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Chemistry Paper 2 (Practical), WASSCE (SC), 2023

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Question 1

(a) What is transition element? [2 marks]

(b) Consider the electron configuration of the following elements:
A= 2: 8:6; B = 2: 8:2; C = 2:8:1; D = 2:8:8
State the element which forms a:
(i) doubly charged cation;
(ii) soluble trioxocarbonate (IV).
[2 marks]

(c) Explain **briefly** why there is a general increase in the **first** ionization energies of the elements across the period in the periodic table.
[2 marks]

(d) Give two examples of an aliphatic compound.
[2 marks]

(e) Explain **briefly** why alkanols are stronger bases than water
[3 marks]

(f) State the **major** raw materials used in the solvay process.
[3 marks]

(g) What is geometric isomerism?
[2 marks]

(h) Give a reason why water gas is a better fuel than producer gas.

(i) Define the term heat o/'combustion.

(j) (i) State Faraday second law of electrolysis.
(ii) Calculate the amount of silver deposited when 10920 coulombs of electricity is passed through a solution of a silver salt.

[IF = 96500 c mol-1]
[5 marks]

Observation

This question was compulsory for all candidates and their performance was average.

In part (a), majority of the candidates could not define a transition element.

In part (b), majority of the candidates stated the element which forms a doubly charged cation and soluble trioxocarbonate (IV).

In part (c), majority of the candidates explained why there is a general increase in the irst ionization energies o the elements across the period in the periodic table.

In part (d), majority of the candidates gave two examples of an aliphatic compound.

In part (e), majority of the candidates could not explain why alkanols are stronger bases than water.

In part (f), majority of the candidates stated the major raw materials used in the solvay process.

In part (g), majority of the candidates could not define geometric isomerism.

In part (h), majority of the candidates gave a reason why water gas is a better fuel than producer gas.

In part (i), majority of the candidates stated *Faraday's second law of electrolysis*. However, few candidates were able to calculate the amount of silver deposited when 10920 coulombs of electricity is passed through a solution of a silver salt if 1F =96500 **C** *mol-1*).

The expected answers include:

(a) A transition element is one which has incompletely filled d-orbitals.

(b) (i) B
(ii) C

(c) Across a period (from left to right) there is a gradual increase in the number of protons in the nucleus / effective nuclear-charge**.** This increases the force of attraction between the nucleus and the electrons, hence more energy is needed to remove the outermost electron.

(d) - methane
- ethene
- ethyne
- ethanol
- ethanoic acid

(e) - Alkanols are formed by replacing one hydrogen of water by an alkyl group **(1)**
- Alkyl groups have a positive inductive effect / are electron releasing/ electron donating
- This increases the electron density of the oxygen

(f) - NaCl
- $CaCO_3$
- NH_3
- C

(g) Geometric isomerism is the existence of two compounds with the same molecular formula but differ in the arrangement of groups attached to the carbon containing the double bond

(h) This is because constituents of water gases (CO and H2) are both combustible and give a higher calorific / heat value than producer gas.

(i) It is defined as the heat change/ released when 1 mole of a substance is burnt in excess oxygen
OR
It is defined as the heat change/ released when 1 mole of a substance is completely burnt in air

(j) (i) When the same quantity of electricity is passed through different electrolytes, the relative number of moles of the elements discharged are inversely proportional to the charges on the ions of the element.

(ii) 96500 C liberates 1.0 mol of Ag(s)
∴ 10920 C will liberate $\frac{10920}{96500}$
= 0.113 mole

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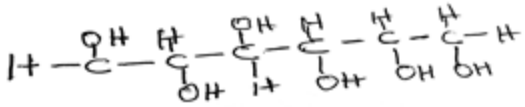
Question 2

(a) In an experiment, 20.0cm3 of a solution containing 4 g dm-3 of sodium hydroxide was
neutralized by 8.0 cm3 of dilute tetraoxosulphate (IV) acid:
(i) write a balanced equation for the reaction;
(ii) calculate the concentration of the acid in mol dm-3
(b) (i) State **two** postulates of the Kinetic theory of gases which real gases do **not** obey.
(ii) Explain **briefly** why real gases do **not** obey the postulates stated in **2**(b)(i)

[6 marks]

(c) Consider the following compound:



(i) name the compound;
(ii) name the **two** structural isomers of the compound;
(iii) state the chemical process involved in the preparation of the compound from starch;
(iv) write the chemical equation for the steps involved in the process in **2**(c)(iii);

(v) name **two** enzymes involved in the process in **2**(c)(iii)
[10 marks]
(d) Explain **briefly** the term structural isomerism
[3 marks]

Observation

This question was popular among the candidates and their performance was average. In part (a), majority of the candidates were able to write and balance the neutralization reaction between NaOH and H_2SO_4.

In part (b), majority of the candidates could not state two postulates of the Kinetic theory of gases which real gases do not obey, and could not explain why real gases do not obey the stated postulates.

In part (c), majority of the candidates did not answer this question, and those who did could not name the compound correctly, and few o them could state the chemical process involved in the preparation of the compound from starch.

In part (d), majority of the candidates were able to explain structural isomerism.

The expected answers include:

a. (i) $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

(ii) Concentration of NaOH **(CB)**

CB = 4/40

= 0.1 mol dm-3

$\frac{CA}{CB} = \frac{VA}{VB} = \frac{1}{2}$

$\frac{CA \times 8}{0.1 \times 20} = \frac{1}{2}$

$CA = \frac{0.1 \times 20 \times 1}{2 \times 8}$

= 0.125 mol dm-3

Alternative method

CB = 4/40 = 0.1 moldm-3

VB = 20/1000 = 0.02dm3

nB = 0.1 x 0.02 = 0.002 mol

∴ nA = 0.002/2 = 0.001 mol

8 cm3 of acid ≡ 0.001 mol

∴ 1000 cm3 = 0.0018 x 1000

= 0.125 moldm-3

(b) (i) - The volume of a gas is negligible compared to the total volume of the container

- There are no forces of attraction or repulsion between molecules of the gas **/** collision between molecules are elastic

(ii) The volume of a gas is not negligible because at high pressure the molecules occupy volume which is appreciable and at low temperature the intermolecular forces of attraction and repulsion become significant

(c) (i) - Glucose

(ii) - Fructose

- Galactose

(iii) -hydrolysis

(d) - Is the existence of compounds with the same molecular formula but different structural formulae **/** arrangement of the atoms / linkage of the atoms

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Question 3

(a) A compound contains 52.2% C, 13.1 % H and Oxygen only. The vapour density of the
compound is 23.
(i) Determine its empirical formula.
(ii) Determine its molecular formula.
(iii) The compound reacts with sodium metal to produce hydrogen gas and when warmed with acidified $KMnO_4(aq)$ gives a solution which turns from purple to colourless.
It also forms a sweet smelling liquid when heated with ethanoic acid in the presence of concentrated H_2SO_4.
(I) name the functional group present in the compound;
(II) draw the structural formula of the compound
[H = 1.0, C = 12.0, O = 16.0]
[10 marks]

(b) Outline the chemical equations for the production of ethanol from cooked cassava.
[6 marks]

(c) (i) Explain **briefly** why a piece of aluminium does **not** react with water.
(ii) How can a pure sample of aluminium chloride crystals be prepared from aluminium. [6 marks]

(d) Describe how water can be separated from aqueous $CuSO_4$.
[3 marks]

Observation

Majority of the candidates did not answer this question satisfactorily, but they did well in question (a).

In part (a), majority of the candidates were able to determine the empirical formula and the molecular formula of the compound.

In part (b), majority of the candidates could not outline the chemical equations for the production of ethanol from cooked cassava.

In part (c), majority of the candidates were able to explain why a piece of aluminium does not react with water. In addition, they were able to describe how a pre sample of aluminium chloride crystals could be prepared from aluminium.

In part (d), majority of the candidates could not describe how water could be separated from aqueous CuSO4.

The expected answers include:

The expected answers include:

(a) (i) % O = 100 – (52.2 + 13.1)
= 34.7

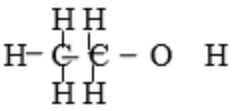
C	H	O
52.2	13.1	34.7
12	1	16
4.35	13.1	2.168
4.35	13.1	2.168
2.168	2.168	2.168
2.00	6.04	1

empirical formula = C_2H_6O

(ii) 2 x vapour density = molecular mass
2 x 23 = 46
(C2H6O)n = 46 **(1)**
[(12x2) + (1x6) + 16]n = 46
46n = 46
n = 1
∴ molecular formula = C2H6O

(iii) I. Hydroxyl

II.



(Accept -OH)

(b) $2(C_6H_{10}O_5)n + nH_2O$ diatase $nC_{12}H_{22}O_{11}$
$C_{12}H_{22}O_{11} + H_2O$ maltase $C_6H_{12}O_6 + C_6H_{12}O_6$
$C_6H_{12}O_6$ zymase $2C_2H_5OH + 2CO_2$

(c) (i) The reaction starts but the metal produces a layer of an oxide / aluminium oxide
Layer on its surface which is impermeable (to water) and stops the reaction.

(ii) Add dilute hydrochloric acid to **excess** aluminium filter off the excess
Metal leave filtrate in a warm place / evaporate filtrate to point of crystallization/ leave in the sun

(d) - The flask is connected to condenser and the solution is heated**.** The water vaporizes and is
converted to (liquid) water in the condenser.

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Question 4

(a) Starting with calcium chloride, describe **briefly** how a solid sample of calcium trioxocarbonate (IV) can be prepared in the laboratory.
[5 marks]

(b) With relevant equations outline the procedure for the purification of impure copper
[7 marks]

(c) Copper reacts with concentrated trioxonitrate (V) acid:
(i) write a balanced chemical equation for the reaction;
(ii) state what would be observed in the reaction;
(iii) state why the copper is oxidized
(iv) an excess of copper is added to 25.0cm3 of 16.0 mol dm-3 HNO_3. Calculate the
volumes of the gas formed at s.t.p.
[H= 1.0, N = 14.0, O = 16.0, Cu = 63.0; Molar volume of gas at s.t.p. = 22.4 dm3]
[9 marks]

(d) (i) pure HNO_3 is a colourless liquid but when exposed to air, it turns yellowish-
brown in colour. Explain **briefly** this observation.
(ii) Write a balanced equation for the laboratory preparation of hydrogen trioxonitrate (V) acid.
[4 marks]

Observation

This question was not popular among the candidates as majority of them avoided it. Few candidates that responded to it performed below average.

In part (a), majority of the candidates could state how a solid sample of calcium trioxocarbonate (IV) can be prepared in the laboratory by starting with calcium chloride.

In part (b), majority of the candidates could not outline the procedure for the purification of impure copper using relevant equations.

In part (c), majority of the candidates could not write a balanced chemical equation for the reaction of copper with concentrated trioxonitrate (V) acid. In addition to this, they could not state what would be observed in the reaction.

In part (d), few candidates stated the brown colour of NO2, but failed to say it dissolved in the acid to cause the colouration.

The expected answers include:

1. (a) Water is added to the $CaCl_2$ to form a solution**.** Na_2CO_3 is then added to the Solution to precipitate $CaCO_3$ which is filtered, washed and dried**.**

(b) Electricity is passed through a solution of $CuSO_4$ using an impure copper as the Anode and pure copper as the cathode.
During electrolysis, the anode loses mass as copper dissolves and the cathode gains mass as
copper is deposited**.**

Anode: $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$
Cathode: $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

(c) (i) $Cu(s) + 4HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2NO_2(g) + 2H_2O(l)$
(ii) - blue solution
- (reddish) brown gas
- gas bubbles / effervescence
- metal dissolves / metal disappears
(iii) Because copper loses electrons **/** oxidation number increases
(iv) Moles of acid = 0.025 x 16
= 0.4 mole

$$\text{Moles of } NO_2 = \frac{\text{moles of acid}}{2}$$

= 0.2 mole
Volume of gas (NO_2) at s.t.p. = 0.2 x 22.4 dm^3 = 4.48 dm^3
Alternative
$C_1V_1 = C_2V_2$
16.0 x 25 = C_2 x 1000
C_2 = 16.0 * 251000
= 0.40 mol
4 mol HNO_3 = 63g Cu
0.4 mol = 6.3g Cu
63g Cu = 2 x 22.4 dm^3 NO_2
6.3 g Cu = 44.863 x 6.3
= 4.48 dm^3

(d) (i) Pure HNO_3 undergoes decomposition to NO_2 (brown gas) **(1).** This gas dissolves (**1)** in the rest
of the acid leaving it with that colour
(ii) - $2KNO_3 + H_2SO_4 \rightarrow K_2SO_4 + 2HNO_3$
- $NaNO_3 + H_2SO_4 \rightarrow NaHSO_4 + HNO_3$
- $2NaNO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2HNO_3$
- $KNO_3 + H_2SO_4 \rightarrow KHSO_4 + HNO_3$

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Question 5

(a) Describe how iron and aluminium reacts with **each** of the following substances:
(i) dilute H_2SO_4;
(ii) dilute HNO_3
[8 marks]

(b) (i) Write an equation for the burning of sulphur in air
(ii) Name the catalyst used in the contact process.
(iii) In the contact process, why is an excess of air used?
(iv) Why is it necessary to cool the catalyst used **5**(b)(ii)?
(v) Give a reason why the air used in the contact process needs to be as clean as possible
(vi) State **two** reasons why SO_2 should **not** be discharged into the atmosphere.
[7 marks]

(c) (i) State the reagents and condition used in the laboratory preparation of chlorine.
(ii) State **two** uses of chlorine
[5 marks]

(d) (i) Name the drying agents for **each** of the following gases:
(I) hydrogen;
(II) Sulphur (IV) oxide;
(III) ammonia.
(ii) State the components of the following alloys;
(I) Bronze;
(II) Brass.
[5 marks]

Observation

This question was popular among the candidates as most of them responded to it.

In part (a), majority of the candidates could not describe the reaction of aluminium and iron with dilute H_2SO_4 and dilute HNO_3.

In part (b), majority of the candidates were able to write an equation for the burning of sulphur in air, named the catalyst in the contact process and gave a reason why excess air is used in the contact process.

In part (c), majority of the candidates stated the reagents and condition used in the laboratory preparation of chlorine. Also, they stated the uses of chlorine.

In part (d), majority of the candidates wrote the names of the drying agents instead of the formulae.

The expected answers include:

(a) (i) Iron dissolves readily in dilute H_2SO_4 liberating hydrogen and forming $FeSO_4$ while with Aluminium there is no reaction
(ii) With aluminium there is no reaction while iron dissolves in dilute HNO_3 liberating Hydrogen and forming $Fe(NO_3)_2$

(b) (i) $S + O_2 \rightarrow SO_2$
(ii) Vanadium (V) oxide **/** platinized asbestos
(iii) To favour the formation of more product / SO_3
(iv) The reaction is exothermic / high temperature favours the formation of more reactants/
backward reaction
(v) Catalysts are easily poisoned / easily damaged by dirt
(vi) - SO_2 damages buildings
- damages living things
- causes acid rain
- causes irritation to eyes, nose and throat
- causes lungs and respiratory diseases eg coughing, bronchitis etc

(c) (i) reagents - manganese (IV) oxide / MnO_2
- concentrated HCl
condition - heating
OR
Concentrated HCl
Bleaching powder / $CaOCl_2$/ $KMnO_4$ crystals
Room temperature

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