

2024 WASSCE CHEMISTRY

OBJECTIVE TEST QUESTIONS

- Which of the following gases could be collected by downward displacement of air? A. Chlorine B. Hydrogen C. Hydrogen chloride D. Sulphur (IV) oxide
- Which of the following substances has the **lowest** boiling point? A. Aqueous sodium chloride B. Ethanol. C. Tetra-chloromethane D. Water
- The branch of science that deals with the nature and properties of substances and how one substance can be converted to another is known as A. biology. B. chemistry. C. geography. D. physics.
- The electron configuration $1s^2 2s^2 2p_x^2$ contravenes the A. Pauli's exclusion principle. B. Aufbau's principle. C. Octet rule. D. Hund's rule.
- The oxidation number of chromium in $\text{Na}_2\text{Cr}_2\text{O}_7$ is A. +2. B. +6. C. +7. D. +12.
- The **most** important ore of aluminium is A. bauxite. B. haematite. C. magnetite. D. monazite.
- Bases normally A. are corrosive B. turn litmus paper from blue to red. C. turn litmus paper from red to blue. D. are non-metal oxides.
- The product of the reaction between ethanol and excess acidified $\text{K}_2\text{Cr}_2\text{O}_7$ is A. $\text{CH}_2=\text{CH}_2$. B. CH_3OCH_3 . C. CH_3COOH . D. CH_3CH_3
- The product formed when concentrated sodium chloride solution is electrolysed using carbon electrodes is A. chloride water. B. hydrochloric acid. C. sodium hydroxide. D. sodium oxochlorate (I).
- Which of the following statements about ammonium salt is **correct**? It A. dissolves in water to form solution of $\text{pH} > 1$. B. dissolves in water to form solution of $\text{pH} < 7$. C. does not decompose on heating. D. is insoluble in water.
- Ethanedioic acid is an organic solid that can be purified by A. decantation. B. distillation. C. crystallization. D. filtration.
- Which of the following functional groups is present in alkanolic acid? A. $-\text{COOH}$ B. $-\text{OH}$ C. $-\text{COOR}$ D. $-\text{CHO}$
- In ethanol, the attractive forces between adjacent molecules are A. covalent bonds only. B. hydrogen bonds only. C. hydrogen bonds and van der Waal's forces. D. van der Waal's forces only.
- At 25°C , the saturated solution of a salt in water was found to contain 0.24 g of the salt in 100 cm^3 . What is the solubility of the salt in g dm^{-3} ? A. 0.024 B. 0.240 C. 2.40 D. 24.0
- The reaction represented by the equation:

$$\text{Ni}_{(\text{aq})}^{2+} + \text{Fe}_{(\text{s})} \longrightarrow \text{Ni}_{(\text{s})} + \text{Fe}_{(\text{aq})}^{2+}$$
 is a redox reaction because
 A. Ni^{2+} ions are oxidized and Fe acts as an oxidizing agent. B. ions are oxidized and Fe acts as a reducing agent. C. Ni^{2+} ions are reduced and Fe acts as an oxidizing agent. D. Ni ions are reduced and Fe acts as a reducing agent.
- Which of the following statements describes transition elements? They A. are very reactive. B. have low melting points. C. possess variable oxidation state. D. form colourless salts.
- Aluminium is suitable for making alloys for aircraft construction because it A. is hard and brittle. B. is light and very resistant to corrosion. C. has high density and also a non-conductor of electricity. D. is amphoteric and allo-tropic
- Which of the following arrangements of elements is in order of increasing ionization energy? A. Si, Al, S, P B. S, P, Si, Al C. Al, Si, P, S D. P, Si, S, Al
- Consider the reaction represented by the equation:

$$\text{C}_3\text{H}_8 + 5\text{O}_{2(\text{g})} \longrightarrow 3\text{CO}_{2(\text{g})} + 6\text{H}_2\text{O}_{(\text{l})}$$
 If 0.1 mole of $\text{C}_3\text{H}_{8(\text{g})}$ was completely burnt, what volume of $\text{CO}_{2(\text{g})}$ would be produced at STP ? [volume at $\text{STP} = 22.4\text{ dm}^3\text{ mol}^{-1}$]. A. 6.72 dm^3 B. 2.24 dm^3 C. 0.30 dm^3 D. 0.10 dm^3
- Naturally occurring Boron is made up of 19.9% ^{10}B and 80.1% ^{11}B . The relative atomic mass of Boron is A. 21.0. B. 10.8. C. 10.5. D. 10.0.
- The number of shared pair of electrons in a molecule of methane is A. 2. B. 4. C. 6. D. 8.
- Isotopes of the same element have similar chemical properties because they have the same number of A. nuclides. B. protons. C. neutrons. D. atoms.
- Which of the following household liquids would be effective in treating someone with too much acid in the stomach? A. Strong salt solution with $\text{pH} 7.0$ B. Tomato juice with $\text{pH} 4.1$ C. Milk of magnesia with $\text{pH} 10.5$ D. Black coffee with $\text{pH} 5.0$
- The percentage by mass of oxygen in $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ is [$\text{Mr} = 246$]. A. 26.0 %. B. 45.5 %. C. 71.5 %. D. 84.0 %.
- Catalysts alter reaction rates by A. providing an alternative reaction pathway. B. lowering the energy of reaction. C. increasing the surface area of reactants. D. aligning the reactant molecules properly.
- Ethane of volume 400 cm^3 was completely burnt in excess oxygen according to the following equation:

$$2\text{C}_2\text{H}_{6(\text{g})} + 7\text{O}_{2(\text{g})} \longrightarrow 6\text{H}_2\text{O}_{(\text{g})} + 4\text{CO}_{2(\text{g})}$$
 Calculate the volume of steam that would be produced. A. 200 cm^3 B. 400 cm^3 C. 600 cm^3 D. 1200 cm^3
- A saturated solution at 30°C will normally to produce crystals at a temperature of A. 50°C . B. 40°C . C. 35°C . D. 20°C .
- The following organic compounds are polymers except A. rubber. B. starch. C. proteins. D. fats.
- According to the collision theory of reaction rates, which of the following conditions is **not** required for two molecules to react? The molecules **must** A. come into contact without loss of energy on colliding with each other. B. collide with enough energy to overcome the activation energy barrier. C. collide in an orientation that makes formation of product possible. D. possess enough speed to overcome inter-molecular forces of attraction.
- A weak acid is one which A. is not corrosive. B. completely ionizes in water. C. does not produce salt with alkali. D. slightly ionizes in water.
- Which of the following conditions are necessary for the preparation of alkanoates from alkanols and alkanolic acids? A. Water and NaOH B. Conc. H_2SO_4 and heat C. NaOH and heat D. Water and aqueous HCl
- The volume of 22 g of CO_2 at STP is equivalent to [$\text{C} = 12$, $\text{O} = 16$, molar volume at $\text{STP} = 22.4\text{ dm}^3$]. A. 22.0 dm^3 . B. 22.4 dm^3 . C. 11.2 dm^3 . D. 5.6 dm^3 .
- Pairs of outermost shell electrons which are not used in bonding are A. lone pairs. B. bonding pairs. C. valence electrons. D. electrovalent electrons.
- ${}_8\text{X}^{2-}$ and ${}_{10}\text{Y}$ are A. isomers. B. isotopes. C. allotropes. D. isoelectronic.
- Pure water contaminated with quicklime will have a pH of A. 1. B. 6. C. 7. D. 8
- The electron configuration of ${}_{29}\text{Cu}$ is A. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$. B. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^9$. C. $1s^2 2s^2 2p^5 3s^2 3p^6 4s^2 3d^{10}$. D. $1s^2 2s^2 2p^6 3s^2 3p^2 4s^1 3d^{10}$.
- When s and p block elements react, the bond formed is A. electrovalent. B. covalent. C. metallic. D. dative-covalent.
- The **hardest** form of carbon is A. charcoal. B. coke. C. diamond. D. graphite.
- The metallic bonding in aluminium is strong because of large number of A. delocalized electrons. B. immobile electrons. C. lone pair electrons. D. valence electrons.
- How many covalent bonds are formed by Nitrogen? A. 1 B. 2 C. 3 D. 4
- When an element exists in **two or more** forms in the same physical state, it exhibits A. isotopy. B. allotropy. C. isobars. D. isomerism.
- An atom of an element in the ground state contains 8 valence electrons. The element is considered as a A. metal. B. semi-metal. C. noble gas. D. halogen.

43. The main function of limestone in the blast furnace during the extraction of iron is to A. act as a catalyst. B. remove impurities. C. act as a reducing agent. D. supply carbon (V) oxide.
44. Which of the following is a monomer of polythene? A. Ethanol B. Vinyl chloride C. Ethene D. Ethane
45. Which of the following compounds is formed by the oxidation of ethanol? A. $C_2H_4CO_2H$ B. C_2H_5OH C. CH_3OH D. CH_3CO_2H
46. Tetraoxosulphate (VI) acid is considered as a heavy chemical because A. its relative molecular mass is high. B. a high tonnage is produced every year. C. it is an inorganic chemical. D. it is used to manufacture heavy chemicals.
47. How many isomers can be formed from a compound with molecular formula C_5H_{12} ? A. One B. Two C. Three D. Four
48. The oxidation number of iron in its free state is A. 0. B. +1. C. +2. D. +3.
49. Water pipes are produced from A. Polyethene. B. Perspex. C. Polystyrene. D. Polyvinyl chloride.
50. Consider the reaction represented by the following equation:
 $xAl + yClU_2 \rightarrow zAlCl_3$
 The value of x, y and z respectively are A. 2, 3 and 2. B. 2, 2 and 3. C. 1, 2 and 1. D. 1, 1 and 1

CHEMISTRY ESSAY SECTION A

- 1(a) What is an *electrochemical cell*?
- (b) State **three** differences between an *electrochemical cell* and an *electrolytic cell*.
- (c) Explain **briefly** what would be observed when powdered zinc is added to a solution of copper (II) tetraoxosulphate (IV) in a beaker.
- d(i) Write an equation for the reaction in 1(c);
- (ii) State the type of reaction which took place in 1(c);
- (e) Name **two** gases which should be prepared in a fume chamber.
- (f) Give **three** factors that favour cracking
- (g) Give the reason why noble gases are chemically inert.
- (h) State **four** properties of a homologous series
- (i) What is *global warming*?
- (j) State **one** cause of global warming.

SECTION B

- 2a(i) Define **each** of the following terms;
 I. Deliquescence; II. efflorescence
- (ii) Give **one** example of a substance that undergoes **each** of the processes in 2a(i)
- b(i) What is meant by *ionization energy*?
- (ii) The second ionization energy value of sodium is **greater** than the first ionization energy. **Briefly** give an explanation for this observation.
- c(i) State *Charles's law*
- (ii) Sketch a graph to illustrate Charles's law.
- (iii) A gas occupies 150 cm^3 at 21°C . What

would be its volume if the temperature is raised to 45°C and the pressure is kept constant?

- d(i) Write chemical equations to illustrate what happens when **each** of the following oxides is dissolved in water:
 (I) sodium oxide;
 (II) phosphorus (III) oxide;
 (III) chlorine (VII) oxide;
 (IV) magnesium oxide.
- (ii) Arrange the solutions in 2d(i) in order of increasing acidity.

- 3a(i) Write balanced chemical equations for the production of lead (II) chloride by:
 I. direct combination of constituent elements;
 II. double decomposition;
 III. displacement reaction.
- (ii) State **one** condition that would increase the rate of reaction for **each** of the reactions stated in 3a(i).
 I. II. III.

- (b) Consider the following reaction equation:
 $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$; $\Delta H = \text{positive}$

- (i) state **two** conditions that would increase the yield of $SO_3(g)$;
- (ii) If 60 cm^3 of SO_2 reacts with 40 cm^3 of O_2 , determine the volume of the residual gas, assuming that the reaction goes to completion in a cylinder;
- (iii) what is the change in the oxidation number of sulphur in the reaction 3(b)?
- (c) Using structural diagrams, explain why cyclopropane is **not** an isomer of n-propane.
- (d) A saturated organic compound X containing **three** carbon atoms reacted with butanoic acid in the presence of dilute H_2SO_4 to form a sweet smelling compound Y.
- (i) Name compounds X and Y
- (ii) State the functional group present in X.
- (iii) Write an equation for the reaction between X and butanoic acid

- 4(a) Write a balanced chemical equation for **each** of the following reactions:

- (i) ammonia gas with copper (II) oxide;
 (ii) ammonia gas with oxygen gas;
 (iii) aqueous potassium iodide with chlorine gas;
 (iv) iron with dilute tetraoxosulphate (VI) acid;
 (v) aqueous lead (II) trioxonitrate (V) with hydrogen chloride gas

- b(i) Describe **briefly** the process involved in the extraction of tin from tin ore.

- (ii) Mention **three** uses of hydrogen.
- (iii) State **two** physical properties of hydrogen.
- (b) State the class of oxide to which **each** of the following compounds belong;
 (i) Na_2O ; (ii) ZnO ; (iii) SO_2 ; (iv) CO_2 ;
 (v) N_2O .

- 5a(i) Write the chemical formula of alumina.

- (ii) In the extraction of aluminum, state

one compound that is used;

- I. to obtain alumina from bauxite;
 II. as solvent for alumina.

- (iii) name the electrodes used in the extraction of aluminum.

- (iv) Give **one** reason why the extraction of aluminum is expensive

- (v) In the extraction of aluminum:

- I. name the substance liberated at the anode;

- II. write the equation for the reaction that leads to decrease in the size of the anode.

- b(i) Give **two** ions that cause hardness of water.

- (ii) State **two** advantages and **two** disadvantages of hard water.

- c(i) What is meant by *destructive distillation* of coal?

- (ii) Name **four** products obtained from the destructive distillation of coal.

- d(i) Name **two** gases which can be used to demonstrate the fountain experiment.

- (ii) Give the reason why the gases named in 5d(i) are used.

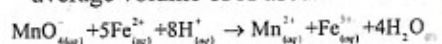
ALTERNATIVE TO PRACTICAL A QUESTIONS

1. A is a solution of $KMnO_4$ containing 0.020 mol dm^{-3} . B is a solution of Fe^{2+} obtained by dissolving 3.8 g of iron granules in 250 cm^3 of solution.

- (a) Put A in the burette. Pipette 20.0 cm^3 or 25.0 cm^3 of B into a conical flask and add 10 cm^3 of H_2SO_4 . Titrate it with A.

Repeat the titration to obtain **concordant** titre values.

Tabulate your result and calculate the average volume of A used.



[$KMnO_4 = 158.0$, $Fe = 56.0$]

- (b) From your results and information provided, calculate the:

- (i) concentration of B in mol dm^{-3} ;
 (ii) concentration of B in g dm^{-3} ;
 (iii) mass of Fe^{2+} in 250 cm^3 of B;
 (iv) percentage of Fe^{2+} in the granules.

2. C is a mixture of **two** simple inorganic salts, **one** of which is a sodium salt. Perform the following exercises on C. Record your observation and identify any gas(es) evolved. State the conclusions you draw from the results of **each** test.

- (a) Put all of C into a test tube and add about 10 cm^3 of distilled water and shake.

- b(i) Put about 2 cm^3 of the filtrate into a boiling tube and heat strongly.

- (ii) Put half of the residue into a test tube and add dil. HCl.

- (iii) To about 2 cm^3 of the clear solution from (ii), add aqueous NaOH in drops, then in excess.

- (iv) To another 2 cm^3 of the clear solution from (ii), add aqueous ammonia in drops, then in excess.

- 3(a) Mention **two** gases that are soluble in water

- (b) Name **two** apparatus that could be

used to measure 9.50 cm^3 of a solution accurately.

What is the use of a fume-cupboard in the laboratory?

Name three personal protective equipment that are used in the laboratory

2014 WAEC CHEMISTRY ALTERNATIVE B QUESTIONS

D contains 6.30 g of HNO_3 in 500 cm^3 of sodium. E was prepared by dissolving 8.20 g of washing soda crystals ($\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$) in 250 cm^3 of distilled water.

Put D into the burette and titrate it against 20.0 or 25.0 cm^3 portion of E using methyl orange as indicator. Repeat the exercise to obtain concordant titre values.

Tabulate your results and calculate the average volume of the acid used.

Write a balance chemical equation for the reaction.

From your results and the information given;

calculate the concentration of E in mol dm^{-3} ;

what is the value of x in $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$?
[$H = 1.0$; $C = 12.0$; $O = 16.0$;
 $Na = 23.0$; $N = 14.0$]

F is an inorganic salt. Carry out the following exercises on F. Record your observations and identify any gas(es) evolved. State the conclusions you draw from the results of each test.

(a) Transfer F into a test tube and add dil. HCl to it until a clear solution is obtained.

(b) Divided the clear solution obtained from (a) into two portions.

(i) To the first portion, add $\text{NaOH}_{(aq)}$ in drops and then in excess. Warm the resulting mixture

(ii) To the second portion, add few drops of potassium hexacyanoferrate (II) solution.

3(a) An aqueous solution of a salt was added to excess sodium trioxocarbonate (IV) solution in a test tube. There was effervescence, the test tube became warm and a white precipitate was observed. State three inferences that could be drawn from these observations.

(b) Consider the following salts;
 NH_4Cl ; PbSO_4 ; NaHCO_3 ; and $\text{Cu}(\text{NO}_3)_2$

Select from the list, the salt(s) which:

- would not readily dissolve in water;
- produce(s) effervescence with dilute mineral acids;

(iii) decompose(s) on heating;

(iv) dissolve(s) in water to form an alkaline solution;

(v) sublime(s) on heating.

(c) A solution of an acid was titrated with sodium hydroxide solution using methylorange as the indicator. State

three precautions that are necessary when carrying out such an experiment.

2014 WASSCE CHEMISTRY (OBJECTIVE) SOLUTIONS

1. B:

- Gases that are denser than air are collected by downward delivery or upward displacement of air.

- Gases that are less dense than air are collected by upward delivery or downward displacement of air.

- It is when the R.M.M of a gas is greater than 28.8 that we consider it denser than air.

- When the R.M.M of a gas is less than 28.8, the gas is less dense than air.

$\text{Cl}_2 = 35.5 \times 2 = 71 \Rightarrow$ Denser than air

$\text{H}_2 = 1 \times 2 = 2 \Rightarrow$ less dense than air

$\text{HCl} = 1 + 35.5 = 36.5 \Rightarrow$ Denser than air

$\text{SO}_2 = 32 + (16 \times 2) = 64 \Rightarrow$ Denser than air

Clearly, hydrogen is the only one here that is less dense than air. It is thus collected by downward displacement of air (or upward delivery).

2. C:

Due to the presence of hydrogen bond, ethanol and water have considerably high boiling point. Tetrachloromethane has no hydrogen bond in its. Its boiling point is therefore relatively low. What of aqueous sodium chloride? Its boiling point is even higher than that of pure water. If we have to rank the four substances based on their boiling point, we will have:
Aqueous $\text{NaCl} > \text{H}_2\text{O} > \text{C}_2\text{H}_5\text{OH} > \text{CCl}_4$.

3. B:

Chemistry deals with the study of matter, its properties, composition, structure and the changes it undergoes. It explores how substances interact with one another and with energy, encompassing various branches such as organic chemistry, inorganic chemistry, physical chemistry, analytical chemistry and biochemistry.

4. D:

You can't pair up the electron in the $2p_x$ orbital when $2p_y$ and $2p_z$ are empty. Thus, the configuration $1s^2 2s^2 2p_x^2$ contravenes Hund's rule.

Hund's rule of maximum multiplicity states that electrons will fill degenerate orbitals singly before pairing occurs.

5. B:

$\text{Na} + 1, \text{O} = -2$.

So, for $\text{Na}_2\text{Cr}_2\text{O}_7$, we have:

$(+1 \times 2) + 2\text{Cr} + (-2 \times 7) = 0$

$2 + 2\text{Cr} - 14 = 0$

$$2\text{Cr} - 12 = 0$$

$$2\text{Cr} = +12$$

$$\text{Cr} = +\frac{12}{2} = +6$$

6. A:

The most important ore of aluminium produce alumina through the Bayer process. Alumina is then smelted into aluminium using the Hall-Heroult process.

7. C:

- Acids are corrosive (strong and conc. ones)

- Alkalis are caustic

- Acid solutions turn blue litmus paper red

- Alkaline solutions turn red litmus paper blue

8. C:

Ethanol reacts with excess acidified $\text{K}_2\text{Cr}_2\text{O}_7$ to produce ethanoic acid. If the oxidizing agent is present in limited amount, ethanal is produced instead of ethanoic acid.

9. C:

The electrolysis of concentrated sodium chloride solution using carbon electrodes results in the production of chlorine gas (Cl_2) at the anode, hydrogen gas (H_2) at the cathode and resultant solution of sodium hydroxide (NaOH).

10. B:

An ammonium salt like NH_4Cl dissolves in water to form a solution whose pH is less than 7.

11. C:

Oxalic acid ($\text{H}_2\text{C}_2\text{O}_4$), also known as ethanedioic acid can be purified through crystallization. It is first dissolved in hot water, impurities are then removed by filtration. Upon cooling, pure form of the acid crystallizes out due to reduced solubility, forming crystals that are separated, washed and dried to obtain a purified product suitable for various applications.

12. A:

Alkanoic acids (also known as carboxylic acids) contain the carboxyl functional group, which is represented as $-\text{COOH}$. This group consists of a carbonyl group ($\text{C} = \text{O}$) and hydroxyl group (OH).

13. C:

Both hydrogen bonds and Van der Waal's forces are involved in the attraction between adjacent molecules of ethanol.

14. C:

Mass of solute = 0.24 g

Volume of solution = 100 cm^3
 $= 0.1 \text{ dm}^3$

Solubility (in g dm^{-3}) = $\frac{0.24 \text{ g}}{0.1 \text{ dm}^3}$
 $= 2.4 \text{ g dm}^{-3}$

15. D:

In the reaction $\text{Ni}^{2+} + \text{Fe} \rightarrow \text{Ni} + \text{Fe}^{2+}$,

- Ni^{2+} is reduced to Ni

- Fe is oxidized to Fe^{2+}

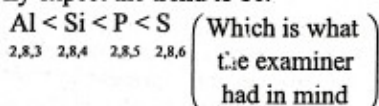
- A species that is reduced is the oxidizing agent

dizing agent while that which is oxidized is the reducing agent. Thus, Ni^{2+} is the oxidizing agent while Fe is the reducing agent.

16. C:
 - Transition elements have variable oxidation state.
 - They form coloured compounds.
 - They form complex ions
 - They have high melting and boiling points

17. B:
 Aluminium is ideal for aircraft construction because it is lightweight, highly resistant to corrosion and strong when alloyed with other metals.

18. C:
 Since ionization energy is known to increase across the period, we can easily expect the trend to be:



NB:

It should be learnt that this commonly submitted opinion is not correct, at least not every time. The ionization energy of phosphorous is actually higher than that of sulphur. Phosphorous has the electron configuration $[\text{Ne}]3s^23p^3$. This half filled p orbital configuration is relatively stable. So, the correct trend should be $\text{Al} < \text{Si} < \text{S} < \text{P}$

19. A:
 $\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$

↓
 0.1 mole

From the balanced equation, 1 mole of C_3H_8 will produce 3 moles of CO_2 . Thus, 0.1 mole of C_3H_8 will produce 0.3 mole of CO_2 .

$$\text{Mole of a gas} = \frac{\text{Volume at stp}}{\text{G.M.V.}}$$

$$0.3 = \frac{\text{Volume at stp}}{22.4 \text{ dm}^3}$$

$$\text{Volume at stp.} = (0.3 \times 22.4) \text{ dm}^3 = 6.72 \text{ dm}^3$$

20. B:
 $\text{R.A.M.} = m_1 \times \%_1 + m_2 \times \%_2$
 $= 10 \times \frac{19.9}{100} + 11 \times \frac{80.1}{100}$
 $= 1.99 + 8.811$
 $= 10.801$

21. B:
 A molecule of methane (CH_4) has four shared pairs of electrons. Each hydrogen atom forms a single covalent bond with the carbon atom, and each covalent bond consists of a pair of shared electrons.

22. B:
 Isotopes of the same element have the same number of protons but different number of neutrons. Since they have the same number of protons but different number of neutrons. Since they have the same number of protons, they will also have the same number

of electrons their chemical properties are thus expected to be similar since chemical properties depend on electronic structures.

23. C:
 A substance that can be used to treat excess acidity must be alkaline (the pH must be greater than 7).

24. C:
 $\text{MgSO}_4 \cdot 7\text{H}_2\text{O} = 246 \text{ g/mol}$.
 Here, there are a total of eleven oxygen atoms.

$$\begin{aligned} \therefore \% \text{ oxygen} &= \frac{16 \times 11}{246} \times 100\% \\ &= \frac{176}{246} \times 100\% \\ &= 71.54\% \end{aligned}$$

25. A:
 Catalysts alter reaction rate by lowering the activation energy. They achieve this by providing an alternative pathway for the reaction to occur.
 NB:

Do not mistake the energy of reaction for the activation energy. The energy of reaction is simply the enthalpy change.

26. D:
 $2\text{C}_2\text{H}_6 + 7\text{O}_2 \rightarrow 6\text{H}_2\text{O} + 4\text{CO}_2$
 Let the volume of steam produced be V .
 From the equation of reaction, we have:

$$\begin{array}{ccc} \text{C}_2\text{H}_6 & & \text{H}_2\text{O} \\ \text{C}_2\text{H}_6 & \times & \text{H}_2\text{O} \\ 400 \text{ cm}^3 & & V \\ V = \frac{400 \text{ cm}^3 \times 6}{2} = 1200 \text{ cm}^3 \end{array}$$

27. D:
 A saturated solution at 30°C will normally produce crystals at any temperature that is less than 30°C .

28. D:
 Rubbers, starch and proteins are all polymers. Fats, on the other hand, are not polymers. They are triglycerides, consisting of three fatty acid chains attached to a glycerol molecule. While fats are large molecules, they are not composed of repeating units

29. A:
 The collision theory assumes that the colliding molecules have sufficient energy to overcome the intermolecular forces of attraction and the activation energy barrier, but it does not require that the collision be perfectly elastic (no loss of energy)

30. D:
 A strong acid is one which ionizes completely in solution while a weak acid ionizes only partially.

31. B:
 The reaction between alkanols and alkanolic acids to produce alkanoates is known as **esterification**. Esterification requires the following conditions:
 - **Acid catalyst**: Typically sulphuric acid to speed up the reaction.
 - **Heat**: To provide the necessary energy for the reaction

32. C:
 Molar mass of $\text{CO}_2 = 44 \text{ g/mol}$.

$$\text{Mole of } \text{CO}_2 = \frac{22 \text{ g}}{44 \text{ g mol}^{-1}} = 0.5 \text{ mol}$$

$$\begin{aligned} \text{Volume at s.t.p.} &= \text{mole} \times \text{G.M.V.} \\ &= (0.5 \times 22.4) \text{ dm}^3 \\ &= 11.2 \text{ dm}^3 \end{aligned}$$

33. A: Lone pairs of electrons are pairs of valence electrons that are not involved in chemical bonding. Lone pairs can influence the shape and reactivity of molecules.

34. D:
 ${}_8\text{X}$ contains 8 protons and consequently 8 electrons. However, ${}_8\text{X}^{2-}$ will contain 2 more electrons since an atom becomes negatively charged after gaining electrons. Thus, ${}_8\text{X}^{2-}$ contains 10 electrons. Also, ${}_{10}\text{Y}$ contains 10 electrons. Thus, ${}_8\text{X}^{2-}$ and ${}_{10}\text{Y}$ are isoelectronic (they contain equal number of electrons).

35. D:
 Quicklime is basic. Thus, a sample of water contaminated with quicklime will have a pH greater than 7.

36. A:
 ${}_{24}\text{Cr} \neq 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^4$
 ${}_{24}\text{Cr} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$.
 This is because the second configuration offers greater stability.

37. A:
 When s -block elements (which are metals) react with p -block elements (which are often non-metals), the bond formed is electrovalent/ionic. The s -block element loses electron(s) to become a cation and the p -block element gains the electron(s) to become an anion. The attraction between the ions form ionic bond

38. C:
 The hardest form of carbon is diamond. Diamond has a crystal lattice structure where each carbon atom is tetrahedrally bonded to four other carbon atoms, creating a very strong and rigid three-dimensional network, which accounts for its exceptional hardness.

39. A:
 The strength of the metallic bond in aluminium is due to the large number of delocalized electrons. Aluminium atoms contribute three valence electrons each to the sea of electrons that surrounds the positively charged metal ions. This high density of delocalized electron results in strong metallic bonding.

40. C:
 Nitrogen forms three covalent bonds. This is because nitrogen has five valence electrons and needs three more electrons to complete its valence shell and achieve a stable octet configuration. In forming three covalent bonds, nitrogen can share three of its valence electrons with other atoms, resulting in a total of 8 electrons in its valence shell.

41. B:
 Allotropy is the phenomenon where

an element can exist in two or more different physical forms in the same physical state. These different forms have distinct structures and properties. For example, carbon has several allotropes including diamond, graphite and graphene, each with unique arrangements of carbon atoms and corresponding physical properties.

42. C: Noble gases contain 8 valence electrons, with the exception of helium, which has 2 valence electrons. This configuration provides them with a complete valence shell, making them very stable and chemically inert.

43. B: In the blast furnace during iron extraction, limestone decomposes at high temperature to form calcium oxide and carbon (IV) oxide. The calcium oxide then reacts with silica (SiO_2), an impurity in the iron ore, to form calcium silicate (CaSiO_3), a slag that floats on the molten iron. This slag is easily removed, thereby purifying the iron.

44. C: Ethene is the monomer used to produce polythene. During polymerization process, ethene molecules undergo a chemical reaction to form long chains, creating the polymer known as polythene.

45. D: The complete oxidation of ethanol produces ethanoic acid (CH_3COOH).

46. B: H_2SO_4 is considered a heavy chemical because it is produced in large quantities and is fundamental to many industrial processes. It is used in the manufacture of fertilizers, petroleum refining etc.

47. C: C_5H_{12} has three isomers:

(i) $\text{C}-\text{C}-\text{C}-\text{C}-\text{C} \Rightarrow n\text{-heptane}$

(ii) $\text{C}-\text{C}-\text{C}-\text{C} \Rightarrow 2\text{-methylbutane}$

(iii) $\text{C}-\text{C}-\text{C} \Rightarrow 2,2\text{-dimethylpropane}$

48. A: The oxidation number of any element (not just iron) in its free state is zero.

49. D: Water pipes are produced from PVC (Polyvinyl chloride) because PVC is durable, light, relatively inexpensive and resistant to corrosion. They are also easy to install and maintain

50. A: The balanced equation of reaction is:
 $2\text{Al} + 3\text{Cl}_2 \rightarrow 2\text{AlCl}_3$
 If compared to $x\text{Al} + y\text{Cl}_2 \rightarrow z\text{AlCl}_3$, it follows that $x = 2$, $y = 3$ and $z = 2$

ESSAY THEORY SOLUTIONS SECTION A

1. Electrochemical cell is a device for converting chemical energy to electrical energy. It is a device that uses a chemical or redox reaction to generate

electrical current.

(b)

Electrochemical Electrolytic cell cell

• Chemical reaction produces electricity

• Electrons are produced as a result of oxidation at anode

• Cathode is the positive electrode

• Anode is the negative electrode

• Electrodes are in separate compartments (two half cells) with salt bridge

• Does not require an external source of energy i.e. it is spontaneous

(c) **Observation:** Colour of the solution changes from blue to colourless and a brown deposit is observed.

d(i) $\text{Zn}_{(s)} + \text{CuSO}_{4(aq)} \rightarrow \text{Cu}_{(s)} + \text{ZnSO}_{4(aq)}$

(ii) Displacement/Redox reaction

(e) - Chlorine, - Sulphur (IV) oxide,

- Hydrogen sulphide, - Ammonia

(f) **Factors that favour cracking:**

- high temperature, - high pressure, - catalyst

(g) The noble gases are chemically inert because their outermost shells or valence shells are completely filled

(h) Properties of homologous series

• A member differs from the preceding/successive member by $-\text{CH}_2$ or 14 amu

• Members conform to a general formula.

• Members have similar method of preparation

• Members have similar chemical properties

• There is a gradual change in physical properties as the molar mass increases

• They have the same functional group.

(i) **Global warming** is the increase in the temperature of the atmosphere (earth) as a result of trapping of heat by green-

house gases such as CO_2 etc.

(j) Cause of global warming

- Burning of fossil fuels
- Deforestation
- Excess CO_2

2a(i) **Deliquescence** is the phenomenon of a substance absorbing water vapour from the atmosphere resulting in the formation of a solution.

II. **Efflorescence** refers to the phenomenon of a substance to give off its water crystallization when exposed to the atmosphere.

(ii) Examples of deliquescence:

MgCl_2 , NaOH , FeCl_3 , KOH , P_2O_5 , $\text{Ca}(\text{NO}_3)_2$.

Examples of Deliquescence:

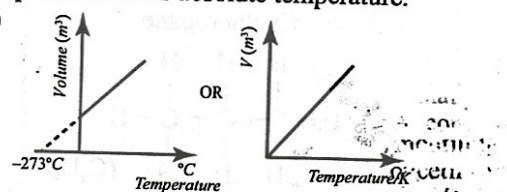
$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$

b(i) **Ionization energy** is the energy required to remove one mole of electron from the valence shell of a gaseous atom to form one mole of the gaseous cation.

(ii) The first ionization energy removes the valence electron from a gaseous sodium atom, the remaining electrons are more strongly attracted to same number of protons in the nucleus and therefore more energy is required to remove the second electron.

c(i) **Charles's law** states that the volume of a fixed mass of a gas at fixed mass of a gas at constant pressure is directly proportional to its absolute temperature.

(ii)



(iii) given: $V_1 = 150 \text{ cm}^3$, $T_1 = 21^\circ\text{C} = 21 + 273 = 294\text{K}$, $T_2 = 45^\circ\text{C} = 45 + 273 = 318\text{K}$, $V = ?$

at constant pressure,

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$V_2 = \frac{V_1 T_2}{T_1} = \frac{150 \times 318}{294}$$

$$C_2 = 162.24 \text{ cm}^3$$

d(i) I. $\text{Na}_2\text{O} + \text{H}_2\text{O} \rightarrow \text{NaOH}$

II. $\text{P}_2\text{O}_3 + 3\text{H}_2\text{O} \rightarrow 2\text{H}_3\text{PO}_3 + 6\text{H}_2\text{O} \rightarrow 4\text{H}_3\text{PO}_3$

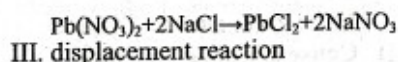
III. $\text{Cl}_2\text{O}_7 + \text{H}_2\text{O} \rightarrow 2\text{HClO}_4$

IV. $\text{MgO} + \text{H}_2\text{O} \rightarrow \text{Mg}(\text{OH})_2$

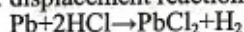
(ii) $\text{NaOH} \rightarrow \text{Mg}(\text{OH})_2 \rightarrow \text{H}_3\text{PO}_3 \rightarrow \text{HClO}_4$
 Increasing acidity

3a(i) Production of lead (II) chloride by

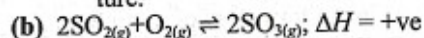
- direct combination
 $\text{Pb} + \text{Cl}_2 \rightarrow \text{PbCl}_2$
- double decomposition



III. displacement reaction



- (ii) I. Increasing the surface area of lead or by using powdered lead.
II. Increasing temperature or concentration of the reactant.
III. Increasing the concentration ratio of HCl, or increasing surface area of lead or increasing the temperature.



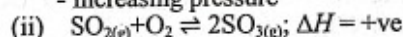
(i) Increasing yield of $\text{SO}_{3(g)}$

- By removing the product (SO_3 formed)

- Addition of any of the reactants (O_2 , SO_2)

- Increasing pressure

- Increasing pressure



2 mol : 1 mol

2 cm³ : 1 cm³

40 cm³ : 30 cm³ : 60 cm³

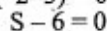
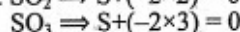
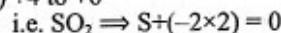
Excess volume of O_2

= 40 - 30 = 10 cm³

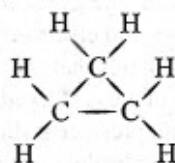
$$\therefore \left(\begin{array}{c} \text{Residual} \\ \text{gas} \end{array} \right) = \left(\begin{array}{c} \text{Volume} \\ \text{of} \\ \text{product} \end{array} \right) + \left(\begin{array}{c} \text{Volume} \\ \text{of unused} \\ \text{reactant} \end{array} \right)$$

$$= 60 + 10 = 70 \text{ cm}^3$$

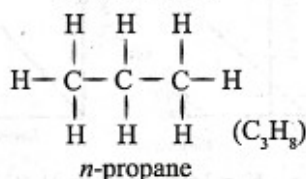
(iii) +4 to +6



(c) cyclopropane (C_3H_6)



Cyclopropane



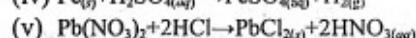
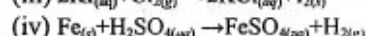
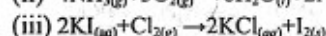
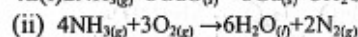
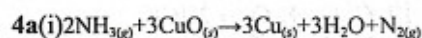
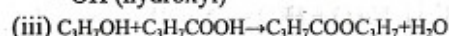
Cyclopropane and n-propane are two different compounds as seen from their molecular formula. They do not belong to the same homologous series, so, they cannot be isomers.

d(i) X is propanal

Y is propylbutanoate

(ii) The functional group of X is

-OH (hydroxyl)



b(i) Extraction of tin from tin ore:

Tin ore is crushed, and washed with

water. It is then filtered and roasted in air to remove impurities (such as sulphur, arsenic and antimony) the product is then mixed with powdered charcoal or coke and heated, the molten tin is then tapped off.

(ii) Uses of hydrogen:

- in the production of margarine
- used in rocket fuel
- as a reducing agent
- in filling balloons
- used in the production of ammonia
- in the synthesis of HCl

(iii) Physical properties of hydrogen:

- odourless, colourless
- less dense than air
- gas at room temperature
- insoluble in water.

b(i) Na_2O - basic oxide

(ii) ZnO - amphoteric oxide

(iii) SO_2 - acidic oxide

(iv) CO_2 - acidic oxide

(v) N_2O - neutral oxide

5a(i) Chemical formula of alumina - Al_2O_3

(ii) I - NaOH (caustic soda)

II - Na_3AlF_6 (cryolite)

(iii) electrodes used in the extraction of aluminium

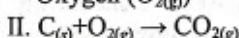
- anode : graphite

- cathode : graphite

(iv) this is because much electricity is consumed. It is also because the anode is constantly being replaced during the extraction.

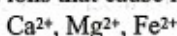
(v) I. Substance liberated at the anode:

Oxygen ($\text{O}_{2(g)}$)



NB: In this reaction, the anodes are gradually oxidized, so, they must be frequently replaced.

b(i) ions that cause hardness of water:



(ii) Advantages of hard water:

- less likely to cause corrosion in lead pipes;
- can improve the taste of the water because of the presence of cations;
- presence of calcium and magnesium in the hard water are beneficial for strengthening teeth, bones and the shell of aquatic animals.

Disadvantages of hard water:

- does not easily form lather with soap, making cleaning or hand-washing difficult;
- increase in corrosion of metal pipes as a result of accumulation of min-

erals present in such water.

c(i) the destructive distillation of coal is the process of heating coal in the absence or limited supply of air,

(ii) coke, coal gas, gaseous carbon, coal and ammonia liquor.

d(i) Hydrogen chloride gas $\text{HCl}_{(g)}$ and ammonia gas $\text{NH}_{3(g)}$.

(ii) They are suitable for use in this experiment because of their high solubility in water.

2024 WAEC CHEMISTRY ALTERNATIVE (A) SOLUTIONS

1(a) Volume of pipette = 25.0 cm³

i.e. volume of B used = 25.0 cm³

$V_B = 25.0 \text{ cm}^3$

Burette readings (cm ³)	Rough	1st titre	2nd titre
Final burette readings	18.10	36.30	18.10
Initial burette readings	0.00	8.10	0.00
Volume of A (KMnO_4 used)	18.10	18.20	18.10

Volume of A used

$$\frac{18.10 + 18.20 + 18.10}{3}$$

$V_A = 18.13 \text{ cm}^3$

b(i) Given:

$V_A = 18.13 \text{ cm}^3$ & $C_A = 0.020 \text{ mol/dm}^3$

$V_B = 25.0 \text{ cm}^3$

$$\frac{n_A}{n_B} = \frac{1}{5}$$

From:

$$\frac{C_A V_A}{C_B V_B} = \frac{n_A}{n_B}$$

$$\frac{0.020 \times 18.13}{C_B \times 25.0} = \frac{1}{5}$$

$$C_B = \frac{0.020 \times 18.13 \times 5}{25}$$

$$= 0.07252$$

$$\approx 0.1 \text{ mol dm}^{-3}$$

(ii) Gram conc. of B = $\frac{308 \text{ g}}{250 \text{ cm}^3}$

$$= \frac{3.8 \times 1000}{250}$$

$$= 15.2 \text{ g dm}^{-3}$$

(iii) No of moles in B = volume \times molarity
In 250 cm³ of B,

$$\text{no of moles} = \frac{250}{1000} \times 0.1$$

$$= 0.025 \text{ moles}$$

Mass of Fe^{2+} in 250 cm³ of
= molar mass \times no of moles
= $56 \text{ g/mol} \times 0.025 = 1.4 \text{ grams}$

(iv) Percentage of Fe^{2+} in granules

$$= \frac{1.4}{3.8} \times 100\% \\ = 36.8\%$$

2.

	Test	Observation	Inference
(a)	C + 10cm ³ of H ₂ O	C partially dissolves	C is a mixture of a soluble and insoluble salt.
b(i)	2cm ³ of filtrate + heat	colourless, odourless gas in form of bubbles	CO ₃ ²⁻ suspected
(ii)	residue of dil. HCl	no visible reaction	NO ₃ ⁻ , SO ₄ ²⁻ suspected
(iii)	Solution from b(ii) + NaOH(aq) in drops and then in excess	white precipitate which dissolves in excess	Zn ²⁺ , Pb ²⁺ , Al ³⁺ suspected.
(iv)	Solution from b(ii) + NH ₃ (aq) in drops and in excess	white precipitate insoluble in excess	Pb ²⁺ confirmed.

3a(i) Carbon (IV) oxide

(ii) Oxygen

(iii) Nitrogen

(iii) Ammonia gas

b(i) Burette

(ii) Pipette

(iii) Volumetric flask

(iv) Retort stand

c(i) To capture and remove air-borne hazardous substances generated during laboratory experiment.

(ii) It protects the user from inhaling toxic gases.

d(i) Eye protector

(ii) Lab coats

(iii) Gloves

(iv) Nose cover

2024 WAEC CHEMISTRY ALTERNATIVE (B) SOLUTIONS

1(a) Volume of pipette, $V_B = 25.00 \text{ cm}^3$

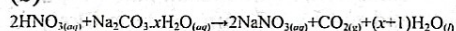
Burette readings (cm ³)	Rough	1st titre	2nd titre
Final burette reading	21.00	41.80	20.90
Initial burette reading	0.00	21.00	0.00
Volume of acid, A used	21.00	20.80	20.90

Average volume of acid used

$$= \frac{21.00 + 20.80 + 20.90}{3}$$

$$= 20.90 \text{ cm}^3$$

(b)



c(i) concentration of E in mol/dm³

conc. of HNO₃ in g/dm³

$$= \frac{6.30}{500} \times 1000$$

$$= 12.6 \text{ g/dm}^3$$

Molar mass of HNO₃(aq)

$$= 1 + 14 + (6 \times 3) = 63 \text{ g/mol}$$

Molar conc. of acid,

$$C_A = \frac{\text{gram conc. at acid}}{\text{molar mass of HNO}_3}$$

$$= \frac{12.6}{63}$$

$$= 0.2 \text{ mol/dm}^3$$

$$\text{Using } \frac{C_A V_A}{C_B V_B} = \frac{n_A}{n_B}$$

Concentrated of B,

$$C_B = \left(\frac{n_B}{n_A} \right) \left[\frac{C_A V_A}{V_B} \right]$$

$$= \left(\frac{1}{2} \right) \left[\frac{0.2 \times 20.90}{25} \right]$$

$$C_B = 0.0836 \text{ mol/dm}^3$$

(ii) Mass of Na₂CO₃ · xH₂O in dm³

$$= \frac{8.20 \times 1000}{250} = 32.8 \text{ g/dm}^3$$

Molar mass of Na₂CO₃ · xH₂O

$$= \frac{\text{Mass conc.}}{\text{Molar conc.}} = \frac{32.8}{0.0836}$$

$$= 392.34 \text{ g/mol}^{-1}$$

Molar mass of Na₂CO₃ · xH₂O

$$= 106 + 18x = 392.34$$

$$x = \frac{392.34 - 106}{18}$$

$$= \frac{286.34}{18}$$

$$x = 15.91$$

$$x \approx 16$$

2. $F = (\text{NH}_4)_2\text{CO}_3$

TEST	OBSERVATION	INFERENCE
(a) F + dil. HCl	Effervescence of colourless odourless gas. Gas evolved turned limewater milky	Gas is CO ₂ HCO ₃ ⁻ /CO ₃ ²⁻
b(i) First portion + drops of NaOH(aq)	No ppt./No visible reaction (no gas evolved)	
Then in excess and warming	Colourless pungent/choky/irritating smelling gas evolved. Gas turned red litmus to blue/Produces dense white fumes with conc. HCl	Gas is NH ₃ from NH ₄ ⁺

(ii) Second portion + few drops of potassium hexacyanoferrate (II) solution	No ppt. formed/No visible reaction observed	Fe ²⁺ /Fe ³⁺ absent
---	---	---

3a(i) Salt solution is acidic.

Reaction is exothermic.

White precipitate is likely a trioxocarbonate (IV) salt of Al, Ca, and Zn.

Prepared solution contained soluble salt of Al, Ca and Zn

b(i) PbSO₄

(ii) NaHCO₃

(iii) Cu(NO₃)₂/NaHCO₃

(iv) NaHCO₃

(v) NH₄Cl

(c)- Rinse burette with the acid

- Rinse pipette with the NaOH solution

- Remove air bubble from the burette and pipette

- Avoid leakage of the burette

- Avoid parallax error