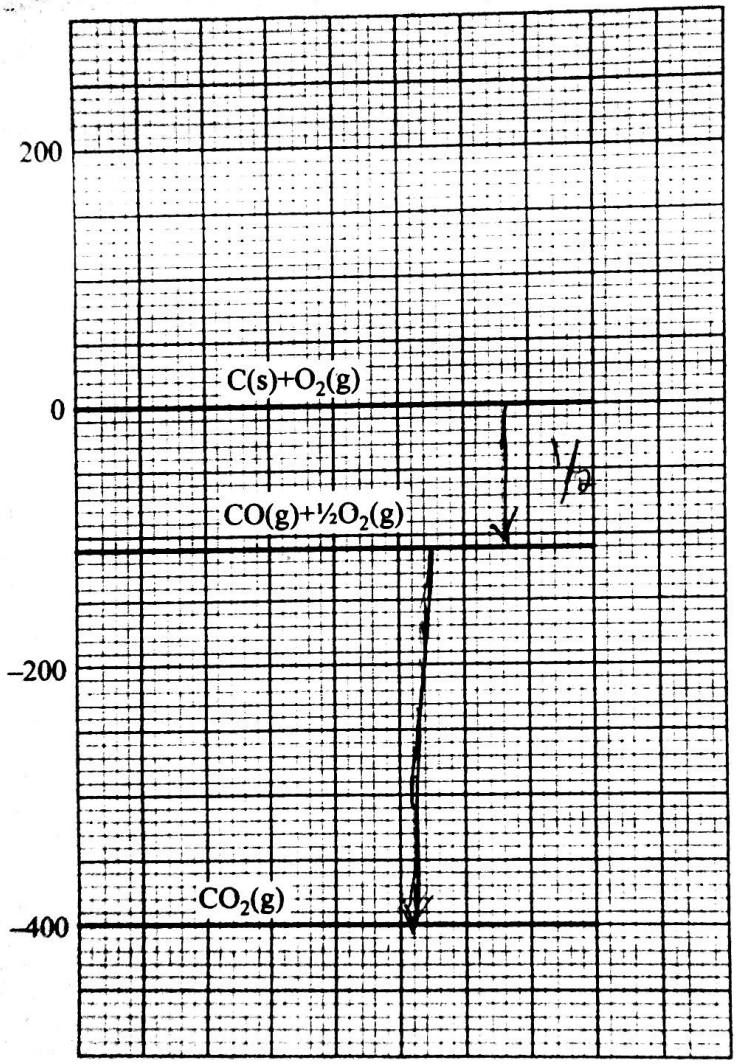

Figure 1

Determine the enthalpy change of:

(i) formation of carbon(II) oxide (1 mark)

$\Delta H^\circ f = -110\ kJ/mol$ ✓ (1mk) — −110 (1mk)

(ii) combustion of carbon(II) oxide (1 mark)

$\Delta H = -400 - (-110) = -290kJ$ — −290 (1mk)

Don't penalise without units

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4. (a) Give a reason why painting or galvanising iron sheets protects them from rusting. (1 mark)

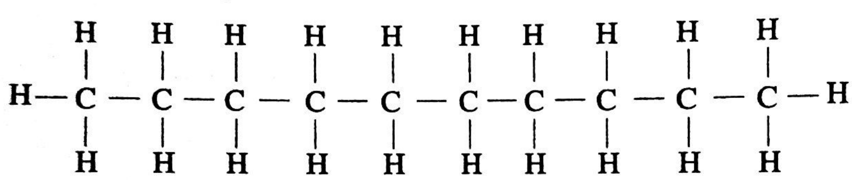
- Both methods provide coatings that keep iron away from oxygen and water (Aspect of keeping off water & oxygen ...)

(b) Explain the advantage of galvanising over painting of iron sheets. (More durable) (2 marks)

- In galvanising, zinc acts as sacrificial (1) metal since it is more reactive than iron thus prevents rusting; In painting rusting will take place if coat is broken (1)

- Galvanising = More durable ✓(1) (Wear or peeling off exposure of metal) - Painting ✓(1)

5. (a) The structure of compound A is:



Give its:

(i) name (1 mark)

Decane ✓(1) ($C_{10}H_{22}$)

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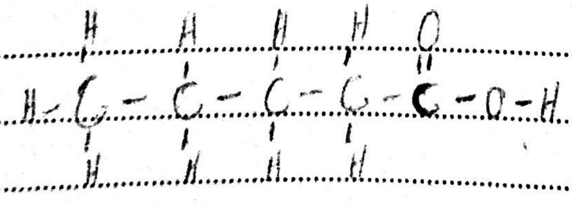
(ii) empirical formula (1 mark)

C_5H_{11} ✓(1)

(b) Draw the structure of an alkanoic acid whose molecular formula is $C_5H_{10}O_2$. (1 mark)



Accept -OH but...

OH

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6. The following equilibrium exists in a closed system.

$$\underset{\text{(Pale yellow)}}{N_2O_4(g)} \rightleftharpoons \underset{\text{(Brown)}}{2\,NO_2(g)}; \quad \Delta H = +27.5\,kJ$$

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State and explain **two** conditions under which the intensity of the brown colour of the equilibrium mixture can be increased. (1½ marks)

Condition I

Increase temperature (½) // The forward reaction is endothermic (½) // Formation of $NO_2(g)$ is favoured by increase in temp. (1)

(1½ marks)

Condition II

Reduction in Pressure (½), Forward reaction proceeds with increase in number of molecules (Volume Increases) (1) of Pressure. Production of $NO_2(g)$ is therefore favoured by low Pressure (1)

7. (a) Determine the oxidation numbers of:

(i) hydrogen in CaH_2 (1 mark)

O.N of CaH_2 = +2 + 2H = 0 (½)

2H = -2

O.No of H = -1 (½) // √(1)

(ii) oxygen in OF_2 (1 mark)

O.No. of OF_2 = O + 2(-1) ½

O = +2 (½)

(b) Write an ionic equation for the reaction between aqueous sodium hydrogen carbonate and ethanoic acid. (1 mark)

$CH_3COOH_{(aq)} + HCO_3^-{}_{(aq)} \rightarrow CH_3COO^-{}_{(aq)} + CO_2 + H_2O_{(l)}$ √(1)

Ionic OR

$H^+_{(aq)} + HCO_3^-{}_{(aq)} \rightarrow CO_{2(g)} + H_2O_{(l)}$ (1)

Ans (a) (i) this

$H^+ + HCO_3^-{}_{(aq)}$

State symbols Penalise (½)

8. The mass of one molecule of a hydrocarbon is 9.33×10^{-23}g.
(Avogadro's number = 6.0×10^{23} mol^{-1}, C = 12.0; H = 1.0)

(a) **Determine its:**

(i) molecular mass (1 mark)

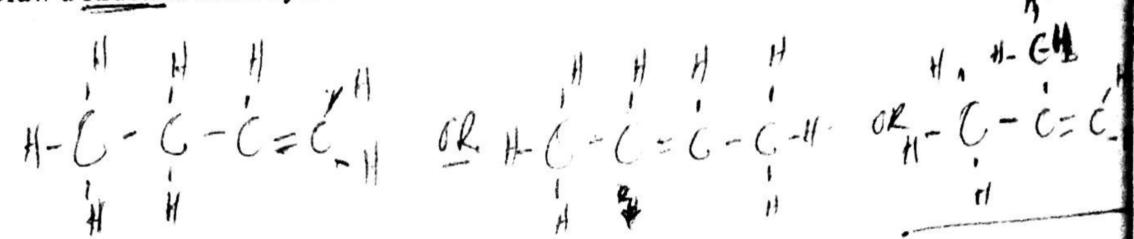
$9.33 \times 10^{-23} \times 6.0 \times 10^{23}$ = 55.98 ✓(½) ✓(½)
≈ 56.5

(ii) molecular formula (1 mark)

C_4H_8 (12)n + (1)n = 56

All bonds must be shown.

(b) Draw a structure of the hydrocarbon in 8(a). (1 mark)



9. (a) Water reacts with hydrogen ions:

(i) write the formula of the product formed (½ mark)

H_3O^+ (½)

(ii) Name the type of bond formed (½ mark)

Dative // Co-ordinate ✓(½)

(b) The melting point of iodine is higher than that of chlorine. Explain. (2 marks)

Iodine has larger Molecular Mass (1) thus stronger Van der Waals forces of attraction than Chlorine which has smaller Mass (1)

Emphasise on — size of molecules — Iodine large (1) — Forces (1)

10. A sample of ammonia gas can be prepared by heating a mixture of ammonium bromide and barium hydroxide.

(a) Write an equation for the reaction. **(1 mark)**

$2NH_4Br_{(s)} + Ba(OH)_{2(s)} \rightarrow BaBr_{2(aq)/(s)} + 2NH_{3(g)} + 2H_2O_{(l)/(g)}$ (1)

(b) State why the gas cannot be dried using anhydrous calcium chloride. **(1 mark)**

Ammonia reacts with Calcium Chloride to form $CaCl_2 \cdot 2NH_3$ which is a Complex Salt (1)

(b) Ammonia reacts with Calcium Chloride to form Complex salt (1) for full Mark: $CaCl_2 \cdot 2NH_3$

(c) Name a suitable drying agent. **(1 mark)**

$CaO_{(s)}$ / Calcium Oxide (1) / Quick lime / Silica gel

11. In an experiment to test for hardness of water from different boreholes, soap solution was added to 1000 cm^3 of water and the volume of soap solution required for lather to start forming recorded. The results are given in **Table 2.**

Table 2

Water sample (1000 cm^3)	Volume of soap solution added (cm^3)	
	Before boiling	After boiling
1	25	3
2	12	8
3	10	10
4	3	3
5	25	24

(a) Select water samples that show:

(i) temporary hardness **(½ mark)**

Sample 1 (½) 2, 5 Wky. High reduction in volume of soap

(ii) no hardness **(½ mark)**

Sample 4 (½) (No reduction of soap volume)

(iii) both temporary and permanent hardness **(½ mark)**

Sample 2 (½) & 5

(b) Describe how water hardness can be removed using an ion exchange resin. (1½ marks)

- Hard water is run (½) into a column containing the ion exchange resin.
- Ca^{2+} and Mg^{2+} (½) ions are exchanged for Na^{+} (½) ion.
- Therefore water coming out is soft.

Accept Diagram well labelled

12. Products of electrolysis at the electrodes for aqueous solutions depend on three factors. Two of these factors are concentration of electrolyte and nature of electrode.

(a) State another factor that affects the products of electrolysis. (1 mark)

- Position of the ion/element in the reactivity series. (1)

(b) Complete **Table 3** to show products of electrolysis for dilute calcium chloride and concentrated calcium chloride at the anode and cathode.

Table 3

Electrolyte	Anode	Cathode
Dilute calcium chloride	Water / Oxygen √(½)	Hydrogen √(½)
Concentrated calcium chloride	Chloride (½)	Hydrogen √(½)

(2 marks)

13. (a) Carbon exhibits different boiling points. Explain. (1 mark)

Carbon exist in different (½) Crystalline forms
Some Physical state hence different boiling Point because of their different structures (½).

Carbon exist in different forms Allotropes As diamond & graphite. (1)

(b) It takes 44 seconds for nitrogen(IV) oxide gas to effuse through an opening. Calculate how long it will take for an equal volume of chlorine gas to effuse through the same opening (N = 14.0; O = 16.0; Cl = 35.5). (2 marks)

Time of effusion of Cl_2 / Time of effusion of NO_2 = Rmm of Cl_2 / Rmm of NO_2

Time of diffusion of Cl_2 = $44 \times \sqrt{\frac{\text{Rmm of } Cl_2}{\text{Rmm of } NO_2}}$

Rmm (NO_2) = 46 (½)

Rmm (Cl_2) = 71 (½)

Time taken by (NO_2) 44 sec

Time taken by (Cl_2) = $44 \times \sqrt{\frac{71}{46}} = 54.66$.

- Molar mass 46 (½)
- " 17 (½)
- Substitution 44 √ (½)
- Answer (½).

Implication - Applied Knowledge (½). once

14. (a) Give an example of a natural polymer made of:

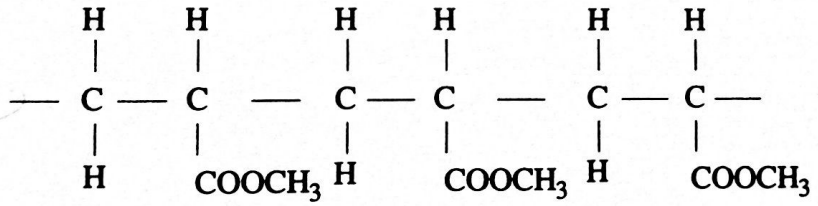
(i) cellulose material (½ mark)

- Cotton (½) Sisal, Wood, Paper, Cotton wool;

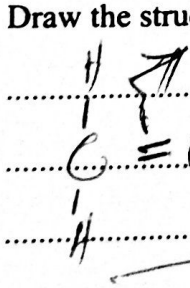
(ii) a hydrocarbon (½ mark)

- Rubber (½) // Latex

(b) Part of the structure of perspex is:



(i) Draw the structure of the monomer of perspex. (1 mark)



Must be there to award

(ii) Give **two** properties of perspex that make it suitable for use in making lenses. (1 mark)

- Transparent (½)
- Strong (½) // Hard.
- Free from Change of Refractive index
- Constant in refractive index

15. **Two allotropes of carbon are graphite and diamond.**

(a) Explain why the density of diamond is higher than that of graphite. (1 mark)

Diamond has tetrahedral structure with all atoms forming four Covalent bonds while in the graphite each atom form three Covalent bonds in a (1) Layer structure which give for them each other. The layers are held together by Van [illegible]

(b) Give **one** use of each of the allotropes and relate the use to properties of the allotrope.

I. Graphite

use - Lubricant (½) // Pencil tips (½ mark)

- Electrode

property - Soft and Slippery (½) (½ mark)

- Conduct of electricity // Delocalize electrons

II. Diamond

use - Tips of drilling tips (½) // Drilling pits (½ mark)

- Jewel // ornament

property - Hard and abrasive (½) // Cutting instrument (½ mark)

- shiny // lustre

16. (a) The graph in **Figure 2** shows radioactive decay curve of a radioactive isotope.

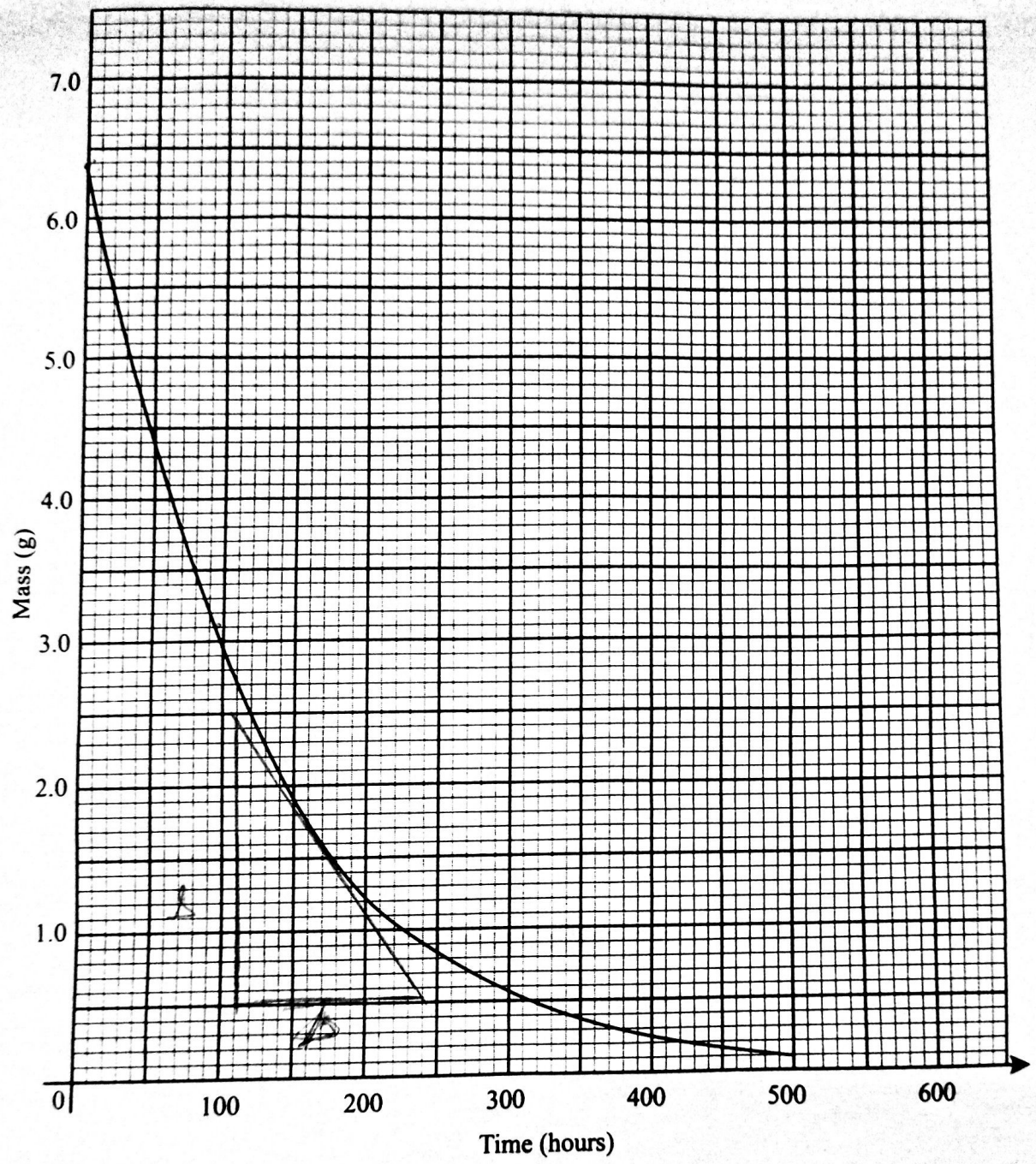


Figure 2

Use the graph to determine the:

(i) half life of the radioactive isotope (1 mark)

Half-life = 85 hours

(8.5 – 9 ohrs) Any Value

(ii) rate of decay at time 150 hours (1 mark)

$\frac{3.0-0.5}{80-240}$ (½) $= \frac{2.5}{-160} = -0.0156$ g/hr (½) (Note -Ve sign)

(0.014 - 0.018) Range. Ignore

0.016 ± 0.002

(b) The half life of two radioactive isotopes A and B are 8 days and 5.2 years respectively. Given that both of them emit beta radiation, explain why A would be more suitable in the treatment of a disease. (1 mark)

A has a shorter half-life than B (½) it will clear from the body faster thus not expose the patient to radiation for a long time (½) (Curing faster ✗)

17. The formula of a hydrated salt of manganese is $MnSO_4 \cdot XH_2O$. Given that the salt contains 24.7% manganese, determine the value of X. (Mn = 55.0; S = 32.0; O = 16.0; H = 1.0) (3 marks)

Sulphur
25 → 24.7
32 → x (½)
$x = 14.4\%$ (½)
then % of O_2
55 → 24.7
64 → ? (½)
$O = 28.9\%$
then % of H_2O
32.2% (½)

$\frac{55}{RFm} \times 100 = 24.7$ (½)
$RFm = \frac{55}{24.7} \times 100$ Imply
$RFm = 222.7$ (½)
RFm of $MnSO_4 = 151$ (1)
$\therefore 151 + 18x = 222.7$ (½)
$18x = 71.7$
$x = 3.98 \approx 4$ (½)

55 → 24.7
151 → ? (1)
$\frac{151 \times 24.7}{55} = 67.8\%$ (½)

Moles $= \frac{67.8}{151}$ (½)
0.449 $MnSO_4$ 1.788 H_2O
32
Mole ratio
$= 4$ (½)

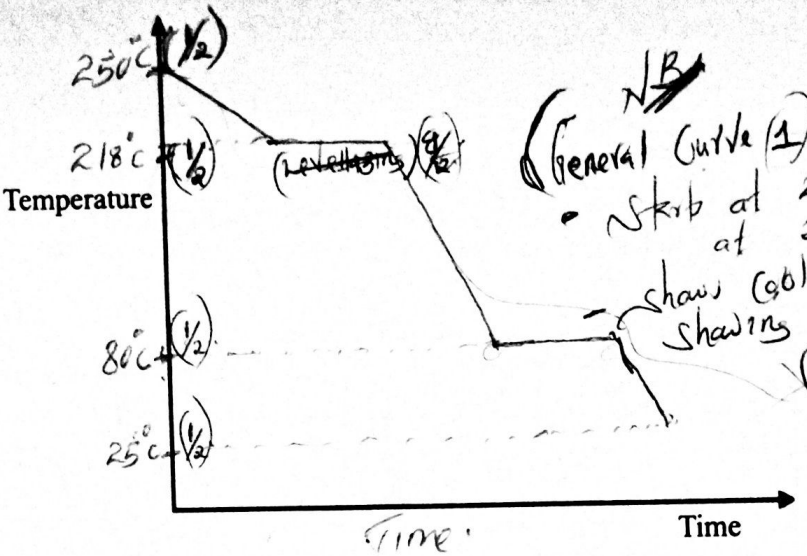
18. Describe the correct procedure of heating a liquid in a test tube using a Bunsen burner. (3 marks)

- Hold the test tube with a test tube holder (½) Keep it slanting (1) tilt/sideways (½) with mouth facing away (½) Other direction heat from top (½) downward and not from bottom to the top while rotating (½) (Rotate)
- Remove/withdraw from flame occasionally

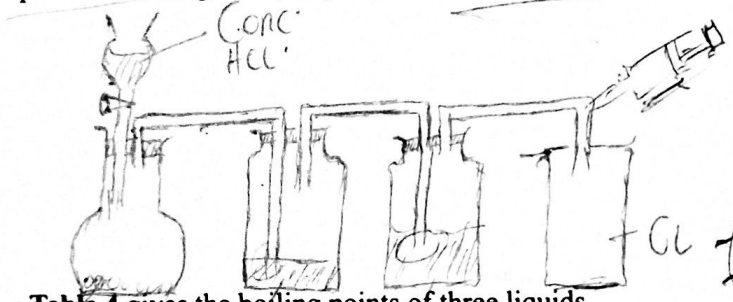
- Test tube holder (½)
- slanting (1)
- face Away (½)
- Heat (½)
- Rotate / Remove (½)

Marking Point

19. The melting and boiling points of naphthalene are 80 °C and 218 °C, respectively. A sample of naphthalene was cooled from 250 °C to 25 °C. On the axes provided, sketch and label the cooling curve that would be obtained. (3 marks)



20. Draw a labelled diagram of a setup that can be used to prepare a dry sample of chlorine gas using potassium manganate(VII) and concentrated hydrochloric acid. (3 marks)



21. Table 4 gives the boiling points of three liquids.

Table 4

Liquid	Boiling point (°C)
Hexane	68.7
Butanol	99.5
Water	100.0

Describe how the following mixtures can be separated:

(a) hexane and butanol (1½ marks)

- Fractional distillation
Put the two liquids in fractionating column; Heat the mixture gently; hexane will distill at 68.7° leaving butanol as residue.

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(b) **hexane and water** (1½ marks)

Drawing - Separating funnel (½) // Burette // Beaker // Dropper // Boat Pipette
Labelling
These are two layers immiscible liquids; hexane will float on water from the bottom of flask. Hexane remains in the funnel. 1½

22. Complete **Table 5** by writing the observations made when aqueous ammonia and aqueous sodium sulphate are added to solutions containing calcium, aluminium and iron(II) ions.

Table 5

Ions present	Aqueous ammonia	Aqueous sodium sulphate
Ca^{2+}	No white ppt insoluble in excess (½)	White ppt (½)
Al^{3+}	White ppt insoluble in excess (½)	No white ppt (½)
Fe^{2+}	Green ppt (½)	No green ppt (½)

(3 marks)

23. (a) Iron is extracted from haematite ore. If the ore contains oxides of silicon and aluminium, explain how these impurities are removed. (2 marks)

They react with Calcium oxide (1) to form $CaSiO_3$ (½) and $CaAl_2O_4$ (½) which are removed as slag.

Words
- Accept Equation - Equation Accept with ⊕ (1)
- Must be Correct (formula)
- Word equation

(b) The extraction process of iron produces waste gases. State how these waste gases can be used to lower the operational cost of the extraction process. (1 mark)

- The waste gases are at high temp. The heat can be recycle (½) to pre-heat incoming air (½)
- CO - reusing the gas (increase reaction)
= - recycling the heat

(Carbon (II) oxide)
(comment)

24. When chlorine is bubbled into a sample of water, the solution smells strongly of chlorine. If aqueous sodium hydroxide is added to the solution, the smell of chlorine disappears:

The following equation shows the reaction that occurs.

$$Cl_2(g) + H_2O(l) \rightleftharpoons HCl(aq) + HOCl(aq)$$

Partial reaction (½) Presence of Chlorine (½) // Equilibrium on left.

With reference to the equation for the reaction, explain why the:

(a) solution smells strongly of chlorine **(1 mark)**

- Chlorine reacts Partially with Water. There is a strong smell due to (i) presence of chlorine Molecules ✓½ equilibrium lies on the left.

(b) addition of sodium hydroxide removes the smell **(2 marks)**

NaOH Neutralizes/reacts two Acids (1)
- Chlorine Consume/Equilibrium (1).
- Addition of NaOH neutralize (1) HCl(aq) and HOCl(aq); equilibrium shifts to the right; Chlorine Molecules are Consume (1) hence the smell disappears.

25. **Figure 3** shows how nitric(V) acid can be obtained.

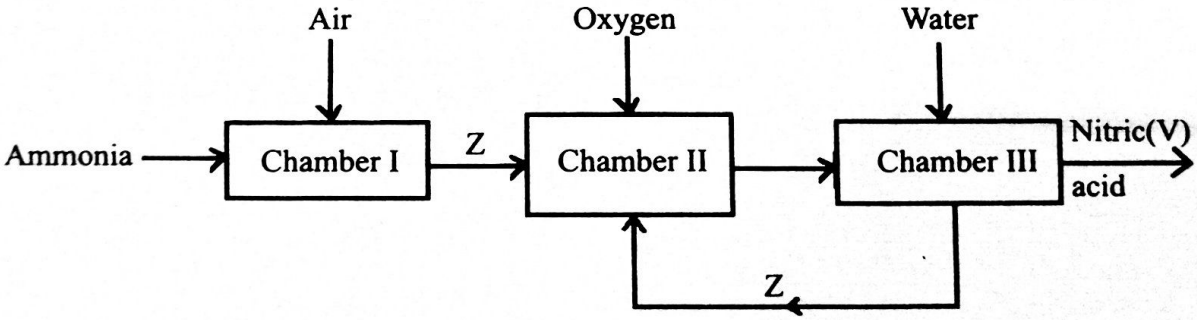

Figure 3

(a) Identify the chamber in which a catalyst is used. **(1 mark)**

Chamber (1) ✓(1)

(b) Name substance Z. **(1 mark)**

Nitrogen (II) Oxide (NO) (1) formula Must be correct (commandment)

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

$3NO_{2(g)} + H_2O_{(l)} \rightarrow 2HNO_{3(aq)}$

$2NO_2 + H_2O_{(l)} \rightarrow HNO_{2(aq)} + HNO_{3(aq)}$

~~HNO~~ $_{2(g)}$ due ~~to Z~~ of final Nitric Acid.

26. The formula of the complex ion formed when aqueous zinc sulphate reacts with aqueous sodium hydroxide is given as:

$[Zn(OH)_4]^x$

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Explain how the value of **x** is determined. (2 marks)

Oxidation state of Zinc is +2 (½) - Getting oxidation of Zn (½)
OH⁻ has a Charge of -1 (½) - Getting of OH⁻ (½)
∴ +2 + (-1 × 4) = X (½) - Equate to X multiply by 4 (½)
⇒ X = -2 (½) - sum up to get X for (½)

27. Copper can be obtained from copper(II) oxide using carbon(II) oxide or coke.

(a) Name another reagent that can be used to obtain copper from copper(II) oxide. (1 mark)

Hydrogen gas (1) // Ammonia // Methane // Natural gas

(b) The equation for the reaction with carbon(II) oxide is:

$$CuO(s) + CO(g) \rightarrow Cu(s) + CO_2(g)$$

Calculate the maximum mass of copper that would be obtained using 200 dm³ of carbon(II) oxide (Cu = 63.5; Molar volume of gas = 24.0 dm³). (2 marks)

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CuO(s) + CO(g) → Cu(s) + CO₂(g) ×Moles of Cu = Moles
×Moles CO = ×Moles Cu = 200dm³ / 24 dm³ (1)
×Mass Cu = 200/24 × 63.5 = 529.2 (✓½) (✓½)
Implication = Moles of CO₂ = CO (½) = 200 dm³ ✓½ / 24
From ×ide Alene 200 dm³ / 24 = (1)
Implication = 8.3333 × 63.5
529.16 ✓
(528.95 → 529.2) Range of Answer.
(8.3 × 63.5) 527.05

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