**Term 2 - 2022**

**CHEMISTRY (233/2)**

**PAPER 2**

**FORM FOUR (4)**

**Time: 2 Hours**

**MARKING SCHEME**

**Instructions to candidates**

1. Write your name, stream, and admission number in the spaces provided above.
2. Answer **ALL** the questions in the spaces provided, and working **MUST** be clearly shown
3. This paper consists of **12 printed pages**; Candidates should check the question paper to ascertain that all the pages are printed as indicated, and that no question is missing.

**FOR EXAMINERS’ USE ONLY**

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| --- | --- | --- |
| **QUESTION** | **MAXIMUM SCORE** | **CANDIDATE’S SCORE** |
| **1 – 6**  | **80** |  |

1. The grid below represents part of the periodic table. Study it and answer the questions that follow. The letters do not represent actual symbols of the elements



1. Identify the most reactive non-metal. Explain (2 Marks)

**Element I. It has the smallest atom with the highest effective nuclear force of attraction.**

**[1 mk statement; 1 mk explanation]**

1. What is the name given to the family of elements to which **I** and **J** belong? (1 Mark)

**Halogens Reject: Group VII**

1. Using dots (•) and crosses (×) to represent electrons, show bonding in the compound formed between **C** and **H**. (2 Marks)



1. How does the atomic radius of **F** compare with that of **I**? Explain. (2 Marks)

 **F is larger than I. F experiences a lower effective nuclear force of attraction on its energy levels hence more loosely held // F has fewer protons for the same number of energy levels as I hence its energy levels are more loosely held.**

1. Study the table below and answer the questions that follow.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Substance** | **M** | **N** | **O** | **P** | **Q** | **R** |
| **Melting Point (oC)** | 801 | 1356 | -101 | 26 | -39 | 113 |
| **Boiling Point (oC)** | 1410 | 2850 | -36 | 154 | 457 | 445 |
| **Electrical conductivity in solid state** | Poor | Poor | Poor | Poor | Good | Poor |
| **Electrical conductivity in molten state** | Good | Poor | Poor | Poor | Good | Poor |

1. Explain why **substance M** is a good conductor of electricity in the molten state but not in the solid state. (2 Marks)

 **It has a giant ionic structure. Its ions are held by strong ionic bonds in the solid state but these are weakened in the molten state to allow their movement.**

1. What is the most likely structure and bond in **substance N**? Explain. (2 Marks)

 Structure  **Giant covalent//Giant atomic**  Bond **Covalent**

 **It has high melting point and boiling point and does not conduct electricity in the solid and in the molten state**

**[½mk each for structure and bond; 1mk for explanation]**

1. Identify, with a reason, a substance that exists as a liquid at room temperature. (2 Marks)

 **Q. Its melting point is below room temperature and its boiling point above room temperature.**

1. What name is given to different forms of an element which exist in the same physical state? (1 Mark)

**Allotropes**

1. Name **two** crystalline forms of carbon (1 Mark)

 **Diamond** **Graphite**

1. The figure below is part of a setup used to prepare and collect dry carbon (II) oxide from carbon (IV) oxide.



1. Complete the diagram to show how dry carbon (II) oxide gas is collected. (1 Mark)
2. Identify:
* Substance **U** and state its use

 **Concentrated sodium hydroxide solution // Concentrated potassium hydroxide solution**

* Drying agent **Y**

 **Concentrated sulphuric (VI) acid**

1. Write a chemical equation for the reaction which takes place in the combustion tube (1 Mark)

**CO2 (g) + C (s) 🡪 2CO (g)**

1. Carbon (II) oxide is a major environmental pollutant.
* Give **one** major source of carbon (II) oxide in the atmosphere (1 Mark)

 **Automobile exhaust fumes // Industrial emissions**

* Explain how carbon (II) oxide causes poisoning (1 Mark)

 **It forms stable carboxyhaemoglobin that prevents oxygen from reaching body cells to result in suffocation**

1. State **one** use of carbon (II) oxide (1 Mark)

 **Used as a reducing agent in the extraction of metals from their ores**

 **Used in the industrial production of methanol**

 **A mixture of carbon (II) oxide and hydrogen is used as a fuel (water gas)**

**[the candidate’s first answer for 1 mk]**

1. Write an equation for the formation of water gas. (1 Mark)

**C (s) + H2O (g) 🡪 CO (g) + H2 (g)**

**[rules for writing chemical equations apply]**

1. Explain why sodium hydroxide solution is not used in testing for carbon (IV) oxide gas, while calcium hydroxide is preferably used. (2 Marks)

 **Sodium hydroxide reacts with carbon (IV) oxide to form soluble sodium carbonate hence no change in physical appearance; while calcium hydroxide reacts with carbon (IV) oxide to form a white precipitate which can be used to detect the reaction.**

1. Study the following energy cycle diagram and then answer the questions that follow.

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1. Name the enthalpy change represented by **∆H2**. (1 Mark)

 **Heat of formation of carbon (II) oxide**

1. Use the following information to calculate the value of **∆H1** for 144g of graphite. (2 Marks)

**∆H2** = -110 kJ/mole **∆H3** = -283kJ/mole



1. The following are thermochemical equations for molar enthalpies of combustion for some substances. Study them and answer the questions that follow.

 **C4H10 (g) +** $\frac{13}{2}$**O2 (g) 🡪 4CO2 (g) + 5H2O ∆Hθc = -2877kJ/mole**

 **C (s) + O2 (g) 🡪 CO2 (g) ∆Hθc = -399kJ/mole**

 **H2 (g) + ½O2 (g) 🡪 H2O (l) ∆Hθc = -286kJ/mole**

1. What is molar enthalpy of combustion of a substance? (1 Mark)

 **This is the enthalpy change that occurs when one mole of a substance is completely burnt in oxygen.**

1. Calculate the molar enthalpy of formation of butane (**C4H10**) using the information given above. (3 Marks)



1. The following results were obtained in an experiment, to determine the heat of neutralization of 25cm3 of 2M sodium hydroxide solution, using 25cm3 of hydrochloric acid:

 Initial temperature of acid = 25.0oC

 Initial temperature of alkali = 26.0oC

 Final temperature of mixture of acid + alkali = 38.5oC

 Density of solution =1g/cm3

 Specific heat capacity of solution =4.2 J/g/K

1. Define molar heat of neutralization (1 Mark)

 **This is the enthalpy change that occurs when an acid and a base react to form one mole of water.**

1. Write an **ionic equation** for the neutralization reaction involving hydrochloric acid and sodium hydroxide solution. (1 Mark)

**H+(aq) + OH-(aq) 🡪 H2O (l)**

1. Calculate:
* The enthalpy change during this experiment. (2 Marks)

 **∆T = 38.5 – (**$\frac{25+26}{2}$**) = 13  mass = volume = 25 + 25 = 50g**

 **∆H = mc∆T = 50g x 4.2 J/g/K x 13K  = -2730J**

* The molar enthalpy of neutralization for this reaction (2 Marks)

**Moles H2O**

 **Moles H2O = moles NaOH**

 **If 1000cm3 base contains 2 moles**

 **Then 25cm3 base contains** $\frac{25 ×2}{1000}$ ** = 0.05 moles**

**Molar heat of neutral**

 **Since 0.05 moles of base evolves -2730 J**

 **1 mole of base evolves =** $\frac{1 × -2730}{0.05}$ **= - 54600J/mole = 54.6kJ/mole**

1. Below is a simplified diagram of the Down’s Cell, used for the manufacture of sodium. Study it and answer the questions that follow.



1. What material is the anode made of? Give the reason why that material is used. (2 Marks)

 **Carbon. It is inert and will therefore not react with the chlorine.**

**[1mk statement; 1mk explanation]**

1. What precaution is taken to prevent chlorine and sodium from re-combining? (1 Mark)

 **The anode is surrounded by wire meshing to prevent chlorine from coming in contact with the hot sodium metal.**

1. Write an ionic equation for the reaction in which chlorine gas is formed (1 Mark)

**2Cl (l) 🡪 Cl2 (g) + 2e-**

1. In the Downs process, (used for manufacture of sodium), a certain salt is added to lower the melting point of sodium chloride from about 800oC to about 600oC.
2. Name the salt that is added. (1 Mark)

**Magnesium chloride**

1. State why it is necessary to lower the temperature in **b)** above (1 Mark)

 **To lower the amount of energy required to maintain the electrolyte in the molten state [hence lower production cost].**

1. Explain why aqueous sodium chloride is not suitable as an electrolyte for the manufacture of sodium in the Down’s Process. (2 Marks)

 **H+ is preferentially discharged, and not Na+ at the anode since Na+ (aq) requires a high potential.**

 **The Na formed will also react explosively with water.**

1. Sodium metal reacts with air to form two oxides. Give the formulae of the two oxides (1 Mark)

 **Na2O** **Na2O2 Reject: Na3N Reject names written in words.**

1. State **two** uses of sodium (2 Marks)

 **The yellow glow of sodium is used in making fog-lights and street lamps**

 **Sodium chloride is used as a food additive**

 **It is used as a reducing agent in the extraction of titanium from its ore**

**[1st two of the candidate’s answers]**

1. The diagram below shows part of the Frasch process, used for the extraction of sulphur. Use it to answer the questions that follow.

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1. Identify **X**  **molten sulphur and water** (1 Mark)
2. Why is it necessary to use superheated water and hot compressed air in this process? (2 Marks)

 **Superheated water melts the sulphur deposits while hot compressed air increases pressure in the sulphur deposit to push the molten sulphur up the middle concentric pipe.**

1. State **two** physical properties of sulphur that makes it possible for it to be extracted by this method. (2 Marks)

 **It does not does not dissolve in water**

 **It has a low melting point // It melts easily**

1. The diagram below shows part of the process in the manufacture of sulphuric (VI) acid. Study it and use it to answer the questions that follow.

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1. Give **two** reasons why air is referred to as a mixture (2 Marks)

 **Its components can be separated by physical means**

 **It does not have a specific melting and boiling point.**

1. What is the role of concentrated sulphuric (VI) acid in **Chamber A**? (1 Mark)

 **It dries the gas produced // It acts as a drying agent.**

1. Name **two** catalysts that can be used in the Catalytic **Chamber B**. (2 Marks)

 **Vanadium (V) oxide**

 **Platinum**

1. State **two** roles of the heat exchanger (2 Marks)

 **It preheats the mixture of sulphur (IV) oxide and air before being taken to the catalytic chamber**

 **It coo ls down the sulphur (VI) oxide prepared in the catalytic chamber**

1. Describe the test for sulphite anion, **SO32**- (2 Marks)

 **Add a few drops of barium nitrate solution to a small of the test substance. Add 1cm3 of hydrochloric acid to the resultant mixture. If a white precipitate that dissolves on addition of hydrochloric acid is observed, it indicates that sulphite ions are present.**

**[marking points are underlined, each scores ½ mark]**

1. Explain the observation made when a few drops of concentrated sulphuric (VI) acid are added to crystals of hydrated copper (II) sulphate. Explain your answer. (2 Marks)

 **The blue crystals turn to white. Blue hydrated copper (II) sulphate loses its water of crystallization and changes to white powder.**

1. Study the reaction scheme below and answer the questions the follow:

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1. What is the distinguishing physical property of **Substance P**? (1 Mark)

 **It has a pleasant smell Reject: It has a sweet smell**

1. Identify a suitable reagent that can be used in **Step I**. (1 Mark)

 **Sodium metal // Potassium metal**

1. Describe a chemical test on how **C3H7COOH** can be distinguished from **C4H9OH**. (2 Marks)

 **Put samples of the C3H7COOH and C4H9OH in separate test tubes. Add a spatula of sodium carbonate in both test tubes. Effervescence of a colourless gas is observed in the test tube containing C3H7COOH while no effervescence is observed in the test tube containing C4H9OH.**

1. Write an equation for the reaction that takes place in **Step III** (1 Mark)

**C4H7OH (l) + 6O2 (g) 🡪 4CO2 (g) + 4H2O (l)**

**[rules for writing chemical equations apply; state symbols may only be ignored if they have not been put completely; if one is stated the all MUST be included]**

1. Name the types of reaction that occur in steps **II**, **III**, **V**, and **VII** (2 Marks)

 **II**  **addition reaction** **III**  **combustion reaction**

 **V**  **addition reaction** **VII**  **oxidation**

**[hydrogenation, esterification etc are considered as processes and NOT types of reaction hence cannot answer the question of ‘type of reaction’]**

1. If 7.4g of butanol completely underwent Step III, determine the volume of gas Z produced at s.t.p. (MGV = 22.4 litres, C = 12, H = 1, O = 16) (3 Marks)



1. Write an equation for the reaction between **R** and one mole of fluorine gas (1 Mark)

**C4H10 (g) + F2 (g) 🡪 C4H9F (g) + HF (g)**

1. Describe a chemical test for **liquid** **X** (2 Marks)

 **Add a few drops of liquid X to white anhydrous copper (II) sulphate powder. The white powder turns to blue crystals**

**OR**

 **Add a few drops of liquid X to blue anhydrous cobalt (II) chloride powder. The blue powder turns to pink crystals.**