

# 2024 UTME CHEMISTRY

## OBJECTIVE STRUCTURED QUESTIONS

- Which of the following produces effervescence with sodium hydrogen carbonate? A. Ethanoic acid B. Ethane C. Bromine water D. Propene
- What are the separation techniques involved in obtaining pure alum from powdered mixture of alum and sand? A. Magnetic separation and centrifugation B. Dissolution, filtration and crystallization C. Distillation and chromatography D. Sedimentation and osmosis
- What are the constituents of permalloy? A. Copper, zinc and tin B. Nickel and iron C. Copper, silver and manganese D. Copper, zinc and manganese
- What is the colour obtained when starch iodide paper is introduced into a jar containing chlorine? A. Red B. Blue C. Purple D. Blue-Black
- The only factor that affects the internal energy of an ideal gas is A. pressure B. temperature C. volume D. number of moles
- The element  $X$  that can combine with oxygen to form an oxide of the form  $XO_2$  is A. sulphur B. fluorine C. chlorine D. phosphorous
- Rust on the surface of a metal sheet contains A.  $FeO$  B. hydrated  $Fe_2O_3$  C. hydrate  $Fe_3O_4$  D.  $FeCO_3$
- In the food processing industry, the separation technique used for analytical purpose is A. crystallization B. distillation C. chromatography D. centrifugation
- An example of a solid-gas mixture is A. smoke B. foam C. fog D. mist
- Which of the following will dissolve in water to give a solution with a pH greater than 7? A.  $NaCl$  B.  $Na_2CO_3$  C.  $Na_2SO_4$  D.  $NaHSO_4$
- Which of the following metals react with water at the fastest rate? A. Calcium B. Magnesium C. Sodium D. Iron
- The brown ring test is used to detect the presence of A. nitrate ions B. sulphate ions C. chloride ions D. phosphate ions
- The solubility of a solid in a liquid is increased by A. decreasing the temperature B. increasing the pressure C. increasing the surface area of the solid D. decreasing the volume of the solvent
- The addition of charcoal to a filter bed in a town water supply is for the purpose of A. removing heavy metals B. removing bacteria and viruses C. removing chlorine and organic compound D. softening the water.
- The reaction between ethanol and phosphorous (V) chloride produces A. phosphorous (III) chloride B. phosphorous (V) oxide C. phosphorous oxychloride D. phosphorous (III) oxide
- The dominant intermolecular forces in ethanol are A. London dispersion forces B. Dipole-dipole forces C. hydrogen bonding D. ion-dipole forces
- The method suitable for separating suspended particles in a liquid is A. distillation B. filtration C. magnetization D. Crystallization
- The purity of common salt ( $NaCl$ ) can be determined by A. measuring its boiling point B. measuring its density C. measuring its melting point D. measuring its solubility
- The IUPAC name for the compound  $HOCH_2CH_2CH_2OH$  is A. pentan-1,2-diol B. propan-1,3-diol C. propan-1,2-diol D. 1,2-dihydroxypropane
- The purest form of natural water is A. spring water B. river water C. lake water D. rain water
- What is the main difference between empirical and molecular formulae? A. Empirical formula shows isotopes while molecular formula does not B. Empirical formula shows the simplest whole-number ratio of atoms while molecular formula shows the actual number of atoms in a molecule. C. Empirical formulae are used for ionic compounds while molecular formulae are used for covalent compounds D. Empirical formulae are used for gases while molecular formulae are used for solids
- Which of the following bond types involves the transfer of electrons? A. Hydrogen bonding B. Ionic bonding C. Covalent bonding D. Dipole-dipole interactions
- What is the significance of the equilibrium constant ( $K_c$ ) in a chemical reaction? A. It determines the type of catalyst used B. It determines the bond types in the reacting species C. it determines the concentrations of the reactants and products D. None of the above
- What is the term for the minimum amount of energy required for a chemical reaction to occur? A. Activation energy B. Ionization energy C. Dissociation energy D. Kinetic energy
- What is the term for the amount of heat energy required to raise the temperature of a unit mass of a substance by  $1^\circ C$ ? A. Specific heat capacity B. Molar heat capacity C. Latent heat D. Heat of fusion.
- The most suitable method for separating a mixture of ethanol and water is A. filtration B. distillation C. sublimation D. chromatography
- The molecular formula of a compound with an empirical formula  $CH_2O$  and a molar mass of  $180 g/mol$  is A.  $C_3H_6O_3$  B.  $C_6H_{12}O_6$  C.  $CH_4O$  D.  $C_4H_8O_2$
- The hybridization of carbon in ethene is A.  $sp$  B.  $sp^2$  C.  $sp^3$  D.  $sp^3d$
- Which of the following elements has the highest electronegativity? A. Sodium B. Fluorine C. Carbon D. Nitrogen
- Which of the following is exothermic? A. Melting of ice B. Dissolution of ammonium chloride in water C. Combustion of methane D. Evaporation of water
- Determine the  $pOH$  of a solution of  $H_2SO_4$  whose concentration is  $0.001M$  A. 11.3 B. 2.7 C. 14 D. 3.54
- Which of the following halogens is the least reactive? A. Fluorine B. Iodine C. Chlorine D. Bromine
- In the electrolysis of dilute  $H_2SO_4$ , the gas produced at the anode is A. hydrogen B. sulphur (IV) oxide C. oxygen D. hydrogen sulphide
- Which of the following gases can be collected over water? A.  $HCl$  B.  $NH_3$  C.  $CO_2$  D.  $Cl_2$
- The main ore of aluminium is A. Galena B. Bauxite C. Haematite D. Magnetite
- Which of the following reactions is redox? A.  $NaOH + HCl \rightarrow NaCl + H_2O$  B.  $2Mg + O_2 \rightarrow 2MgO$  C.  $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$  D.  $CaCO_3 \rightarrow CaO + CO_2$
- The number of unpaired electrons in a ground-state nitrogen atom is A. 1 B. 2 C. 3 D. 4
- The bond angle in methane is A.  $90^\circ$  B.  $109.5^\circ$  C.  $120^\circ$  D.  $180^\circ$
- Which of the following is not a property of transition metals? A. formation of coloured compounds B. High melting points C. Low density D. variable oxidation states
- The correct order of increasing boiling points for the following compounds is: A.  $CH_4 < C_2H_6 < C_3H_8 < C_4H_{10}$  B.  $C_4H_{10} < C_3H_8 < C_2H_6 < CH_4$  C.  $C_2H_6 < CH_4 < C_4H_{10} < C_3H_8$  D.  $C_3H_8 < C_4H_{10} < CH_4 < C_2H_6$

## 2024 CHEMISTRY STRUCTURED QUESTIONS SOLUTIONS

- A: Just like any other acid, ethanoic acid reacts with carbonate or hydrogen carbonate to give an effervescence of  $CO_2$ :  
 $CH_3COOH + NaHCO_3 \rightarrow CH_3COONa + H_2O + CO_2$
- B: Alum is soluble in water while sand is not. So, dissolving the mixture in water, filtering and crystallizing can separate alum from sand
- B: Permalloy is a nickel-iron magnetic alloy, composed of approximately 80% nickel and 20% iron. It is known for its high magnetic permeability
- D: Starch iodide paper turns blue-black when exposed to chlorine gas. This is a common test for detecting the presence of chlorine gas.
- B: The internal energy of an ideal gas is a function of its temperature only. This is a fundamental principle in thermodynamics.



6. A: Sulphur combines with oxygen to form sulphur (IV) oxide ( $\text{SO}_2$ ), which is an acid anhydride. So, the element X is carbon. Another element that fits this description is carbon, it forms  $\text{CO}_2$ , another acid anhydride.
7. B: When iron reacts with oxygen and water, rust is formed. Rust is hydrated iron (III) oxide ( $\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$ ).
8. C: Techniques like high-performance liquid chromatography (HPLC) and gas chromatography (GC) are commonly used to analyze food composition, detect contaminants and determine nutritional content.
9. A: Smoke is a solid-gas mixture, consisting of solid particles suspended in a gas (air).
10. B:
- $\text{NaCl}$  and  $\text{Na}_2\text{SO}_4$  dissolve in water to produce a neutral solution ( $\text{pH} = 7$ )
  - $\text{NaHSO}_4$  dissolves in water to produce an acidic solution ( $\text{pH} < 7$ )
  - $\text{Na}_2\text{CO}_3$  dissolves in water to produces an alkaline solution ( $\text{pH} > 7$ )
11. C: The reaction of sodium with water is really violent. It reacts with water in a highly exothermic reaction, releasing hydrogen gas and producing sodium hydroxide solution.
12. A:
- The brown ring test is a chemical test used to detect the presence of nitrate ions ( $\text{NO}_3^-$ ) in solution. It involves adding  $\text{FeSO}_4$  and  $\text{H}_2\text{SO}_4$  to the solution, which produces a brown ring if nitrate ions are present.
13. C: Increasing the surface area of a solid (probably by grinding) allows more particles to come into contact with the solvent, making it easier to dissolve.
14. C: Activated charcoal is often added to filter beds in water treatment processes to remove chlorine, organic compounds and other impurities that can affect the taste and colour of the water.
15. C:
- The reaction between ethanol ( $\text{C}_2\text{H}_5\text{OH}$ ) and phosphorous (V) chloride produces chloroethane (ethyl chloride), phosphorous oxychloride and hydrogen chloride.
- The balanced equation is:
- $$\text{C}_2\text{H}_5\text{OH} + \text{PCl}_5 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{POCl}_3 + \text{HCl}$$
16. C:
- Ethanol is a polar molecule with a hydroxyl ( $-\text{OH}$ ) group, which is capable of forming hydrogen bonds with other ethanol molecules. Hydrogen bonding is a strong intermolecular force.
17. B:
- We can separate suspended particles from a liquid by passing the mixture through a filter. The filter traps the suspended particles, allowing the clear liquid to pass through.
18. C:
- The purity of a solid can be determined by measuring its melting point. A pure solid melts at a sharp, defined temperature or over a narrow temperature range while an impure solid melts over a wide temperature range.
19. B:
- The IUPAC name of  $\text{HOCH}_2\text{CH}_2\text{CH}_2\text{OH}$  is propan-1, 3-diol.
20. D:
- Rain water is considered the purest form of water. It is formed through the earth's water cycle where water evaporates from the oceans, condenses into clouds and precipitates back to the earth as rain. This process distills the water, removing impurities and minerals, resulting in very low levels of contaminants.
21. B:
- Empirical formula shows the simplest whole number ratio of atoms while molecular formula shows the actual number of atoms in a molecule. For instance, the molecular formula of benzene is  $\text{C}_6\text{H}_6$  while its empirical formula is  $\text{CH}$ .
22. B:
- Ionic/electrovalent bonding involves the transfer of electrons between atoms, resulting in the formation of ions with opposite charges.
23. C:
- The equilibrium constant reflects the ratio of the concentrations of products to reactants at equilibrium. A high  $K_c$  value indicates that the products are present in greater proportion while a low  $K_c$  value indicates otherwise.
24. A:
- Activation energy is the minimum amount of energy required for a chemical reaction to occur. It represents the energy barrier that must be overcome for the reaction to occur.
25. A:
- The specific heat capacity of a substance is the amount of heat energy required to raise the temperature of a unit mass of a substance by  $1^\circ\text{C}$ .
26. B:
- Ethanol and water can be separated by distillation because they have different boiling points. Ethanol boils at  $78^\circ\text{C}$  while water boils at  $100^\circ\text{C}$ .
27. B:
- With an empirical formula of  $\text{CH}_2\text{O}$ , the empirical formula mass =  $30\text{g/mol}$ .
- To get the molecular formula, we multiply the ratio of the molar mass to the empirical formula mass by the empirical formula:
- $$\frac{180\text{g/mol}^{-1}}{30\text{g/mol}^{-1}} = 6.$$
- Thus, the molecular formula =  $(\text{CH}_2\text{O})_6 = \text{C}_6\text{H}_{12}\text{O}_6$ .
28. B:
- In ethene, each carbon atom forms three sigma bonds. There is also a Pi bond, leading to  $\text{sp}^2$  hybridization, where one  $p$ -orbital remains unhybridized.
29. B:
- Fluorine is the most electronegative element (of all known elements!).
30. C:
- All combustion processes are exothermic same is true for all neutralization reactions.
31. A:
- $$\text{H}_2\text{SO}_4 \rightarrow 2\text{H}^+ + \text{SO}_4^{2-}$$
- 1                      2
- Then,
- $$[\text{H}^+] = 2 \times 0.001\text{M}$$
- $$= 0.002\text{M}$$
- $$\text{pH} = -\log_{10}^{(0.002)} = 2.69897$$
- $$\text{pH} + \text{pOH} = 14$$
- $$\text{pOH} = 14 - 2.69897 = 11.3$$
32. B:
- Reactivity of halogens decreases down the group due to the decreasing ability to attract electrons. Fluorine is the most reactive while iodine is the least reactive.
33. C:
- In the electrolysis of dilute  $\text{H}_2\text{SO}_4$ , oxygen is produced at the anode while hydrogen is produced at the cathode.
- At the anode
- $$4\text{OH}^- \rightarrow 2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^-$$
- At the cathode
- $$2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$$
34. C:
- $\text{CO}_2$  is only slightly soluble in water and can therefore be collected over water, unlike highly soluble gases like  $\text{HCl}$  and  $\text{NH}_3$ .
35. B:
- Bauxite ( $\text{Al}_2\text{O}_3 \cdot n\text{H}_2\text{O}$ ) is the primary ore from which aluminium is extracted (through electrolysis).
36. B:
- In the reaction, magnesium is oxidized and oxygen is reduced.
37. C:
- $$N = 1s^2 2s^2 2p^3 = \boxed{1\downarrow}\boxed{1\downarrow}\boxed{1\uparrow}\boxed{1\uparrow}\boxed{1\uparrow}$$
- 1s   2s   2p<sub>1</sub> 2p<sub>2</sub> 2p<sub>3</sub>
38. B:
- Methane has a tetrahedral geometry, where the bond angles are  $109.5^\circ$ . The hybridization of the carbon atom is  $\text{sp}^3$ .
39. C:
- Transition metals are generally dense and have high melting points, they exhibit variable oxidation states and form coloured compounds.
40. A:
- As the number of carbon atoms increases in alkanes, the molecular mass increases, leading to stronger Van der Waals forces and higher boiling point.