Candidate's Name: ...JOSEPH JOBS KAYIIRA...

Signature: ...KSM...

Random No.	Personal No.
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(Do not write your School /Centre Name or Number anywhere on this booklet.)

545/2
CHEMISTRY
Paper 2
Oct. /Nov. 2023
2 hours

UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Certificate of Education

CHEMISTRY

Paper 2

2 hours

INSTRUCTIONS TO CANDIDATES:

Section **A** *consists of 10,structured questions. Answer* **all** *the questions in this section.*

Answers to these questions **must** *be written in the spaces provided.*

Section **B** *consists of 4 semi-structured questions. Answer any* **two** *questions from this section. Answers to the questions* **must** *be written in the answer booklet(s) provided.*

In both sections, all working **must** *be clearly shown and* **must** *be in* **blue** *or* **black** ink.

Any work done in pencil, **except** *drawings will* **not** *be marked.*

Mathematical tables and silent non-programmable scientific calculators may be used.

Where necessary use;

[H =1; C = 12; O = 16; Pb =207]

1 mole of gas occupies 24 l at room temperature.

1 mole of gas occupies 22.4 l at s.t.p.

For Examiners' Use Only														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
6	5	4½	5	5	5	5	5	4½	5	15	15	15	15	100

Turn Over

SECTION A (50 MARKS)

Answer **all** *questions in this section.*

1. (a) (i) Name the **three** fundamental particles of an atom. *(1½ marks)*

Protons ✓+ ½ Accept only names
Electrons ✓+ ½
Neutrons ✓+ ½ Emphasize spellings.

(ii) Draw a labelled diagram to show the location of the particles you have named in (a)(i) in a typical atom. *(2½ marks)*

- Emphasize electrons if more than one is labelled
- Reject unlabelled diagram.
- Reject wrong spellings.

(b) The atomic numbers of elements **Y** and **Z** are 15 and 17 respectively. Write the;

(i) electronic configuration of **Y** and **Z**. *(01 mark)*

Y – 2:8:5 ✓+ Accept 2)8)5 or 2,8,5
reject 2;8;5 or 2.8.5
Z – 2:8:7 ✓+

(ii) formula of **one** possible compound that can be formed when **Y** reacts with **Z**. *(01 mark)*

Deny mark if correct answer not underlined YZ_3 ✓ Accept YZ_5 or Z_3Y or Z_5Y.

2. (a) Name;

(i) the alloy of magnesium, which is used for making parts of an aircraft. *(01 mark)*

Duralumin ✓ reject wrong spelling eg Dura lumin
Accept Magnalum reject Aluminium bronze

(ii) **one** other element with which magnesium is combined to make the alloy you have named in (a) (i). *(½ mark)*

Aluminium ✓+ Accept Copper, Manganese for Duralumin
reject formulae of elements.
for both Duralumin and Magnalum. – ½ for @ extra wrong

(b) State **one** property of magnesium, which is the reason for its use in the alloy you have named in (a)(i). (½ mark)

Magnesium is light ✓+ ½ for @ extra wrong.

Accept low density, toughness. ½ for @ extra wrong

(c) (i) State **one** use of steel. (½ mark) Accept any one

Making nails, screws, car bodies, railway lines, ships, bridges, steel rods, girders, cutting tools, rock drills, permanent magnets, wire mesh.

(ii) Give **two** reasons why steel is used more widely than pure iron. (01mark)

Steel is hard, tough and strong

Accept any two.

-½ for @ extra wrong.

(d) State;

(i) the constituents of brass. (01 mark)

Copper and Zinc Accept Cu or Zn reject wrong symbol

(ii) **one** use of brass. (½ mark)

Making nuts, screws, bolts, tubes, rods or ornaments. Accept any one ½ for @ extra wrong

3. Weighed samples of copper(II) nitrate, sodium carbonate and magnesium ribbon were separately heated until there was no further change. On cooling, each sample was reweighed.

(a) State which of the substances showed; Accept formula

(i) increase in mass. (½ mark)

Magnesium

(ii) decrease in mass. (½ mark)

Copper (II) nitrate Accept (ii) or (II)

(iii) no change in mass. (½ mark)

Sodium carbonate.

(b) Lead(II) carbonate when heated, decomposes according to the following equation.

$$PbCO_3(s) \longrightarrow PbO(s) + CO_2(g)$$

Calculate the change in mass that would occur when 3.3 g of lead(II) carbonate was heated. (03 marks)

1 mole of $PbCO_3$ forms 1 mole of CO_2. ✓ mole ratio

1 × (207 + 12 + 48) g of $PbCO_3$ forms (12 + (16×2)) g of CO_2 ✓✓

267 g of $PbCO_3$ forms 44 g of CO_2.

3.3 g of $PbCO_3$ forms $\left(\frac{3.3 \times 44}{267}\right)$ g of CO_2 ✓

$= 0.5438$ g.

Change in mass is 0.5438 g ✓

ACCEPT LOGICAL ALTERNATIVE(S) (3)

4. Copper(II) sulphate was electrolysed using weighed copper electrodes. After the electrolysis, the electrodes were dried and reweighed.

(a) State how the mass of each of the following electrodes would change;

(i) anode. (½ mark)

Mass decreases ✓ Accept alternative correct answers

(ii) cathode. (½ mark)

Mass increases ✓

(b) Give reasons for your answers in (a)(i) and (ii). (01 mark)

The anode dissolves ✓ and copper is deposited ✓ at the cathode. 01

(c) Write an equation to show the reaction that took place at the;

(i) anode. (01 mark)

Accept $Cu(s) - 2e \rightarrow Cu^{2+}(aq)$

$Cu(s) \rightarrow Cu^{2+}(aq) + 2e$ ✓ ①

reject wrong symbols

(ii) cathode. (01 mark)

Accept $Cu^{2+}(aq) \rightarrow Cu(s) - 2e$

$Cu^{2+}(aq) + 2e \rightarrow Cu(s)$ ✓ ① — ½ for wrong state symbol

(d) State **one** practical application of the electrolysis. (01 mark)

Electroplating / Extraction of aluminium or sodium etc / Manufacture of sodium hydroxide / chlorine, etc. Accept any one.

5. (a) Ethanol burns completely in air according to the following equation.

$$C_2H_5OH_{(l)} + 3O_{2(g)} \longrightarrow 2CO_{2\,(g)} + 3H_2O_{(l)} + Heat$$

(i) From the equation, state why ethanol is used as a fuel. (01 mark)

The reaction produces/ evolves/ gives out heat / is exothermic. ①

(ii) State **one** other use of ethanol. (01 mark)

As a solvent, making perfumes / flavours, varnishe drugs etc. reject as a fuel. ①

(b) When 0.6 g of a hydrocarbon **X** was burnt in excess air, the heat evolved raised the temperature of 200 g of water from 25.5 °C to 60.9 °C.

Calculate the heat of combustion of **X**. (The specific heat capacity of water = $4.2 Jg^{-1} °C^{-1}$; The formula mass of **X** = 58) (03 marks)

Heat evolved = $200 \times 4.2 (60.9 - 25.5)$ ✓ Temp. rise ✓

$= 29,736$ Joules. ✓

0.6g of X evolve 29736 J. ✓

58g of X evolve $\left(\frac{58 \times 29736}{0.6}\right)$ ✓

$= 2,874,480 J$ ✓ ③

$\Delta H_{combustion} = -2,874,480 Jmol^{-1}$ ✓

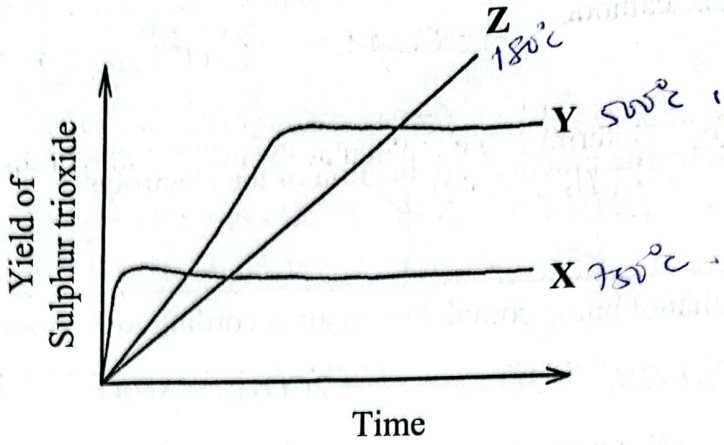
Accept $-2874.48 kJmol^{-1}$

reject $KJmol^{-1}$.

.267 — 223. emphasize units

3.7 — emphasize (−) sign.

6. (a) The reaction between sulphur dioxide and oxygen to produce sulphur trioxide is exothermic. The curves in the diagram below show the effects of different temperatures on the yield of sulphur trioxide.



Identify the curve which represents the reaction at;

(i) 500 °C..... Y ✓ 1 ..... (01 mark)

(ii) 180 °C..... Z ✓ 1 ..... (01 mark)

(iii) 750 °C..... X ✓ 1 ..... (01 mark)

(b) State;

(i) **two** factors, other than temperature, which favour the yield of sulphur trioxide in the contact process during the manufacture of sulphuric acid. (01 mark)

Pressure ✓ and catalyst ✓ Accept concentration of reactants or one of them

(ii) **one** commercial use of sulphuric acid. (01 mark)

Any one except fertilisers) Manufacture of ~~sulphu~~ ammonium sulphate / super phosphate fertilizers, paints dyes and pigments / plastics / detergents / explosives / extraction of metals ✓

7. (a) The anhydrous form of a compound **Q**, of molecular formula $C_wH_xO_y.nH_2O$ consisted of carbon 26.7%, hydrogen 2.2% and oxygen 71.1%. When gently heated, 3.15 g of **Q** gave 2.25 g of its anhydrous form.

(i) Calculate the empirical formula of anhydrous form of **Q**.

(02 marks)

Elements	C	H	O
moles	$\frac{26.7}{12}$	$\frac{2.2}{1}$	$\frac{71.1}{16}$ ✓

Simplest mole ratio $\frac{2.225}{2.2}$ $\frac{2.2}{2.2}$ $\frac{4.44375}{2.2}$ ✓+

1 2 2 ✓+

Empirical formula is CHO_2 ✓ (2)

(ii) Determine the molecular formula of anhydrous form of **Q**. (*01 mark*)

($C_wH_xO_y = 90$)

$(CHO_2)n = 90$ ✓+

$(12+1+32)n = 90$ ✓

$45n = 90$

$n = 2$.

Molecular formula is

$C_2H_2O_4$ ✓+ (1)

(iii) Calculate the number of moles of water of crystallisation, ***n***, in a hydrated form of **Q**. (*02 marks*)

Mass of $H_2O = 3.15 - 2.25 = 0.9g$ ✓+

compounds	$C_2H_2O_4$	:	H_2O	1 : 2
moles	$\frac{2.25}{90}$		$\frac{0.9}{18}$ ✓+	
mole ratio	$\frac{0.025}{0.025}$		$\frac{0.05}{0.025}$ ✓+	$n = 2$ ✓+ (2)

8 (a) State what is observed when zinc carbonate is strongly heated and then

[Annul 3/4] ✓ reject equation

Award accordingly

2.25g of $C_2H_2O_4$ are collected when 3.15g are heated.

90g of $C_2H_2O_4$ are collected when $\left(\frac{90 \times 3.15}{2.25}\right)$ heated $= 126g$.

Turn Over

$C_2H_2O_4 \cdot nH_2O = 126$ | $n = 2$.

$90 + 18n = 126$

$18n = 36$

Alternatively; Award accordingly.

Compounds	$C_2H_2O_4 \cdot nH_2O$	$C_2H_2O_4$
moles	$\frac{3.15}{90+18n}$	$\frac{2.25}{90}$

$\therefore \frac{3.15}{90+18n} = \frac{2.25}{90}$

$2.25(90+18n) = 90 \times 3.15$

$90 + 18n = 126$

$18n = 36$

$n = 2$

0:02½ 0:02½

8. (a) State what is observed when zinc carbonate is strongly heated and then allowed to cool. *(1½ marks)*

White solid/powder turned yellow when hot and white on cooling ✓ ½

(b) When dilute ammonia solution was added to zinc sulphate solution, a white precipitate which dissolved in excess ammonia was formed. Write;

(i) an equation leading to the formation of the white precipitate. *(1½ marks)*

$Zn^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Zn(OH)_{2(s)}$ ✓✓ ½

Accept molecular eqn.

(ii) the formula of the substance formed when ammonia was added in excess. *(01 mark)*

$[Zn(NH_3)_4]^{2+}$ ✓

reject equation

Award accordingly

alternatively;

3.15g are heated.

(c) State what is observed if sodium hydrogencarbonate solution is added to zinc sulphate solution. *(01 mark)*

Colourless solution ✓ formed a white precipitate ✓ (1)

9. Polymers can be classified as synthetic or natural.

(a) State what is meant by the term **polymer**. *(01 mark)*

A large molecule formed by combination of two or more molecules of the same kind or different types ~~mats~~ (1)

(b) Give **one** example of a;

(i) synthetic polymer. *(½ mark)* Any one ½ for @ extra wrong

Nylon ✓, Perspex, Terylene, Polyethene, Polystyrene, ~~Natural rubber~~ Synthetic rubber, etc

(ii) natural polymer. *(½ mark)* Any one

Silk ✓, Cotton, Jute, Proteins, Cellulose, Starch, Lipids, Natural rubber, etc

(c) The structure of a certain polymer is shown below.

$$-(CH_2 - CH_2)_n-$$

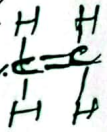
Write the;

(i) name of the polymer. (½ mark)

Polyethene / Polythene / Poly(ethene) / Polyethylene

Accept any one

(ii) structural formula of the monomer. (01 mark)

$H_2C=CH_2$ Accept $H-C\equiv C-H$ reject C_2H_4 or $CH_2=CH_2$ or 

(d) State **one** disadvantage of the polymer you have named in (c)(i). (01 mark)

Non-biodegradable hence pollutes the environment ✓ (1)

10. (a) Nitric acid can be prepared by reacting potassium nitrate with concentrated sulphuric acid. Write an equation for the reaction leading to the formation of nitric acid. (1½ marks)

$KNO_{3(s)} + H_2SO_{4(l)} \longrightarrow KHSO_{4(l/s)} + HNO_{3(g/l)}$

reject (aq) reject (aq) reject ⇌

(b) State what would be observed if nitric acid was heated. (½ mark)

Brown fumes ½

(c) (i) Name the reagent(s) which can be used to distinguish between dilute solutions of nitric and hydrochloric acids. (01 mark)

Lead(II) nitrate solution

reject if word acidified added

ignore followed by nitric acid

accept with warming/heating

reject silver nitrate

emphasize solution

reject formula

(ii) State what would be observed if the acids were treated separately with the reagent(s) you have named in (c) (i). (01 mark)

Nitric acid – NO observable change

Hydrochloric acid – white precipitate (1)

(d) State **one** industrial use of nitric acid. (01 mark) (1)

Manufacture of explosives, nitrate fertilizer

Accept any other correct

SECTION B (30 MARKS)

Answer any **two** *questions from this section.*

Additional question(s) answered will ***not*** *be marked.*

11. (a) In the extraction of iron using the blast furnace, iron is formed by the reaction between iron(III) oxide and carbon monoxide. Write an equation for the reaction leading to the formation of iron. *(1½ marks)*

(b) Hydrogen can be prepared in the laboratory using iron.

(i) State the condition under which hydrogen can be prepared in the laboratory from iron. *(01 mark)*

(ii) Write an equation for the reaction leading to the formation of hydrogen. *(1½ marks)*

(c) The reaction between iron and water to form iron(II, III) oxide is reversible.

(i) State what is meant by the term **reversible reaction**. *(01 mark)*

(ii) Write an equation for the reaction leading to the formation of iron(II, III) oxide and state the condition(s) for the reaction. *(2½ marks)*

(iii) State the condition(s) for the reverse of the reaction in (c) (ii). *(01 mark)*

(d) Iron reacts with water and another substance, **Y**, to form rust. Write the;

(i) chemical name of rust. *(01 mark)*

(ii) name of the substance **Y**. *(½ mark)*

(e) (i) Describe an experiment to show that rusting does not occur in the absence of the substance you named in (d)(ii). *(04 marks)*
(*Diagrams not required*)

(ii) State **one** method of preventing rusting. *(01 mark)*

12. (a) (i) Write an equation to show how hydrogen chloride can be prepared from sodium chloride. *(1½ marks)*

(ii) Explain how aqueous hydrogen chloride can be prepared in the laboratory. *(4½ marks)*
(*No diagram or equation is required*)

(b) State what is observed , and in each case write an equation for the reaction that takes place when aqueous hydrogen chloride is added to;

(i) copper(II) oxide and the mixture is warmed. *(2½ marks)*

(ii) lead(II) nitrate solution and the mixture is warmed. *(03 marks)*

(c) Aqueous hydrogen chloride gives effervescence with magnesium carbonate whereas a solution of hydrogen chloride in methylbenzene does not.

(i) Give a reason for the above observation. (*01 mark*)

(ii) Write an ionic equation for the reaction of aqueous hydrogen chloride with magnesium carbonate. (*1½ marks*)

(d) State **one** use of aqueous hydrogen chloride. (*01 mark*)

13. (a) Sodium sulphate can be prepared by the reaction of dilute solutions of sodium hydroxide and sulphuric acid.

(i) Write an equation for the reaction leading to the formation of sodium sulphate. (*1½ marks*)

(ii) Describe how a dry sample of sodium sulphate can be prepared using the reagents stated. (*6½ marks*)

(b) Explain how sodium sulphate and sodium sulphite solutions can be differentiated using barium nitrate solution. (*06 marks*)
(*Your explanation should include equations*)

(c) Name **one** reagent that can react with sodium sulphate to form lead(II) sulphate. (*01 mark*)

14. (a) Draw a labelled diagram of the setup of the apparatus that can be used to prepare a dry sample of ammonia from ammonium chloride. (*2½ marks*)

(b) State what would be observed and write an equation for the reaction that would take place if;

(i) concentrated hydrochloric acid was passed near an open jar containing ammonia. (*2½ marks*)

(ii) dry ammonia was passed over heated lead(II) oxide. (*03 marks*)

(c) Write an equation for the reaction that takes place when ammonia is burnt is oxygen. (*1½ marks*)

(d) Ammonia is oxidised by oxygen in the presence of a catalyst according to the following equation;

$$4NH_{3(g)} + 5O_{2(g)} \longrightarrow 4NO_{(g)} + 6H_2O_{(l)}$$

(i) Name the catalyst used. (*½ mark*)

(ii) Describe how the product of the oxidation can be used to manufacture nitric acid. (*Equations are required*) (*05 marks*)

END

QN 11

(a) $Fe_2O_3(s) + 3CO(g) \rightleftharpoons 2Fe(l) + 3CO_2(g)$ ✓✓

Accept → emphasize state.

(b) (i) Dilute hydrochloric/sulphuric acid (at room temperature) ✓ (1)

or reject dilute acid / dilute nitric acid.

(ii) $Fe(s) + 2H^+(aq) \rightarrow Fe^{2+}(aq) + H_2(g)$. ✓✓ (1½)

Accept molecular eqn only if H_2SO_4 or HCl is used.

(c) (i) A reaction in which the direction of chemical change can be reversed by changing the conditions under which the reaction is taking place ✓ (1)

(ii) Equation: $3Fe(s) + 4H_2O(l) \rightleftharpoons Fe_3O_4(s) + 4H_2(g)$ ✓✓

Conditions: Red hot iron ✓ and excess steam ✓ (2½)

(iii) Passing excess hydrogen ✓ over heated ✓ iron(II, III) oxide (1)

(5)

(d) (i) Hydrated iron(III) oxide ✓ (1)

(ii) Air/oxygen ✓ (½)

(e) (i) A given volume of water is boiled ✓ in a beaker ✗ for atleast 30 minutes to remove all the air in it ✓

A few clean ✓ iron nails are put in a test tube ✓ and it is filled to the brim with the boiled water. ✓

The test tube is stoppered ✓ and the set up left to stand for several days. ✓

→ Alternatively; Paraffin, vaseline or lubricating oil is added on the surface of water to keep out air and set up left to stand for several days.

The nails do not rust ✓

(ii) Oiling / greasing / alloying with to form stainless steel / Galvanising / Painting / Electroplating, etc. ✓

Accept any one.

Q12

(a) (i) $NaCl_{(s)} + H_2SO_{4(l)} \rightarrow HCl_{(g)} + NaHSO_{4(s)}$

Accept $HSO_{4(l)} + Cl^-_{(s)} \rightarrow HSO^-_{4(s)} + HCl_{(g)}$

Reject $H^+ + Cl^- \rightarrow HCl$.

(ii) Sodium chloride is put in a flat bottomed flask fitted with a tap funnel / dropping funnel / thistle funnel and delivery tube. Concentrated sulphuric acid is added.

ignore warming / heating

Effervescence and misty fumes are observed. The gas is passed through the delivery tube to an inverted funnel whose rim is only just immersed in water in a beaker to avoid sucking back. The resultant solution is aqueous hydrochloric acid.

4½

(b) (i) Black solid dissolves to form pale green / blue solution.

$CuO_{(s)} + 2HCl_{(aq)} \rightarrow CuCl_{2(aq)} + H_2O_{(l)}$

Accept $CuO_{(s)} + 2H^+_{(aq)} \rightarrow Cu^{2+}_{(aq)} + H_2O_{(l)}$

2½

(ii) White precipitate dissolves on warming to form colourless solution and reprecipitate

$Pb(NO_3)_{2(aq)} + 2HCl_{(aq)} \rightarrow PbCl_{2(s)} + 2HNO_{3(aq)}$

Accept $Pb^{2+}_{(aq)} + 2Cl^-_{(aq)} \rightarrow PbCl_{2(s)}$

3

(c) (i) Aqueous hydrogen chloride contains hydrogen ions which react with magnesium carbonate ions to form carbon dioxide whereas a solution of hydrogen chloride in methylbenzene doesn't ionise

1

(ii) $CO^{2-}_{3(s)} + 2H^+_{(aq)} \rightarrow CO_{2(g)} + H_2O_{(l)}$

Accept $MgCO_{3(s)} + 2H^+_{(aq)} \rightarrow CO_{2(g)} + H_2O_{(l)} + Mg^{2+}_{(aq)}$

(d) Preparation of soluble chlorides / removing rust from iron sheets (pickling), etc

Any correct one.

-1 for extra wrong.

Q2 13:

[a] (i) $2NaOH_{(aq)} + H_2SO_{4(aq)} \rightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)}$ ✓✓

reject ionic eqn.

(ii) Either;

A known volume of sodium hydroxide solution is put in a conical flask/beaker and 2 drops of litmus solution added to form a pale blue solution. Dilute sulphuric acid is added from the burette, a little at a time while shaking the mixture carefully until the solution is purple or just red. A little animal charcoal is added and the mixture boiled for sometime and then filtered. The litmus is absorbed on animal charcoal as residue and colourless solution of sodium sulphate formed as filtrate. The filtrate is evaporated to saturation, allowed to cool to allow crystals to form. The crystals are filtered off, washed with a little distilled water and dried between filter papers. 6½

or;

A known volume of sodium hydroxide solution is added to a conical flask/beaker. 2–3 drops of litmus solution are added and the mixture is titrated with dilute sulphuric acid from the burette, a little at a time, while shaking until the solution is just red/pink 6½ The volume of sulphuric acid used is obtained from the burette. The solution is poured away and the procedure repeated using the exact volumes of acid and base but without using litmus. The resultant solution is heated to evaporated to saturation, allowed to cool, crystals begin to form. The crystals are filtered off after sometime, washed with a little distilled water and dried between filter papers.

Accept use of phenolphthalein indicator and corresponding colour changes

(b) ~~To the~~

A few drops of barium nitrate solution are added separately to solutions of ~~to~~ sodium sulphate and sodium sulphite in test tubes, followed by dilute nitric acid

With sodium sulphate; a white precipitate of barium sulphate, insoluble in nitric acid is formed.

With sodium sulphite; a white precipitate of barium sulphite soluble in dilute nitric acid to form a colourless solution and bubbles of a colourless gas

$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

$Ba^{2+}(aq) + SO_3^{2-}(aq) \rightarrow BaSO_3(s)$

$BaSO_3(s) + 2H^+(aq) \rightarrow Ba^{2+}(aq) + SO_2(g) + H_2O(l)$

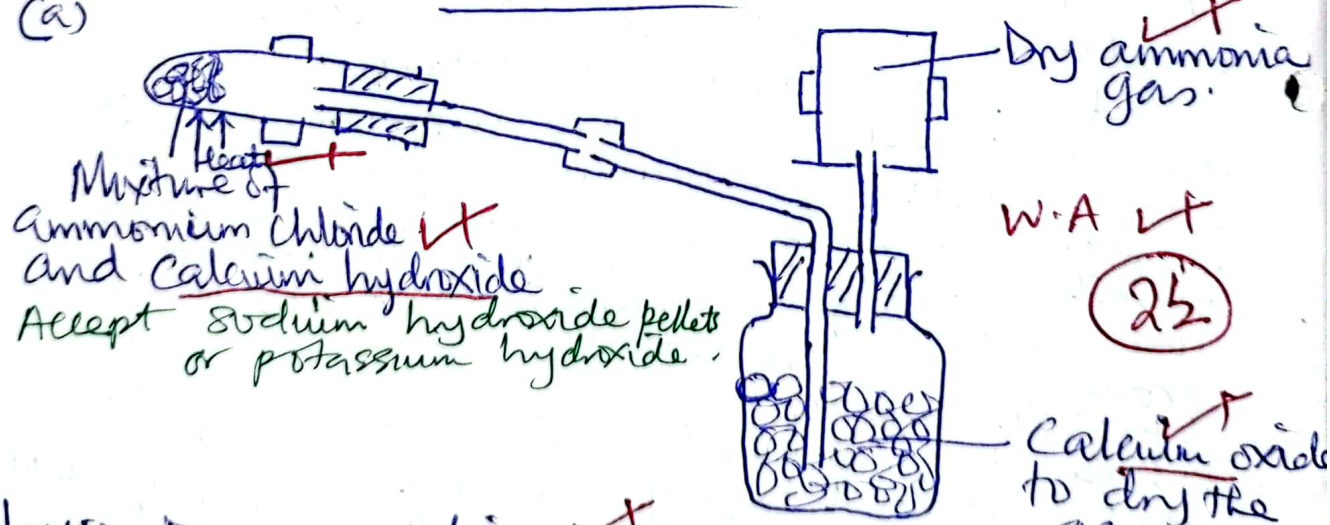
(c) Lead(II) nitrate solution

emphasize solution. reject formula. Accept lead(II) ethanoate solution

6½

Qn 14

(a)



2½

(b)(i) Dense white fumes settle to form a white solid on the sides of the jar

$NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$ 2½

(ii) Reddish-brown solid turned grey and colourless liquid

$3PbO(s) + 2NH_3(g) \rightarrow 3Pb(s) + N_2(g) + 3H_2O(l)$ 2½

(c) $4NH_3(g) + 3O_2(g) \rightarrow 2N_2(g) + 6H_2O(l)$ ✓✓+1

Accept $2NH_3(g) + \frac{3}{2}O_2(g) \rightarrow N_2(g) + 3H_2O(l)$

(d) (i) Platinum – Rhodium ✓ gauze catalyst

Accept Platinum or Copper.

reject formulae.

(ii) Nitrogen monoxide is rapidly cooled and reacted with oxygen ✓ from excess air to form nitrogen dioxide ✓

$2NO(g) + O_2(g) \rightarrow NO_2(g)$ ✓✓ Accept $\rightleftharpoons$

Nitrogen dioxide, in presence of excess ✓ air is absorbed in hot water ✓ to form nitric acid ✓

$4NO_2(g) + O_2(g) + 2H_2O(l) \rightarrow 4HNO_3(aq)$ ✓✓ (5)