TERM 2 - 2023

CHEMISTRY – PAPER 2 (233/2)

FORM THREE (3)

Time - 2 Hours

MARKING SCHEME

1. Below is a grid representing part of the periodic table. Study it and use it to answer the questions that follow. The letters do not represent actual symbols of elements.

M			**Z**		**R**	**A**	**D**	**X**
E	**J**		**W**	**Y**		**H**	**V**	
Q								

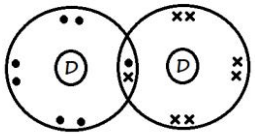
(a) Compare the atomic radii of **M** and **A**. Explain (2 marks)

Radius of M is larger than radius of A.

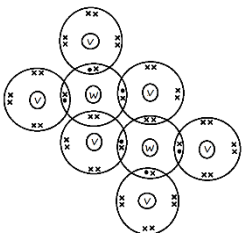
M experiences lower effective nuclear charge than A || M has fewer protons than A for the same number of occupied energy levels.

(b) Using dots and crosses to represent elements, show the bonding in the compounds formed between atoms of:

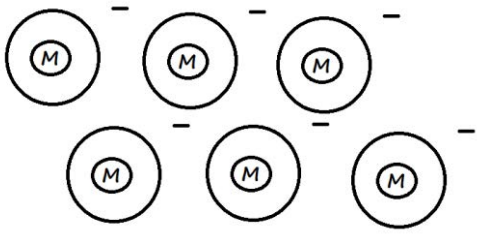
(i) **D** to form a molecule (2 marks)



(ii) **W** and **V** (2 marks)



(iii) 6 atoms of **M** (2 marks)



(c) State **two** attributes of element **W** that makes it the preferred material for use in making overhead power cables (2 marks)

- **It has many delocalised electrons per atom hence conveys current with little resistance.**
- **It is light**
- **It does not corrode easily**

(d) Element **W** was heated in the presence of chlorine gas. The residue was dissolved in water. State and explain the observations made when a spatula of sodium hydrogen carbonate is added to the resultant solution. (2 marks)

Bubbles of a colourless gas are observed. The chloride of W hydrolyses in water to form an acidic solution [which attacks the $NaHCO_3$].

(e) A burning sample of element **J** was lowered into a gas jar of carbon (IV) oxide.

(i) State and explain the observation made (2 marks)

Element J continued burning brightly.

Element J burns with a hot flame that is able to split carbon (IV) oxide into carbon and oxygen and uses the oxygen for burning || Element J is more reactive than carbon and can displace oxygen from a compound of carbon.

(ii) Write an equation for the reaction that took place in the gas jar (1 mark)

$$2J_{(s)} + CO_{2(g)} \quad 2JO_{(s)} + C_{(s)} \text{ OR}$$

$$Mg_{(s)} + CO_{2(g)} \quad 2MgO_{(s)} + C_{(s)}$$

2. During the laboratory preparation of hydrogen gas, 3g of Zn metal was added to $50cm^3$ of 1.5M hydrochloric acid solution. The following information was indicated on the label of the bottle containing the stock solution used to prepare the 1.5M hydrochloric acid solution: (Zn = 56)

Percentage purity – 37%

Density – 1.18g/cm^3

Formula mass – 36.6

(a) Determine the reactant that was in excess (2 marks)

moles Zn = $\frac{3}{56}$ = 0.05357 moles (½mk)	**moles HCl = $\frac{1.5 \times 50}{1000}$ = 0.075 moles (½mk)**
HCl solution is in excess (1mk)	

(b) If all the products were collected, and the setup was cooled to room temperature after the experiment, determine the volume of gas collected (molar gas volume at r.t.p. = 24,000cm^3) (2 marks)

Mole H_2 = moles Zn = 0.05357 moles

Vol H_2 = moles H_2 X molar gas volume = 0.05357 X 24000 = 1285.68cm^3

(c) Calculate the molarity of the concentrated acid that was used in preparing the 50cm^3 of 1.5M hydrochloric acid solution (2 marks)

1cm^3 contains 1.18g 1000cm^3 contains 1.18 X 1000 = 1180g	**purity = 37% hence pure HCl = 1180 X $\frac{37}{100}$ = 436.6g**	**moles HCl = $\frac{436.6}{36.5}$ = 11.96 moles**
= 11.96 M		

(d) Calculate the volume of the concentrated acid that was diluted to form the 1.5M hydrochloric acid solution (2 marks)

$$M_cV_c = M_dV_d$$

$$11.96 \text{ X } V_c = 1.5 \text{ X } 50$$

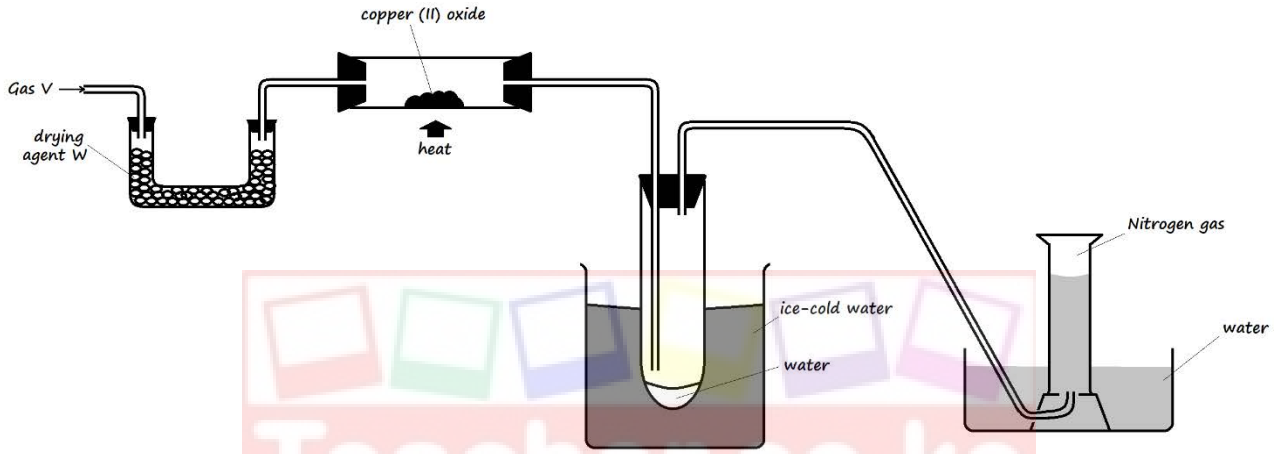
$$V_c = 6.271\text{cm}^3$$

(e) If each student in a class of 45 was to carry out the experiment individually, determine the total volume of dilute acid to be prepared
(1 mark)

$$= 45 \text{ X } 50$$

$$= 2{,}250\text{cm}^3$$

3. The setup below was used to prepare and collect nitrogen gas in the laboratory. Study it and use it to answer the questions that follow.



(a) What property of nitrogen allows it to be collected as shown? (1 mark)

It is <u>only</u> slightly soluble in water || It is insoluble in water

(b) State and explain the observation made in the combustion tube during the experiment (2 marks)

Black copper (II) oxide changes to a brown residue || Black copper (II) oxide changes to brown copper metal. REJ: Black copper (II) oxide changes to brown.

Ammonia reduces copper (II) oxide to brown copper metal.

(c) Write an equation for the reaction that took place in the combustion tube (1 mark)

$$2NH_{3\,(g)} + 3CuO_{\,(s)} \quad 3Cu_{\,(s)} + N_{2\,(g)} + 3H_2O_{\,(l)}$$

Rules for writing chemical equations apply

(d) State and explain the observation made in the combustion tube if copper (II) oxide is replaced with magnesium oxide. (2 marks)

The white solid remains white.

Magnesium is more reactive than nitrogen, hence ammonia cannot removed combined oxygen from magnesium oxide.

(e) Describe a positive chemical test for the gas collected when copper (II) oxide is replaced with magnesium oxide (2 marks)

Dip moist red and blue litmus paper into a gas jar containing the gas.

Moist red litmus paper changes to blue while moist blue litmus paper remains blue.

(f) What property of gas V is demonstrated in the experiment? (1 mark)

Reducing property REJECT: Reducing agent

(g) Name any **one** gas that can be used to replace **gas V**. (1 mark)

Carbon (II) oxide || Laboratory gas

4. 300cm^3 of nitrogen gas at 30^{o}C takes 40 seconds to diffuse through a membrane at 740mmHg pressure.

(a) How long will it take 70cm^3 of oxygen to diffuse through the membrane under the same conditions of temperature and pressure? (N = 14, O = 16) (3 marks)

$$\frac{RN2}{RO2} = \sqrt{\frac{MO2}{MN2}}$$

$$\mathbf{R_{N2} = \frac{300}{40} = 7.5\ cm^3/s}$$

$$\frac{7.5}{RO2} = \sqrt{\frac{32}{28}}$$

$$\mathbf{R_{O2} = 7.016}$$

$$\mathbf{T_{O2} = \frac{70}{7.016} = 9.977s}$$

(b) What is the molecular mass of 200cm^3 of gas **M**, that takes 11.7 seconds to travel through the same membrane? (2 marks)

$$\mathbf{R_M = \frac{200}{11.7} = 17.09\ cm^3/s}$$

$$\frac{RN2}{RM} = \sqrt{\frac{Mm}{MN2}}$$

$$\frac{7.5}{17.09} = \sqrt{\frac{Mm}{28}}$$

$$\mathbf{M_M = 5.392 \approx 5.4}$$

(c) What will be the volume of gas **M** at 50°C and 760mmHg? (2 marks)

$$\frac{P1V1}{T1} = \frac{P2V2}{T2}$$

$$\frac{740 \times 20}{303} = \frac{760 \times V2}{323}$$

$V_2 = 1.478cm^3$

(d) The pressure of a fixed mass of gas increases with a decrease in volume at constant temperature. Explain this observation.
(2 marks)

Decrease in volume results in a decrease in distance travelled by gas particles before colliding with the walls of its container.

The rate of collision of the particles with the walls therefore increases.

5. Compound **W** is a white crystalline substance. When heated strongly in a boiling tube it yielded a solid residue **G** and fumes of a brown gas **L**. Residue **G** was added to warm dilute hydrochloric acid to form a colourless solution **V** which formed a white precipitate when the setup was allowed to cool to room temperature.

(a) Name:

(i) Compound **W** **Lead (II) nitrate || $Pb(NO_3)_2$** (½ mark)

(ii) Residue **G** **Lead (II) oxide || PbO** (½ mark)

(b) Write a chemical equation for:

(i) The thermal decomposition of compound **W** (1 mark)

$$Pb(NO_3)_{2\,(s)} \quad PbO_{\,(s)} + 2NO_{2\,(g)} + O_{2\,(g)}$$

(ii) The formation of solution **V** (1 mark)

$$PbO_{\,(s)} + 2HCl_{\,(aq)} \quad PbCl_{2\,(s)} + H_2O_{\,(l)}$$

(c) State another observation that is made in the boiling tube during the process. (1 mark)

White crystals change to a residue that is orange when hot and yellow when cold.

(d) State and explain the observation made if residue **G** was added to warm dilute sulphuric (VI) acid. (2 marks)

A white sediment would be observed.

The lead (II) oxide reacts with the acid to form insoluble lead (II) sulphate which forms an impermeable coat around the oxide.

(e) During the process of heating, the gas **V** was passed through a U-tube dipped in a large beaker with ice-salt mixture to form substance **E**

(i) Name substance **E** (1 mark)

Dinitrogen tetraoxide || N_2O_4

(ii) Describe the appearance of substance **E**. (1 mark)

It is a pale yellow liquid

(f) The metal in compound **W** is not suitable for use in making overhead power transmission cables. Give **two** reasons for this. (2 marks)

It is heavy

It has low electrical conductivity.

6. The following is a list of reagents that were assembled for use in the preparation of some substances in the laboratory: Sodium sulphate, copper (II) carbonate, copper (II) oxide, dilute hydrochloric acid, calcium granules, sodium hydroxide solution, and dilute sulphuric (VI) acid, dilute nitric (V) acid, distilled water.

(a) Name the reagent which would react with dilute sulphuric (VI) acid and give off:

(i) Hydrogen gas (1 mark)

Calcium granules

(ii) Carbon (IV) oxide (1 mark)

Copper (II) carbonate

(b) What name is given to the reaction between sodium hydroxide and the two acids in separate boiling tubes? (1 mark)

Neutralisation reaction

(c) Write an ionic equation for the reaction between solid copper (II) oxide and dilute hydrochloric acid (1 mark)

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

(d) Name **three** reagents in the list above that can be used to efficiently prepare calcium sulphate (3 marks)

Calcium granules, dilute nitric (V) acid, sodium sulphate.

(e) Describe how calcium sulphate may be prepared using the reagents named in **(d)** above. (3 marks)

Add excess calcium granules to a volume of dilute nitric (V) acid to form calcium nitrate solution. Filter the mixture to remove excess calcium granules as a residue, and calcium nitrate solution as the filtrate. Add sodium sulphate to the filtrate to form a mixture of calcium sulphate as a sediment and sodium nitrate solution. Filter the mixture to obtain calcium sulphate as a residue.

7. When a 10g sample of zinc carbonate was heated in a boiling tube, 6.48g of residue was left.

(a) State the observation made in the boiling tube during reaction. (1 mark)

White zinc carbonate changed to a residue that is yellow when hot and orange when cold.

(b) Write a chemical equation representing the reaction in **(a)** above. (1 mark)

$$ZnCO_{3\,(s)} \quad ZnO_{(s)} + CO_{2\,(g)}$$

(c) If $25cm^3$ of hydrochloric acid reacted completely with the residue determine:

(i) The expected colour change in the reaction vessel if methyl orange indicator was used. (1 mark)

Methyl orange changes from orange to yellow

(ii) The concentration of the acid. (Zn = 65, C = 12, O = 16, Cl = 35.5) (3 marks)

Moles ZnO $= \frac{6.48}{72} =$ **0.09 moles**

Zn : HCl = 1:2 hence moles HCl = 0.09 X 2 = 0.18 moles

Molarity HCl $= \frac{0.18 \times 1000}{25} =$ **7.2M**

(iii) The mass of salt that may be obtained if the solution is crystallized and all the salt recovered (2 marks)

Since

$$ZnO_{(s)} + 2HCl_{(aq)} \quad ZnCl_{2\,(aq)} + H_2O_{(l)}$$

Mole ratio $ZnCl_2$: HCl = 2:1

Moles $ZnCl_2 = \frac{0.18}{2} = 0.09$moles

Mass $ZnCl_2$ = 0.09 X molar mass

= 0.09 X (56 + 2[35.5])

= 11.43g

8. Study the table below and use it to answer the questions that follow.

Element	A	D	E	G	J	L	M	Q
Atomic number	11	12	13	14	15	16	17	18
Atomic radii (nm)	0.191	0.160	0.130	0.118	0.110	0.102	0.099	0.095
Boiling point (°C)	890	1110	2470	2360	280	445	34.2	-186
Formula oxide	**A_2O**	DO	**E_2O_3**	**GO_2**	J_2O_5	**LO**	M_2O	
Boiling point of oxide (°C)	1193	3075	2045	1728	563	-72	-91	

(a) Complete the table to show the formulae of the oxides of **A**, **E**, **G**, and **L** (2 marks)

(b) Select an oxide that reacts with both sodium hydroxide solution and dilute hydrochloric acid solution (1 mark)

E_2O_3

(c) Explain the difference in atomic radii between elements **E** and **M** (2 marks)

E has a larger atomic radius than M.

E has more protons than M for the same number of occupied energy levels || Energy levels of M experience greater effective nuclear force of attraction than E

(d) Write the formula of the compound formed between elements **E** and **M** (1 mark)

E_2M_6

(e) Explain the difference in boiling points between the oxides of elements **D** and **L** (2 marks)

Oxide of D has a giant ionic structure with strong ionic bonds that require a lot of energy while oxide of L has a simple molecular structure with weak Van der Waal's forces that require little energy.

(f) Write a chemical equation for the reaction between the oxide of element **D** and water. (1 mark)

$$DO_{(s)} + H_2O_{(l)} \quad D(OH)_{2\,(aq)}$$

(g) State and explain an observation made in the reaction vessel in **(f)** above (1 mark)

A white precipitate is observed.

The hydroxide formed is only slightly soluble.