TERM 2 - 2023

CHEMISTRY – PAPER 1 (233/1)

FORM THREE (3)

Time - 2 Hours

MARKING SCHEME

1. Hydrogen is a **group I** element:

(a) It is the lightest known element but cannot be used in hot air balloons. Explain (1 mark)

Hydrogen is explosive when exposed to air and heat.

(b) State any one use of hydrogen gas which is also a use of carbon (II) oxide gas (1 mark)

It is used as a reducing agent for obtaining metals from their ores.

2. A piece of burning magnesium was lowered into a gas jar of nitrogen gas, and it was observed to be burning even brighter.

(a) Explain this observation (1 mark)

Burning magnesium has sufficient energy to break the triple covalent bond of nitrogen and form magnesium nitride.

(b) Write an equation for the reaction which took place in the gas jar in **(a)** above (1 mark)

$$3Mg_{(s)} + N_{2(g)} \quad Mg_3N_{2(s)}$$

Rules for writing chemical equations apply.

(c) Water was added to the product formed above and the resultant solution was tested with litmus paper. State and explain the observation that was made. (2 marks)

Red litmus paper changed to blue while blue litmus paper remained blue. Magnesium nitride reacts with water to form magnesium hydroxide, which is alkaline.

3.

(a) What is a saturated solution? (1 mark)

A solution in which no more solute can dissolve [at a given temperature].

(Accept answer without the bracketed part, since we are borrowing from the form 1 concept of saturation when crystallising)

(b) Describe a laboratory procedure that can be used to determine that a given solution is saturated. (2 marks)

Heat the solution over a water bath and dip a glass rod periodically. When a white crust is observed on the tip of the glass rod, it indicates that the solution is saturated and ready to form crystals.

(The answer must be presented in the form of a procedure, to score)

4. Trona is a double salt that contains sodium carbonate and sodium hydrogen carbonate. It exists in alkaline lakes, mixed with sodium chloride. Name the method of separation that is used to obtain it from its mixture with sodium chloride. (1 mark)

Fractional crystallisation.

5. Using the listed reagents only, describe the steps that can be used to obtain a dry sample of lead (II) sulphate in the laboratory: lead (II) carbonate powder, sodium sulphate solution, and dilute nitric (V) acid solution. (3 marks)

Add excess lead (II) carbonate into a volume of dilute nitric (V) acid. Filter the mixture to remove excess lead (II) carbonate as a residue and lead (II) nitrate solution as a filtrate. Add an excess of the filtrate to sodium carbonate and filter to obtain insoluble lead (II) sulphate as a residue.

6. Iron (II) bromide can be prepared in the laboratory by passing dry bromine vapour over hot iron wool.

(a) Name this method of salt preparation (1 mark)

Direct combination [of elements].

(b) Iron (II) bromide must be prepared in a dry environment. Explain. (1 mark)

The salt is deliquescent [and might absorb moisture from the atmosphere to form a solution].

(Award, if the part in square brackets is omitted]

(c) During this preparation, calcium oxide is preferred to anhydrous calcium chloride as a drying agent. Explain. (1 mark)

It acts both to:

- absorb moisture and keep the product dry, and to (½ mark)

- absorb excess chlorine to prevent its emission to the environment (½ mark)

7. When iron filings and sulphur powder are put together in a glass beaker, the resultant substance is only said to be a mixture. When the beaker is heated gently, a red glow is observed, and the resultant substance is now said to be a compound.

(a) Explain these observations. (2 marks)

Before heating, a magnet can attract the iron filings and sulphur still has its yellow appearance. After heating a magnet cannot attract the resultant substance and it does not have the yellow appearance of sulphur.

(b) State any characteristics of the type of change that occurs when the glass beaker is heated (2 marks)

It is accompanied by absorption of heat.

A new substance is formed.

There is change in mass.

(Any two correct responses by the candidate)

8.

(a) State Charles' Law. (1mark)

The volume <u>of a fixed mass of gas</u> is directly proportional to its <u>absolute temperature</u> at constant pressure.

(b) An L.P.G. gas cylinder had gas which occupied 300cm^3 when the warehouse temperature was 47°C. what volume will the gas occupy when the warehouse temperature is reduced to the s.t.p. in readiness for refilling? (2 marks)

$$\frac{300}{(273+47)} = \frac{V2}{(273+0)}$$

$$\mathbf{V_2 = \frac{320 \times 273}{320}}$$

$$\mathbf{V_2 = 273cm^3}$$

9. 15cm^3 of an acid with the formula **H_2Y** required 25cm^3 of 0.1M NaOH for complete neutralization.

(a) How many moles of sodium hydroxide reacted with the acid? (1 mark)

$$\mathbf{moles\ NaOH = \frac{0.1 \times 25}{1000}}$$

$$\mathbf{= 0.0025 moles}$$

(b) Calculate the concentration of the acid in moles per litre. (2 marks)

2 moles base reacts with 1 mole acid

$$\mathbf{Moles\ acid = \frac{moles\ base}{2} = \frac{0.0025}{2} = 0.00125\ moles}$$

$$\mathbf{Molarity\ acid = \frac{moles\ acid \times 1000}{volume} = \frac{0.00125 \times 1000}{15} = 0.08M}$$

10. An oxide of element **Q** has the formula **Q_2O_3**.

(a) State the valency and oxidation number of element **Q** (1 mark)

Valency **3** Oxidation number **+3 Rej: 3+**

(b) What is the most likely structure of the compound **Q_2O_3**? (1 mark)

Giant ionic structure (reject: ionic structure)

11. Distinguish the term 'allotrope' from 'isotope'. (2 marks)

Allotropes are different forms of an element in the same physical state while isotopes are atoms of the same element that have different mass numbers//atoms with the same number of protons but different number of neutrons.

12. A hot piece of aluminium metal was lowered into a gas jar of chorine gas. The resulting residue was mixed with water and filtered. 3 drops of methyl orange indicator were added to the filtrate.

(a) State and explain the observation made when methyl orange was added to the filtrate. (2 marks)

The indicator changed from orange to red/pink.

The chloride of aluminium hydrolyses in water to form an acidic solution.

(b) Name the process that occurred when the residue was added to water (1 mark)

Hydrolysis.

13. A hydrated salt has the following composition by mass: Iron 20.2%, Oxygen 23.0%, sulphur 11.5% and the rest is water. Determine the formula of the hydrated salt (Fe = 56, S = 32, O = 16, H = 1) (3 marks)

	Fe	S	O	H_2O
Mole	$\frac{20.2}{56} = 0.3607$	$\frac{11.5}{32} = 0.3594$	$\frac{23}{16} = 1.4375$	$\frac{45.3}{18} = 2.517$
ratio	$\frac{0.3607}{0.3594} = 1.004 \approx 1$	$\frac{0.3594}{0.3594} = 1$	$\frac{1.4375}{0.3594} = 3.9997 \approx 4$	$\frac{2.517}{0.3594} = 7.003 \approx 7$

$FeSO_4 \cdot 7H_2O$

14. A sample of the compound **CH_3CCH** was burnt in the laboratory. State and explain the observations made during the burning process. (2 marks)

The compound burned with a yellow smoky flame.

The hydrocarbon has a high carbon to hydrogen ratio.

15. Concentrated hydrochloric acid was added to potassium manganate (VII) crystals in flat bottomed flask. The gas produced was bubbled through water.

(a) State the colour of solution formed (1 mark)

Pale yellow solution

(b) Blue litmus paper was dipped into the solution. State and explain the observation made. (2 marks)

Blue litmus paper changed to red, then to white. (1 mark)

Chlorine dissolves in water to form a mixture of two acids. (½ mark)

One acid HOCl adds nascent oxygen, to cause bleaching. (½ mark)

(c) Write an equation for the reaction that occurred in **(b)** above. (1 mark)

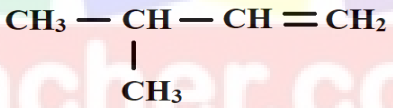
$$HOCl_{(aq)} + dye \quad HCl_{(aq)} + \{dye + [O]\}$$

16. Solid **W** is a white crystalline substance. It readily dissolves in water to form a colourless solution. It melts at low temperature to yield a liquid that does not conduct electricity. Its solution does not cause a bulb to light when inert electrodes are introduced. State and explain the most likely structure of solid **W**. (2 marks)

Simple molecular structure. [1 mark]

It has a <u>low melting point</u> and <u>does not conduct electricity in the molten or aqueous state</u>. [1 mark]

17. Study the compound shown and use it to answer the questions that follow.



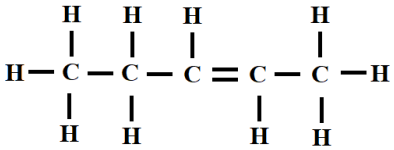
(a) To which homologous series does the compound belong? (1 mark)

Alkenes.

(b) State the IUPAC name of the compound (1 mark)

3-methylbut-1-ene

(c) Draw the structure of any isomer of the compound. (1 mark)



18. A form three student weighed a piece of plain paper and wrote his name on it using a pencil of pure graphite. He then re-weighed the paper and obtained the following results:

Mass of plain paper = 1.042g

Mass of paper after writing = 1.143g

Determine the number of carbon atoms present in the pencil marks (C = 12.0, L = $6.023X10^{23}$) (2 marks)

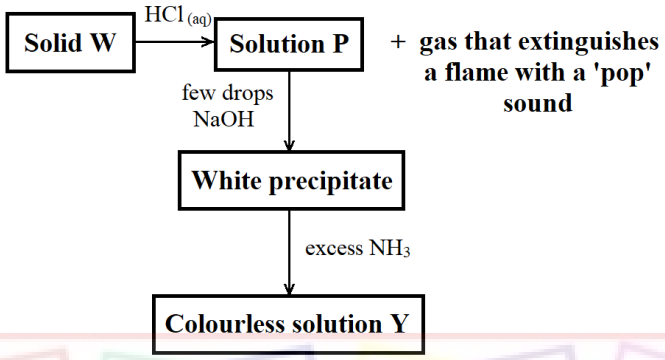
Mass carbon = 1.143 – 1.042 = 0.101g

Moles carbon $= \frac{mass\ carbon}{molar\ mass\ carbon} = \frac{0.101}{12}$ **= 0.008417 moles**

Number of atoms = moles X L = 0.008417 X 6.023X10^{23}

= 5.070X10^{21} carbon atoms.

19. The scheme below shows a series of reactions, starting with a solid **W**.



(a) Identify solid **W** (½ mark)

Zinc metal

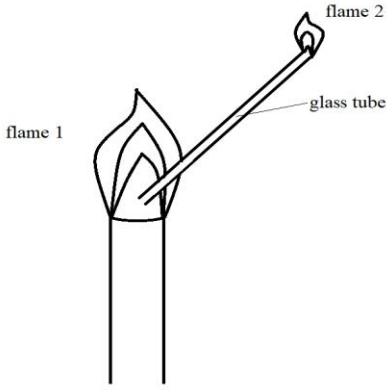
(b) Write an equation for the reaction that occurs between solid **W** and dilute hydrochloric acid (1 mark)

$Zn_{(s)} + 2HCl_{(aq)} \quad ZnCl_{2(aq)} + H_{2(g)}$

(c) Write the formula of the complex ion present in solution **Y**. (½ mark)

$[Zn(NH_3)_4]^{2+}$

20. The setup below was arranged and used to study the characteristics of a Bunsen burner flame.



(a) What does the experiment show? (1 mark)

The almost colourless region of a Bunsen burner flame contains unburnt laboratory gas.

(b) Name the type of flame labelled **flame 1**. (1 mark)

Non luminous flame

(c) What type of flame is shown by **flame 2**? Explain. (2 marks)

Luminous flame.

The laboratory gas travelling through the glass tube does not mix with air.

21. Some potassium carbonate of unknown mass was dissolved in water and the solution made up to the 250cm^3 mark. 25cm^3 of this solution neutralized 20cm^3 of 0.25M nitric (V) acid solution. Determine the unknown mass of potassium carbonate used. (K = 39, O = 16, C = 12) (3 marks)

Moles $HNO_3 = \frac{0.25 \times 20}{1000} = 0.005$

Moles K_2CO_3 in 25cm^3 $= \frac{moles\ HNO3}{2} = \frac{0.005}{2} = 0.0025$ moles

Moles K_2CO_3 in 250cm^3 $= \frac{250 \times 0.0025}{25} = 0.025$ moles

Mass K_2CO_3 = moles X molar mass = 0.025 X [2(39) + 12 + 3(16)]

= 3.45g

22.

(a) State Gay Lussac's Law. (1 mark)

When gases react, they do so in volumes that bear a simple ratio to one another as long as the reactants and products are all gaseous.

(b) What volume of a hydrocarbon gas (CH_4) would remain if a burner containing 40cm^3 of the gas burns in 40cm^3 of enclosed air? (Assume oxygen is 20% by volume of air) (2 marks)

Vol oxygen $= \frac{20}{100}$ X 40 = 8cm^3 (½ mark)

Equation for reaction: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Reacting volume of CH_4: if 2 rep 8cm^3 then 1 rep $\frac{1 \times 8}{2}$ = 4cm^3 (½ mark)

Remaining volume = total volume – reacting volume = 40 – 4 = 36cm^3 (1 mark)

23. During the laboratory preparation of carbon (II) oxide, an acid **G** is added to solid substance **L**. The product is bubbled through concentrated potassium hydroxide solution, and carbon (II) oxide gas collected over water.

(a) Name:

(i) Acid **G** **Concentrated sulphuric (VI) acid)** (1 mark)

(ii) Solid **L** **Methanoic acid // Ethanedioic acid)** (1 mark)

(b) What is the role of the concentrated potassium hydroxide solution? (1 mark)

To remove carbon (IV) oxide from the mixture of gases.

(c) What would be observed if the concentrated potassium hydroxide solution was replaced with calcium hydroxide solution? (1 mark)

A white precipitate which dissolves when excess carbon (IV) oxide is bubbled, is observed.

24. Organic compounds **CH_3CH_2OH** and **$CH_3CH_2CH_2CH_3$** have close molecular masses. However, **CH_3CH_2OH** exists as a liquid at room temperature, while **$CH_3CH_2CH_2CH_3$** exists as a gas at room temperature. Explain this observation (2 marks)

$CH_3CH_2CH_2CH_3$ only has weak Van der Waal's forces of attraction between its molecules, while CH_3CH_2OH has strong hydrogen bonds in addition to the weak Van der Waal's forces of attraction.

25. Element **R** has two isotopes 69 31 **R** and 71 31 **R** the percentage composition of the isotope with lower mass is 60%.

(a) Calculate the R.A.M. of **R**. (2 marks)

R.A.M. $= \frac{(69 \times 60)+(71 \times 40)}{100}$

= 69.8

(penalise answer if units are included)

(b) Isotopes have similar chemical properties but may have different physical properties. Explain this observation. (2 marks)

<u>Similarity in atomic number</u> results in similar electron configuration, hence they lose or gain the same number of electrons; however, the <u>difference in atomic mass</u> results in difference in physical properties such as melting and boiling point.

26. A 5.0g of an alloy of platinum and zinc was reacted with excess dilute hydrochloric acid. 840cm^3 of hydrogen gas was evolved at s.t.p. Calculate the percentage of zinc in the alloy. (Zn = 56, molar gas volume at s.t.p. = 22400cm^3). (3 marks)

Moles H_2 $= \frac{840}{22400}$ **= 0.0375 moles (½ mark)**

Moles Zn = moles H_2 = 0.0375 moles (½ mark)

Mass Zn = 0.0375 X 56 = 2.1g (1 mark)

%Zn = $\frac{2.1}{5}$ X 100 = 42% (1 mark)

27. When a few drops of aqueous ammonia are added to a copper (II) nitrate solution, a pale blue precipitate is formed. On addition of more aqueous ammonia, a deep blue solution is formed.

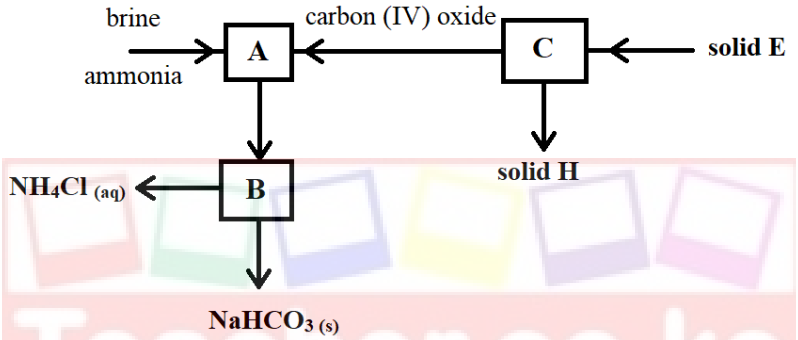
(a) Identify the pale blue precipitate (1 mark)

Copper (II) hydroxide

(b) Write the formula of the complex ion present in the deep blue solution (1 mark)

$[Cu(NH_3)_4]^{2+}$

28. The diagram below shows a part of the Solvay Process



(a) Write the overall equation for the reaction that takes place in **A** (1 mark)

$NH_{3\,(g)} + CO_{2\,(g)} + NaCl_{(aq)} + H_2O_{(l)} \quad NaHCO_{3\,(s)} + NH_4Cl_{(aq)}$

(b) Name solid **E** (1 mark)

Limestone

(recommend rejection of calcium carbonate since the raw material is not a pure substance)

(c) State any **one** use of solid **H** (1 mark)

-Manufacture of glass

-A laboratory drying agent

(the candidate's first answer)

(d) Name any one apparatus/material that can be used in the laboratory to carry out the process that takes place in chamber **B** (1 mark)

Filter paper // clean cloth