WBJEE Chemistry Sample Paper-14

Duration: 60 Minutes **Maximum Marks: 50**

Instructions

- This paper contains **40** Multiple Choice Questions divided into **3 Categories**.
- **Section A (Q1–Q30):** Each correct answer carries **+1 mark**. Incorrect answer: **−0.25** marks. Only **one** correct option.
- **Section B (Q31–Q35):** Each correct answer carries **+2 marks**. Incorrect answer: **−0.5** marks. Only **one** correct option.
- **Section C (Q36–Q40):** Each correct answer carries **+2 marks**. **No negative marking**. One or **more** correct options may be correct; full marks only if all correct options are marked.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Section A - 30 Questions × 1 Mark Each
(Negative Marking: −0.25) [Single Correct]

Q1. A solution containing 2.56 g of sulfur dissolved in 100 g of CS_2 (boiling point = 46.30°C) exhibits an elevation in boiling point of 0.256°C. If the molal elevation constant (K_b) of CS_2 is 2.56 K kg mol^{-1}, the atomicity of sulfur in this solution is (Atomic mass of S = 32 u):

(A) 2

(B) 4

(C) 6

(D) 8

Q2. If the wavelength of the first line of the Balmer series in the hydrogen spectrum is λ, then the wavelength of the second line of the same series will be:

(A) $\frac{20}{27}\lambda$

(B) $\frac{3}{4}\lambda$

(C) $\frac{4}{9}\lambda$

(D) $\frac{27}{20}\lambda$

Q3. The correct order of decreasing dipole moments for the given molecules is:

(A) $CH_3Cl > CH_3F > CH_3Br > CH_3I$

(B) $CH_3F > CH_3Cl > CH_3Br > CH_3I$

(C) $CH_3Cl > CH_3Br > CH_3F > CH_3I$

(D) $CH_3F > CH_3Cl > CH_3I > CH_3Br$

Q4. At a given temperature, a certain mass of an ideal gas occupies a volume V at a pressure P. If the absolute temperature is doubled and the pressure is reduced to one-third of its initial value, the final volume of the gas becomes:

(A) $6V$

(B) $\frac{2}{3}V$

(C) $\frac{3}{2}V$

(D) $3V$

Q5. For a reversible isothermal expansion of one mole of an ideal gas at 300 K from an initial volume of 10 L to a final volume of 100 L, the change in entropy of the surroundings (ΔS_{surr}) is approximately:

(A) $-19.15\ \text{J K}^{-1}\ \text{mol}^{-1}$

(B) $+19.15\ \text{J K}^{-1}\ \text{mol}^{-1}$

(C) $-38.30\ \text{J K}^{-1}\ \text{mol}^{-1}$

(D) $0\ \text{J K}^{-1}\ \text{mol}^{-1}$

Q6. For the equilibrium reaction $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$, the degree of dissociation at a total equilibrium pressure P is α. The correct expression representing the equilibrium constant K_p is:

(A) $\frac{\alpha^2 P}{1-\alpha^2}$

(B) $\frac{\alpha^2 P^2}{1-\alpha}$

(C) $\frac{\alpha P}{1-\alpha^2}$

(D) $\frac{\alpha^2}{1-\alpha^2}$

Q7. For a first-order chemical reaction, a graph plotted between $\log[\mathrm{A}]_t$ (where $[\mathrm{A}]_t$ is the concentration of reactant at time t) and time t yields a straight line. The slope of this line is equivalent to:

(A) $-k$

(B) $-\frac{k}{2.303}$

(C) $\frac{k}{2.303}$

(D) $-2.303k$

Q8. In a specific acidic medium, 20 mL of 0.05 M $KMnO_4$ solution completely oxidizes 25 mL of a given H_2O_2 solution. The strength of this H_2O_2 solution in grams per litre ($\mathrm{g\ L^{-1}}$) is closest to:

(A) 1.70

(B) 3.40

(C) 0.85

(D) 2.55

Q9. The limiting molar conductivities (Λ_m°) of NH_4Cl, NaOH, and NaCl are x, y, and z $\mathrm{S\ cm^2\ mol^{-1}}$ respectively. The value of Λ_m° for an aqueous solution of NH_4OH is given by:

(A) $x + y - z$

(B) $y + z - x$

(C) $x + z - y$

(D) $x - y + z$

Q10. When metallic sodium is dissolved in liquid ammonia, a deep blue solution is formed which is highly conducting. This specific coloration is primarily due to the presence of:

(A) Sodium hydride formation

(B) Ammoniated sodium cations

(C) Ammoniated electrons

(D) Sodium amide formation

Q11. Among the given structural combinations of oxoacids of phosphorus, which pair contains a distinct $P-P$ direct bond in its molecular structure?

(A) Pyrophosphoric acid and Hypophosphoric acid

(B) Hypophosphoric acid and Diphouncous acid

(C) Pyrophosphorous acid and Pyrophosphoric acid

(D) Orthophosphoric acid and Hypophosphoric acid

Q12. When potassium dichromate ($K_2Cr_2O_7$) is heated intensely with concentrated sulphuric acid and a solid chloride salt, deep red vapors of a specific compound X are evolved. Compound X dissolves in an aqueous NaOH solution to form a yellow solution of Y. Compounds X and Y are respectively:

(A) CrO_2Cl_2 and Na_2CrO_4

(B) $CrCl_3$ and $Na_2Cr_2O_7$

(C) CrO_3 and Na_2CrO_4

(D) CrO_2Cl_2 and $Na_2Cr_2O_7$

Q13. The correct electronic configuration and the calculated spin-only magnetic moment (μ_s) of the central metal ion in the high-spin complex $[Mn(H_2O)_6]^{2+}$ are respectively:

(A) $t_{2g}^3 e_g^2$ and 5.92 BM

(B) $t_{2g}^5 e_g^0$ and 1.73 BM

(C) $t_{2g}^4 e_g^1$ and 4.90 BM

(D) $t_{2g}^3 e_g^2$ and 4.90 BM

Q14. Photochemical smog, a prevalent environmental issue in warm and dry climates, is initiated primarily by a series of photochemical reactions. Which of the following chemical species is NOT a primary or secondary constituent typically found in photochemical smog?

(A) Ozone (O_3)

(B) Peroxyacetyl nitrate (PAN)

(C) Sulphur dioxide (SO_2)

(D) Nitric oxide (NO)

Q15. The correct IUPAC nomenclature for the organic molecule structurally represented as $CH_3 - CH(OH) - CH_2 - C(CH_3)_2 - COOH$ is:

(A) 2,2-Dimethyl-4-hydroxypentanoic acid

(B) 4-Hydroxy-2,2-dimethylpentanoic acid

(C) 2,2,4-Trimethyl-4-hydroxybutanoic acid

(D) 4-Hydroxypentan-2,2-dimethylcarboxylic acid

Q16. When an alkene X undergoes reductive ozonolysis ($O_3/Zn - H_2O$), it produces an equimolar mixture of propan-2-one and formaldehyde. The structure of alkene X is:

(A) But-1-ene

(B) 2-Methylprop-1-ene

(C) But-2-ene

(D) 2-Methylbut-2-ene

Q17. The major organic product obtained when 2-bromobutane is heated with an excess of ethanolic potassium hydroxide (KOH) is:

(A) But-1-ene

(B) trans-But-2-ene

(C) cis-But-2-ene

(D) Butan-2-ol

Q18. When phenol is treated with chloroform ($CHCl_3$) in the presence of aqueous sodium hydroxide followed by acidification, salicylaldehyde is formed as the major product. The reactive intermediate involved in this functional transformation is:

(A) Carbocation

(B) Carbanion

(C) Dichlorocarbene

(D) Free radical

Q19. When benzaldehyde is warmed with a concentrated aqueous solution of sodium hydroxide (NaOH), it undergoes a self-redox reaction. The corresponding organic products isolated from this reaction mixture are:

(A) Benzyl alcohol and Sodium benzoate

(B) Benzene and Sodium benzoate

(C) Benzyl alcohol and Phenol

(D) Sodium benzoate and Phenol

Q20. An organic amine X reacts with benzene sulfonyl chloride (Hinsberg's reagent) to yield a solid precipitate that remains completely insoluble in an aqueous sodium hydroxide solution. The amine X is classified as a:

(A) Primary aliphatic amine

(B) Secondary amine

(C) Tertiary aromatic amine

(D) Primary aromatic amine

Q21. Complete hydrolysis of starch yields exclusively a single type of monomeric unit. This carbohydrate monomer is:

(A) D-Glyceraldehyde

(B) α-D-Glucopyranose

(C) β-D-Fructofuranose

(D) β-D-Glucopyranose

Q22. Nylon-6,6 is a widely utilized synthetic polyamide polymer. The monomeric structural units required for the laboratory preparation of Nylon-6,6 are:

(A) Caprolactam and Water

(B) Hexamethylenediamine and Adipic acid

(C) Styrene and 1,3-Butadiene

(D) Ethylene glycol and Terephthalic acid

Q23. The total number of radial and angular nodes possessed by a $4p$ orbital of a hydrogenic atom are respectively:

(A) 2 and 1

(B) 1 and 2

(C) 3 and 1

(D) 2 and 2

Q24. Among the given covalent molecular architectures, which molecule exhibits a structural geometry that can be rationalized using sp^3d^2 hybridization at its central atom?

(A) SF_4

(B) BrF_5

(C) PCl_5

(D) IF_7

Q25. For an ideal gas expanding adiabatically into a complete vacuum (joule expansion), the correct set of thermodynamic parameters defining this process is:

(A) $w = 0, \Delta T < 0, \Delta U = 0$

(B) $w = 0, \Delta T = 0, \Delta U = 0$

(C) $w \neq 0, \Delta T = 0, \Delta U < 0$

(D) $w = 0, \Delta T = 0, \Delta U < 0$

Q26. Equal volumes of 0.2 M CH_3COOH ($K_a = 1.8 \times 10^{-5}$) and 0.1 M NaOH solutions are thoroughly mixed together. The pH of the resulting buffer solution will be equal to:

(A) pK_a

(B) $pK_a + \log 2$

(C) $pK_a - \log 2$

(D) 7.0

Q27. For a pseudo-first-order reaction $A + B \longrightarrow$ Products, where reactant B is present in large excess, the half-life period ($t_{1/2}$) of the reaction is:

(A) Inversely proportional to the initial concentration of A

(B) Independent of the initial concentration of A

(C) Directly proportional to the initial concentration of A

(D) Independent of the concentration of B

Q28. Boric acid (H_3BO_3) behaves as a weak monobasic acid in an aqueous medium. It does not act as a proton donor in the primary step, but rather functions as:

(A) A Lewis base by donating a lone pair of electrons to water

(B) An Arrhenius acid by dissociating to give H^+ ions directly

(C) A Lewis acid by accepting a hydroxyl ion (OH^-) from a water molecule

(D) A Bronsted-Lowry base by capturing hydronium ions

Q29. The compound that possesses the highest thermal stability among the given alkaline earth metal carbonates is:

(A) $MgCO_3$

(B) $CaCO_3$

(C) $SrCO_3$

(D) $BaCO_3$

Q30. Among the given organic isomeric structures, which molecule is capable of existing as a pair of enantiomers exhibiting optical isomerism?

(A) 2-Chlorobutane

(B) 1-Chlorobutane

(C) 2-Chloropropane

(D) 2-Methylpropane

Section B - 5 Questions × 2 Mark Each
(Negative Marking: −0.5) [Single Correct]

Q31. Consider the following standard reduction potentials at 298 K: $E^\circ(Fe^{3+}/Fe^{2+}) = +0.77$ V, $E^\circ(I_2/I^-) = +0.54$ V. The standard Gibbs free energy change (ΔG°) for the spontaneous cell reaction $2Fe^{3+}(aq) + 2I^-(aq) \rightarrow 2Fe^{2+}(aq) + I_2(s)$ is approximately ($F = 96500$ C mol^{-1}):

(A) −44.4 kJ

(B) +44.4 kJ

(C) −22.2 kJ

(D) −88.8 kJ

Q32. When 1.00 g of a non-volatile non-electrolyte solute is dissolved in 50.0 g of benzene, the freezing point of benzene is lowered by 0.40 K. The freezing point depression constant (K_f) of benzene is 5.12 K kg mol^{-1}. The molar mass of the solute (g mol^{-1}) is:

(A) 256

(B) 128

(C) 342

(D) 64

Q33. Nitrogen gas (N_2) is prepared industrially and in laboratories via several chemical routes. Which of the following chemical reactions does NOT yield nitrogen gas (N_2) as a principal product?

(A) Thermal decomposition of ammonium dichromate, $(NH_4)_2Cr_2O_7$

(B) Direct heating of sodium azide, NaN_3

(C) Reaction of excess ammonia with chlorine gas

(D) Reaction of calcium phosphide with water

Q34. An organic compound with the molecular formula C_4H_8O does not form a silver mirror with Tollen's reagent but reacts readily with hydroxylamine to form an oxime. Furthermore, it gives a positive yellow precipitate when treated with iodine and sodium hydroxide. The correct IUPAC name of this compound is:

(A) Butanal

(B) Butan-2-one

(C) Cyclobutanol

(D) 2-Methylpropanal

Q35. The single-bonded covalent radii of transition elements do not decrease uniformly down a group from the 4d to the 5d series. Specifically, zirconium (Zr, atomic number 40) and hafnium (Hf, atomic number 72) possess nearly identical ionic and atomic radii. This anomalous behavior is explicitly attributed to:

(A) Shielding effect of s-electrons

(B) Actinoid contraction

(C) Lanthanoid contraction

(D) Diagonal relationship

Section C - 5 Questions × 2 Marks Each
(No Negative Marking) [One or More Correct]

Q36. Which of the following statements regarding the kinetic theory of gases and real gas behavior is/are correct?

(A) Real gases approach ideal behavior at very low pressures and high temperatures.

(B) The compressibility factor Z for an ideal gas is equal to 1 at all temperatures and pressures.

(C) At the Boyle temperature, a real gas obeys ideal gas laws over an appreciable range of pressure.

(D) The van der Waals constant 'a' is a direct measure of the structural volume occupied by gas molecules.

Q37. For the chemical equilibrium system established as $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, the forward reaction is characteristically endothermic ($\Delta H > 0$). Which of the following perturbations applied to the system at equilibrium will shift the position of equilibrium towards the right (favouring product formation)?

(A) Increasing the total temperature of the system

(B) Decreasing the external pressure at constant temperature

(C) Adding an inert gas like Argon at constant volume

(D) Continuous removal of NO_2 gas from the reaction vessel

Q38. Which of the following coordination complex ions is/are expected to be paramagnetic in nature according to Crystal Field Theory or Valence Bond Theory?

(A) $[Fe(CN)_6]^{3-}$

(B) $[CoF_6]^{3-}$

(C) $[Ni(CN)_4]^{2-}$

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

Q39. Identify the reaction(s) that will successfully yield an alkyl halide or aryl halide as a major organic product:

(A) $CH_3CH_2OH + SOCl_2 \xrightarrow{\text{Pyridine}}$

(B) $C_6H_6 + Cl_2 \xrightarrow{\text{Anhydrous } FeCl_3\text{, Dark}}$

(C) $CH_3CH = CH_2 + HBr \xrightarrow{\text{Peroxides}}$

(D) $CH_3CH_2OH + NaCl \xrightarrow{\text{Water}}$

Q40. Which of the following statements is/are correct concerning the properties and chemical behavior of p-block elements?

(A) Nitric acid (HNO_3) acts exclusively as a powerful reducing agent.

(B) $BiCl_3$ is more stable than $BiCl_5$ due to the inert pair effect.

(C) Oxygen exhibits an anomalous maximum covalency of four, whereas heavier congeners can expand their coordination numbers.

(D) PH_3 has a higher boiling point than NH_3 because of stronger intermolecular hydrogen bonding.

Detailed Solutions

Q1.

Solution

Concept:
The elevation in boiling point is a colligative property given by $\Delta T_b = K_b \cdot m$, where m is the molality of the solution. By finding the experimental molecular mass (M_2) of sulfur in the solvent, its atomicity can be calculated relative to its atomic mass (32 u).

Solution:
Step 1: Identify the given data from the problem:
Mass of sulfur solute (w_2) = 2.56 g
Mass of CS_2 solvent (w_1) = 100 g
Elevation in boiling point (ΔT_b) = 0.256 K
Molal elevation constant (K_b) = 2.56 K kg mol^{-1}

Step 2: Relate boiling point elevation to the molar mass (M_2) of the solute:

$$\Delta T_b = K_b \times \frac{w_2 \times 1000}{M_2 \times w_1}$$

Step 3: Rearrange the equation to isolate and calculate the unknown molar mass M_2:

$$M_2 = \frac{K_b \times w_2 \times 1000}{\Delta T_b \times w_1}$$

$$M_2 = \frac{2.56 \times 2.56 \times 1000}{0.256 \times 100} = 256 \text{ g mol}^{-1}$$

Step 4: Determine the atomicity (n) by dividing the calculated molecular mass by the atomic mass of sulfur:

$$n = \frac{\text{Molecular Mass}}{\text{Atomic Mass}} = \frac{256}{32} = 8$$

Thus, sulfur exists as S_8 molecules in this specific solution environment.

Final Answer: $\boxed{8}$

Answer: (D)

Go Back to Question 1

Q2.

Solution

Concept:

The Rydberg formula describes the wavelengths of spectral lines in hydrogen-like systems: $\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$. For the Balmer series, transitions terminate at $n_1 = 2$. The first line corresponds to $n_2 = 3 \longrightarrow n_1 = 2$, and the second line corresponds to $n_2 = 4 \longrightarrow n_1 = 2$.

Solution:

Step 1: Write the equation for the first line of the Balmer series where $\lambda_1 = \lambda$:

$$\frac{1}{\lambda} = R_H\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = R_H\left(\frac{1}{4} - \frac{1}{9}\right) = \frac{5R_H}{36}$$

$$R_H = \frac{36}{5\lambda}$$

Step 2: Write the equation for the second line of the Balmer series with unknown wavelength λ_2:

$$\frac{1}{\lambda_2} = R_H\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = R_H\left(\frac{1}{4} - \frac{1}{16}\right) = \frac{3R_H}{16}$$

Step 3: Substitute the value of R_H into the expression for λ_2:

$$\frac{1}{\lambda_2} = \left(\frac{36}{5\lambda}\right) \times \left(\frac{3}{16}\right) = \frac{27}{20\lambda}$$

Step 4: Take the reciprocal of both sides to obtain the explicit value for λ_2:

$$\lambda_2 = \frac{20}{27}\lambda$$

Final Answer: $\boxed{\frac{20}{27}\lambda}$

Answer: (A)

Go Back to Question 2

Q3.

Solution

Concept:

The dipole moment (μ) is determined by the product of charge separation (q) and bond length (d). In methyl halides (CH_3X), down the group, halogen electronegativity decreases (q drops) and bond length increases (d rises). Due to the exceptionally small size of the fluorine atom, the bond distance of C – F is short enough to make its overall dipole moment lower than that of CH_3Cl.

Solution:

Step 1: Compare chloromethane and fluoromethane. Chlorine is less electronegative than fluorine, but its significantly larger carbon-halogen bond length compensates for the charge difference, maximizing the product $q \times d$. Thus, $\mu(CH_3Cl) > \mu(CH_3F)$.

Step 2: Examine the remaining trends. Beyond chlorine, the dramatic reduction in halogen electronegativity becomes the dominant factor, causing the dipole moment to drop continuously from bromine to iodine.

Step 3: Combine these factors to establish the final decreasing order of dipole moments:

$$CH_3Cl > CH_3F > CH_3Br > CH_3I$$

Final Answer: $\boxed{CH_3Cl > CH_3F > CH_3Br > CH_3I}$

Answer: (A)

Go Back to Question 3

Q4.

Solution

Concept:

For a fixed mass of an ideal gas, the number of moles remains constant. This allows the state parameters to be interlinked using the combined gas law relation: $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$.

Solution:

Step 1: Group the initial and final states given in the problem statement:

Initial State: $P_1 = P, V_1 = V, T_1 = T$

Final State: $P_2 = \frac{P}{3}, T_2 = 2T, V_2 = ?$

Step 2: Set up the algebraic equation using the combined ideal gas law:

$$\frac{P \times V}{T} = \frac{\left(\frac{P}{3}\right) \times V_2}{2T}$$

Step 3: Simplify the expression by dividing out the common parameters P and T:

$$V = \frac{V_2}{3 \times 2} = \frac{V_2}{6}$$

Step 4: Solve for V_2 to find the final volume:

$$V_2 = 6V$$

Final Answer: $\boxed{6V}$

Answer: (A)

Go Back to Question 4

Q5.

Solution

Concept:
In a perfectly reversible thermodynamic path, the net entropy change of the universe is zero ($\Delta S_{\text{sys}} + \Delta S_{\text{surr}} = 0$). Therefore, the entropy change of the surroundings is equal in magnitude but opposite in sign to the system: $\Delta S_{\text{surr}} = -\Delta S_{\text{sys}}$. The entropy change for the isothermal expansion of an ideal gas is given by $\Delta S_{\text{sys}} = 2.303 \cdot nR \log\left(\frac{V_2}{V_1}\right)$.

Solution:
Step 1: Identify the values: $n = 1$ mol, $V_1 = 10$ L, $V_2 = 100$ L, $R \approx 8.314$ J K^{-1} mol^{-1}.

Step 2: Compute the entropy change experienced by the system:

$$\Delta S_{\text{sys}} = 2.303 \times 1 \times 8.314 \times \log\left(\frac{100}{10}\right)$$

$$\Delta S_{\text{sys}} = 2.303 \times 8.314 \times \log(10) = 19.15 \text{ J K}^{-1} \text{ mol}^{-1}$$

Step 3: Determine the entropy change of the surroundings using the reversibility condition:

$$\Delta S_{\text{surr}} = -\Delta S_{\text{sys}} = -19.15 \text{ J K}^{-1} \text{ mol}^{-1}$$

Final Answer: $\boxed{-19.15 \text{ J K}^{-1} \text{ mol}^{-1}}$

Answer: (A)

Go Back to Question 5

Q6.

Solution

Concept:

For a gas-phase equilibrium reaction, the equilibrium constant K_p can be expressed in terms of the total pressure P and the equilibrium partial pressures of each component. The partial pressures are calculated using Dalton's law, where $P_i = X_i \cdot P$ (X_i being the mole fraction of component i).

Solution:

Step 1: Set up the equilibrium table for the dissociation of $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$:
Initial moles: Let moles of $PCl_5 = 1$, $PCl_3 = 0$, $Cl_2 = 0$.
Equilibrium moles: $PCl_5 = 1 - \alpha$, $PCl_3 = \alpha$, $Cl_2 = \alpha$.

Step 2: Calculate the total number of moles present at equilibrium:

$$\text{Total Moles} = (1 - \alpha) + \alpha + \alpha = 1 + \alpha$$

Step 3: Determine the equilibrium partial pressures for each gas component:

$$P_{PCl_5} = \frac{1-\alpha}{1+\alpha}P, \quad P_{PCl_3} = \frac{\alpha}{1+\alpha}P, \quad P_{Cl_2} = \frac{\alpha}{1+\alpha}P$$

Step 4: Write the expression for the equilibrium constant K_p and substitute the values:

$$K_p = \frac{P_{PCl_3} \times P_{Cl_2}}{P_{PCl_5}} = \frac{\left(\frac{\alpha}{1+\alpha}P\right) \times \left(\frac{\alpha}{1+\alpha}P\right)}{\left(\frac{1-\alpha}{1+\alpha}P\right)}$$

Step 5: Simplify the algebraic fraction to get the final consolidated formula:

$$K_p = \frac{\alpha^2 P^2}{(1+\alpha)^2} \times \frac{1+\alpha}{(1-\alpha)P} = \frac{\alpha^2 P}{(1+\alpha)(1-\alpha)} = \frac{\alpha^2 P}{1-\alpha^2}$$

Final Answer: $\boxed{\frac{\alpha^2 P}{1-\alpha^2}}$

Answer: (A)

Go Back to Question 6

Q7.

Solution

Concept:

The integrated rate law for a first-order chemical reaction is mathematically defined by the expression $k = \frac{2.303}{t} \log \frac{[A]_0}{[A]_t}$. Converting this expression into a linear equation of the form $y = mx + c$ allows us to analyze the graphical parameters directly.

Solution:

Step 1: Rearrange the integrated rate equation to isolate the log term containing the variable concentration:

$$\log \frac{[A]_0}{[A]_t} = \frac{k \cdot t}{2.303}$$

Step 2: Apply logarithmic identity properties to split the ratio into separate numerator and denominator terms:

$$\log[A]_0 - \log[A]_t = \frac{k}{2.303} t$$

Step 3: Isolate the dependent variable $\log[A]_t$ on the left side of the equation:

$$\log[A]_t = -\left(\frac{k}{2.303}\right) t + \log[A]_0$$

Step 4: Compare this rewritten expression with the straight-line equation $y = mx + c$:
Here, $y = \log[A]_t$, the independent variable $x = t$, and the vertical intercept $c = \log[A]_0$.

Step 5: Extract the coefficient of t to determine the mathematical value of the slope (m):

$$\text{Slope} = -\frac{k}{2.303}$$

Final Answer: $\boxed{-\frac{k}{2.303}}$

Answer: (B)

Go Back to Question 7

Q8.

Solution

Concept:
In redox titrations, the chemical equivalents of the oxidizing agent must equal the chemical equivalents of the reducing agent at the stoichiometric equivalence point. This balance can be quantified using the normality relation: $N_1V_1 = N_2V_2$. Normality is related to molarity through the valence factor (n-factor) via the expression $N = M \times n$.

Solution:
Step 1: Identify the balanced half-reactions to determine the respective n-factors in an acidic medium:
For $KMnO_4$: $Mn^{7+} + 5e^- \longrightarrow Mn^{2+}$, so $n_1 = 5$.
For H_2O_2: $O_2^{2-} \rightarrow O_2 + 2e^-$, so $n_2 = 2$.

Step 2: Apply the law of equivalence linking the two reacting chemical solutions:

$$N_1V_1 = N_2V_2 \implies (M_1 \times n_1) \times V_1 = (M_2 \times n_2) \times V_2$$

Step 3: Insert the given numerical values to calculate the unknown molarity (M_2) of H_2O_2:

$$(0.05 \times 5) \times 20 = (M_2 \times 2) \times 25 \implies 5 = 50 \cdot M_2 \implies M_2 = 0.1 \text{ M}$$

Step 4: Calculate the concentration strength of the H_2O_2 solution in grams per litre (g L^{-1}):

$$\text{Strength} = \text{Molarity} \times \text{Molar Mass of } H_2O_2$$

$$\text{Strength} = 0.1 \text{ mol L}^{-1} \times 34 \text{ g mol}^{-1} = 3.40 \text{ g L}^{-1}$$

Final Answer: $\boxed{3.40}$

Answer: (B)

Go Back to Question 8

Q9.

Solution

Concept:

Kohlrausch's law of independent migration of ions states that the limiting molar conductivity of an electrolyte can be represented as the sum of the individual contributions of its constituent anions and cations. This allows values for weak electrolytes to be derived via linear combinations of strong electrolytes.

Solution:

Step 1: Express the limiting molar conductivities of the given strong electrolytes as individual ionic components:

$$\Lambda_m^\circ(NH_4Cl) = \lambda_{NH_4^+}^\circ + \lambda_{Cl^-}^\circ = x$$

$$\Lambda_m^\circ(NaOH) = \lambda_{Na^+}^\circ + \lambda_{OH^-}^\circ = y$$

$$\Lambda_m^\circ(NaCl) = \lambda_{Na^+}^\circ + \lambda_{Cl^-}^\circ = z$$

Step 2: Define the target ionic formulation for the weak electrolyte ammonium hydroxide (NH_4OH):

$$\Lambda_m^\circ(NH_4OH) = \lambda_{NH_4^+}^\circ + \lambda_{OH^-}^\circ$$

Step 3: Combine the given electrolyte equations linearly to eliminate unwanted spectator ions (Na^+ and Cl^-):

$$\Lambda_m^\circ(NH_4OH) = \Lambda_m^\circ(NH_4Cl) + \Lambda_m^\circ(NaOH) - \Lambda_m^\circ(NaCl)$$

Step 4: Substitute the variable equivalents to write the explicit functional solution:

$$\Lambda_m^\circ(NH_4OH) = x + y - z$$

Final Answer: $\boxed{x + y - z}$

Answer: (A)

Go Back to Question 9

Q10.

Solution

Concept:

Alkali metals dissolve smoothly in liquid ammonia solvent systems to form deeply colored solutions. This chemical behavior is driven by ionization, where the solvent molecules solvate both the ejected valence electrons and the resulting metal cations.

Solution:

Step 1: Write down the chemical equation representing the dissolution and solvation processes:

$$\text{Na} + (x + y)\text{NH}_3 \rightarrow [\text{Na}(\text{NH}_3)_x]^+ + [e(\text{NH}_3)_y]^-$$

Step 2: Identify the ionic species formed in this solution mixture. The processes yield ammoniated sodium cations, $[\text{Na}(\text{NH}_3)_x]^+$, and ammoniated free electrons, $[e(\text{NH}_3)_y]^-$.

Step 3: Rationalize the origin of the optical absorption. The solvated free electrons absorb energy in the visible red region of the electromagnetic spectrum to undergo electronic excitation.

Step 4: Determine the complementary color expressed. The absorption of red light wavelengths causes the transmitted light to appear deep blue, imparting a characteristic coloration to the system.

Final Answer: $\boxed{\text{Ammoniated electrons}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 10

Q11.

Solution

Concept:

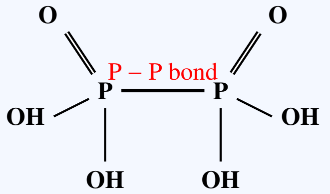
Structures of Oxoacids of Phosphorus.

Solution:

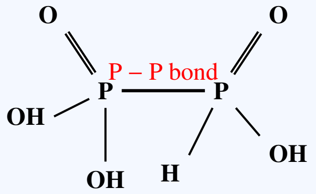
Step 1: Let us analyze the connectivity and direct bonding configurations of the phosphorus atoms within each oxoacid listed in the choices:

- **Hypophosphoric acid ($H_4P_2O_6$):** In this molecule, phosphorus is in the +4 oxidation state. The two phosphorus atoms are linked together directly via a single $P - P$ bond, with no bridging oxygen atom.
- **Diphosphorous acid ($H_4P_2O_5$):** Also known as pyrophosphorous acid, it contains a direct $P-P$ bond in its asymmetrical tautomeric structure, where one phosphorus atom is bonded to a hydrogen atom and another is part of a phosphoryl linkage $[\mathrm{H-PO(OH)-O-PO(OH)_2} \rightleftharpoons \mathrm{(OH)_2P-PO(OH)_2}]$. It is widely recognized in structural chemistry textbooks for containing a characteristic direct $P - P$ covalent link.
- **Pyrophosphoric acid ($H_4P_2O_7$):** Contains a bridging oxygen atom, forming a distinct $P - O - P$ linkage.
- **Orthophosphoric acid (H_3PO_4):** A monomeric species containing only a single central phosphorus atom, which eliminates the possibility of a $P - P$ bond.

Step 2: Therefore, both hypophosphoric acid and diphosphorous acid contain a direct $P - P$ linkage in their molecular architectures.



Hypophosphoric acid ($H_4P_2O_6$)



Diphosphorous acid ($H_4P_2O_5$)

Final Answer: $\boxed{\text{B}}$

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept:

Chromyl Chloride Test (d-block chemistry and qualitative analysis).

Solution:

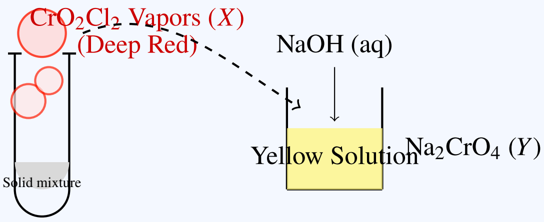
Step 1: When a solid chloride salt (such as NaCl) is heated intensely with potassium dichromate ($K_2Cr_2O_7$) and concentrated sulphuric acid (H_2SO_4), a characteristic volatilization reaction occurs. This transformation leads to the generation of deep red/orange vapors of **chromyl chloride** (CrO_2Cl_2), which represents compound X.

$$K_2Cr_2O_7 + 4\,NaCl + 6\,H_2SO_4 \xrightarrow{\Delta} 2\,CrO_2Cl_2 \uparrow (X) + 2\,KHSO_4 + 4\,NaHSO_4 + 3\,H_2O$$

Step 2: When these deep red vapors of chromyl chloride (X) are passed into or dissolved in an aqueous sodium hydroxide (NaOH) solution, a neutralization and coordination conversion happens, forming a yellow solution containing **sodium chromate** (Na_2CrO_4), which represents compound Y.

$$CrO_2Cl_2 + 4\,NaOH \longrightarrow Na_2CrO_4(Y) + 2\,NaCl + 2\,H_2O$$

Step 3: Therefore, compounds X and Y are CrO_2Cl_2 and Na_2CrO_4, respectively.



Final Answer: $\boxed{\text{A}}$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 12

Q13.

Solution

Concept:

Crystal Field Theory (CFT) dictates that when an octahedral coordination environment forms, the d-orbitals split into lower-energy t_{2g} and higher-energy e_g sets. Water (H_2O) acts as a weak-field ligand, meaning the crystal field splitting energy (Δ_o) is less than the electron pairing energy (P), producing a high-spin electron configuration. The spin-only magnetic moment (μ_s) is calculated via the formula $\mu_s = \sqrt{n(n+2)}$ BM, where n is the number of unpaired electrons.

Solution:

Step 1: Determine the oxidation state and valence electronic shell of the central manganese ion in $[Mn(H_2O)_6]^{2+}$:

Since H_2O is neutral, Mn exists as Mn^{2+}. The atomic configuration transitions from $[Ar]3d^54s^2$ to the ionic state $[Ar]3d^5$.

Step 2: Distribute the five $3d$ electrons into the split octahedral energy levels. Because water is a weak-field ligand ($\Delta_o < P$), Hund's rule is obeyed across both levels without pairing:

$$\text{Configuration} = t_{2g}^3 e_g^2$$

Step 3: Count the total number of unpaired electrons (n) from the subshell distribution:

$$n = 5$$

Step 4: Evaluate the spin-only magnetic moment using the algebraic equation:

$$\mu_s = \sqrt{5(5+2)} = \sqrt{35} \approx 5.92 \text{ BM}$$

Final Answer: $\boxed{t_{2g}^3 e_g^2 \text{ and } 5.92 \text{ BM}}$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 13

Q14.

Solution

Concept:
Photochemical smog is a oxidizing type of air pollution generated via solar-radiation-driven atmospheric interactions between hydrocarbons and nitrogen oxides (NO_x). In contrast, classical (sulfurous) smog develops in cool, humid conditions and is dominated by reducing agents such as sulfur oxides and smoke particles.

Solution:
Step 1: Identify the primary pollutants initiated by automobile emissions that fuel photochemical smog: nitric oxide (NO) and unburned volatile organic hydrocarbons.

Step 2: Trace the secondary pollutants produced when these primary precursors react under sunlight:

$$NO_2 \xrightarrow{h\nu} NO + O$$

$$O + O_2 \rightarrow O_3 \quad \text{(Ozone)}$$

Hydrocarbons react with ozone and oxygen to yield peroxyacetyl nitrate (PAN) and acrolein.

Step 3: Evaluate sulfur dioxide (SO_2) against these reaction mechanisms. Sulfur dioxide is an industrial pollutant linked directly to classical smog and acid rain chemistry, rather than the secondary oxidant path of photochemical smog.

Final Answer: $\boxed{\text{Sulphur dioxide } (SO_2)}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 14

Q15.

Solution

Concept:

IUPAC rules dictate that for polyfunctional organic molecules, a specific functional group priority hierarchy determines the principal suffix. Carboxylic acids ($-COOH$) possess priority over hydroxyl groups ($-OH$) and alkyl branches ($-CH_3$). The principal carbon chain must be numbered starting from the carboxylic carbon to give it the lowest possible locant (C1).

Solution:

Step 1: Find the longest continuous carbon chain containing the principal functional group. The backbone contains 5 carbon atoms, making the parent alkane chain pentanoic acid.

Step 2: Number the carbon chain sequentially starting directly at the carbonyl carbon:

$$\overset{5}{C}H_3 - \overset{4}{C}H(OH) - \overset{3}{C}H_2 - \overset{2}{C}(CH_3)_2 - \overset{1}{C}OOH$$

Step 3: Identify the remaining functional groups and structural variations as prefixes:
At Carbon-2: Two methyl substituents, designated as 2,2-dimethyl.
At Carbon-4: One hydroxyl group, designated as 4-hydroxy.

Step 4: Arrange the prefixes alphabetically to construct the full systematic IUPAC name. "Hydroxy" precedes "methyl" alphabetically:

$$\text{Name} = \text{4-Hydroxy-2,2-dimethylpentanoic acid}$$

Final Answer: $\boxed{\text{4-Hydroxy-2,2-dimethylpentanoic acid}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 15

Q16.

Solution

Concept:

Reductive Ozonolysis of Alkenes.

Solution:

Step 1: Reductive ozonolysis ($O_3/Zn - H_2O$) cleaves the carbon-carbon double bond ($C = C$) of an alkene and converts each carbon atom of the double bond into a carbonyl group ($C = O$).

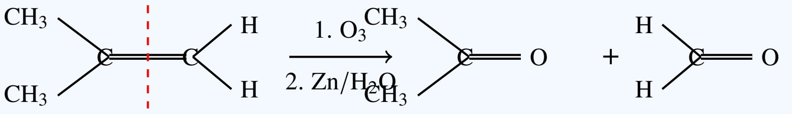
Step 2: To find the structure of the starting alkene X, we can align the carbonyl groups of the given products facing each other, remove the oxygen atoms, and join the two carbon atoms with a double bond:

- **Propan-2-one (Acetone):** $(CH_3)_2C = O$
- **Formaldehyde (Methanal):** $H_2C = O$

Step 3: Connecting the fragments:

$$(CH_3)_2C = O + O = CH_2 \xrightarrow{\text{Combine}} (CH_3)_2C = CH_2$$

The IUPAC name for $(CH_3)_2C = CH_2$ is **2-Methylprop-1-ene**.



2-Methylprop-1-ene (X) **Propan-2-one** **Formaldehyde**

Final Answer: $\boxed{B}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 16

Q17.

Solution

Concept:

Dehydrohalogenation of Alkyl Halides ($E2$ Elimination and Zaitsev's Rule).

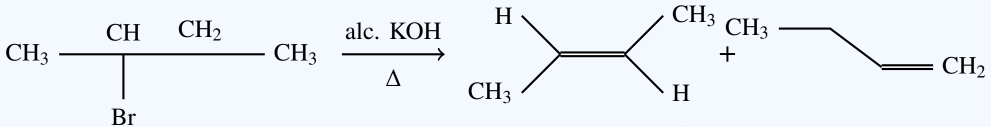
Solution:

Step 1: When 2-bromobutane is heated with an excess of alcoholic potassium hydroxide (KOH), it undergoes an **E2 elimination reaction** (dehydrohalogenation) to form an alkene.

Step 2: Base-induced elimination follows **Zaitsev's rule**, which states that the highly substituted, more stable alkene will be formed as the major product.

- Elimination involving a β-hydrogen from C_1 yields **But-1-ene** (monosubstituted, minor product).
- Elimination involving a β-hydrogen from C_3 yields **But-2-ene** (disubstituted, major product).

Step 3: Between the two stereoisomeric forms of but-2-ene, **trans-But-2-ene** is thermodynamically more stable than **cis-But-2-ene** due to significantly lower steric hindrance between the two bulky methyl (CH_3) groups. Therefore, *trans*-but-2-ene constitutes the major organic product.



2-Bromobutane **trans-But-2-ene (Major)** **But-1-ene (Minor)**

Final Answer: $\boxed{B}$

Answer: (B)

Go Back to Question 17

Q18.

Solution

Concept:

The conversion of phenol to salicylaldehyde by treatment with chloroform and aqueous sodium hydroxide is known as the Reimer-Tiemann reaction. This classic organic transformation proceeds via an electrophilic aromatic substitution pathway initiated by a highly reactive, neutral divalent carbon species generated in situ through alpha-elimination.

Solution:

Step 1: Analyze the reaction between chloroform ($CHCl_3$) and the strong base (NaOH). The hydroxide ion abstracts a strongly acidic proton from chloroform to form a trichlorocarbanion intermediate:

$$CHCl_3 + OH^- \rightleftharpoons :CCl_3^- + H_2O$$

Step 2: Trace the subsequent alpha-elimination of a chloride ion from the unstable carbanion intermediate:

$$:CCl_3^- \rightarrow :CCl_2 + Cl^-$$

This step yields dichlorocarbene ($:CCl_2$), an electron-deficient species containing a neutral carbon atom with an incomplete octet (six valence electrons).

Step 3: Identify the role of dichlorocarbene in the cycle. It acts as a powerful electrophile that undergoes ortho-attack by the electron-rich phenoxide ring, eventually yielding salicylaldehyde after hydrolysis.

Final Answer: $\boxed{\text{Dichlorocarbene}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 18

Q19.

Solution

Concept:

Cannizzaro Reaction (Self-oxidation and reduction of aldehydes lacking α-hydrogens).

Solution:

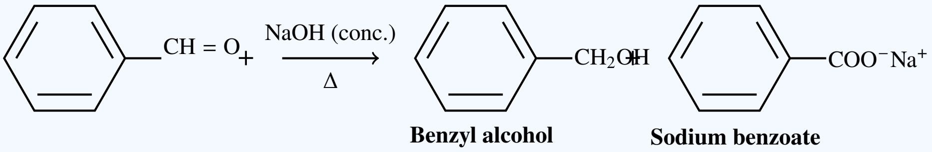
Step 1: Benzaldehyde (C_6H_5CHO) does not contain any α-hydrogen atoms. When it is treated with a concentrated strong base like aqueous sodium hydroxide (NaOH), it undergoes a disproportionation (self-redox) reaction known as the **Cannizzaro reaction**.

Step 2: In this reaction, one molecule of benzaldehyde is reduced to a primary alcohol, while another molecule is oxidized to a carboxylic acid salt:

- **Reduction product:** Benzaldehyde is reduced to **Benzyl alcohol** ($C_6H_5CH_2OH$).
- **Oxidation product:** Benzaldehyde is oxidized to benzoic acid, which in the presence of NaOH forms **Sodium benzoate** (C_6H_5COONa).

Step 3: The balanced chemical equation representing this chemical transformation is:

$$2\,C_6H_5CHO + NaOH\ (conc.) \xrightarrow{\Delta} C_6H_5CH_2OH + C_6H_5COONa$$



Final Answer: $\boxed{A}$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 19

Q20.

Solution

Concept:

The Hinsberg test utilizes benzene sulfonyl chloride ($C_6H_5SO_2Cl$) to differentiate between primary, secondary, and tertiary amines based on their nucleophilic substitution behavior and the solubility of the resulting sulfonamide derivatives in an aqueous alkaline medium.

Solution:

Step 1: Characterize the behavior of a primary amine ($R-NH_2$). It reacts to form an N-alkylbenzene sulfonamide that contains a highly acidic hydrogen atom attached directly to the nitrogen. This acidic proton reacts with NaOH to form a water-soluble salt, meaning it dissolves in alkali.

Step 2: Characterize the behavior of a secondary amine (R_2NH). It reacts with benzene sulfonyl chloride to yield an N, N-dialkylbenzene sulfonamide product:

$$C_6H_5SO_2Cl + R_2NH \rightarrow C_6H_5SO_2NR_2 + HCl$$

This sulfonamide derivative lacks any acidic hydrogen atoms attached to the nitrogen atom.

Step 3: Assess the solubility of the secondary sulfonamide product. Because it lacks an acidic proton, it cannot react with sodium hydroxide to form a soluble salt. Consequently, it precipitates as a solid that remains completely insoluble in an aqueous NaOH solution.

Step 4: Match these observations with the experimental description of compound X. Since amine X forms an alkali-insoluble precipitate, it is classified as a secondary amine.

Final Answer: $\boxed{\text{Secondary amine}}$

Answer: (B)

Go Back to Question 20

Q21.

Solution

Concept:

Starch is a natural homopolysaccharide that functions as the primary energy storage molecule in plants. It is composed of two distinct structural components: amylose (a linear polymer) and amylopectin (a branched polymer). Both fractions are constructed entirely from a single type of repeating monosaccharide unit linked via glycosidic bonds. Complete acid-catalyzed or enzymatic hydrolysis breaks all glycosidic linkages, converting the macromolecule into its constituent monomers.

Solution:

Step 1: Identify the structural units of amylose. Amylose consists of unbranched, linear chains of several hundred to thousands of glucose units joined exclusively by α-(1$\rightarrow$4) glycosidic linkages.

Step 2: Identify the structural units of amylopectin. Amylopectin is a highly branched polymer where the linear backbone features α-(1$\rightarrow$4) glycosidic bonds, and branching points occur via α-(1$\rightarrow$6) glycosidic bonds every 24 to 30 glucose residues.

Step 3: Analyze the monomer common to both fractions. Since both amylose and amylopectin are built solely from glucose rings in the alpha-anomeric form, the only monomeric building block present is α-D-glucopyranose.

Step 4: Conclude the final hydrolysis product. Because the macromolecule is a homopolymer of alpha-glucose, complete chemical cleavage yields α-D-glucopyranose exclusively.

Final Answer: $\boxed{\alpha\text{-D-Glucopyranose}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 21

Q22.

Solution

Concept:

Nylon-6,6 is a synthetic polyamide prepared through a condensation polymerization (or step-growth polymerization) reaction. The designation "6,6" indicates that both of the reacting bifunctional monomers contain exactly six carbon atoms within their molecular frameworks. During polymerization, the amine groups react with the carboxylic acid groups to form recurring amide linkages ($-CO-NH-$) with the simultaneous elimination of water molecules.

Solution:

Step 1: Identify the diamine monomer. The six-carbon diamine utilized is hexamethylenediamine, which possesses the structural formula:

$$H_2N-(CH_2)_6-NH_2$$

Step 2: Identify the dicarboxylic acid monomer. The six-carbon dicarboxylic acid utilized is adipic acid (hexanedioic acid), which possesses the structural formula:

$$HOOC-(CH_2)_4-COOH$$

Step 3: Map out the condensation reaction between n molecules of each monomer under high temperature and pressure conditions:

$$n\,H_2N(CH_2)_6NH_2+n\,HOOC(CH_2)_4COOH \longrightarrow \left[-NH-(CH_2)_6-NH-CO-(CH_2)_4-CO-\right]_n+2n\,H_2O$$

Step 4: Match the required monomers with the given options. The pairing corresponds to hexamethylenediamine and adipic acid.

Final Answer: $\boxed{\text{Hexamethylenediamine and Adipic acid}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 22

Q23.

Solution

Concept:

Nodes are regions in an atom where the probability density of finding an electron is exactly zero. The total number of nodes in any given atomic orbital is determined by its principal quantum number (n) and is equal to $n-1$. These nodes are divided into two categories: angular nodes (planar or conical nodes) and radial nodes (spherical nodes). The number of angular nodes is given by the azimuthal quantum number (l), while the number of radial nodes is calculated using the formula:

$$\text{Radial Nodes} = n - l - 1$$

Solution:

Step 1: Identify the quantum numbers for a $4p$ orbital:

Principal quantum number (n) = 4

Azimuthal quantum number (l) = 1 (since $s = 0, p = 1, d = 2, f = 3$)

Step 2: Calculate the number of angular nodes directly using the value of l:

$$\text{Angular Nodes} = l = 1$$

Step 3: Calculate the number of radial nodes using the established algebraic formula:

$$\text{Radial Nodes} = n - l - 1 = 4 - 1 - 1 = 2$$

Step 4: Combine the results sequentially to match the required order (radial and angular nodes):

$$\text{Radial Nodes} = 2 \quad \text{and} \quad \text{Angular Nodes} = 1$$

Final Answer: $\boxed{\text{2 and 1}}$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 23

Q24.

Solution

Concept:

Hybridization and Molecular Geometry (VSEPR Theory).

Solution:

Step 1: To determine the hybridization of the central atom in a covalent molecule, we calculate its steric number (Z), which is given by:

$$Z = \text{Number of } \sigma\text{-bonds} + \text{Number of lone pairs on the central atom}$$

Step 2: Let us evaluate the steric number and hybridization for each given molecule:

- **(A) SF_4**: The central sulfur atom (Group 16) has 6 valence electrons. It forms 4 single (σ) bonds with fluorine atoms, leaving 1 lone pair.

$$Z = 4 + 1 = 5 \implies sp^3d \text{ hybridization (See-saw geometry)}$$

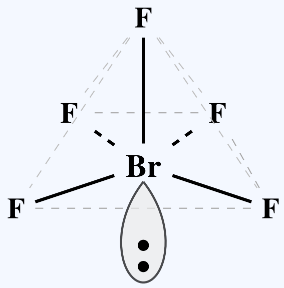
- **(B) BrF_5**: The central bromine atom (Group 17) has 7 valence electrons. It forms 5 single (σ) bonds with fluorine atoms, leaving 1 lone pair.

$$Z = 5 + 1 = 6 \implies sp^3d^2 \text{ hybridization (Square pyramidal geometry)}$$

- **(C) PCl_5**: The central phosphorus atom (Group 15) has 5 valence electrons. It forms 5 single (σ) bonds with chlorine atoms, leaving 0 lone pairs.

$$Z = 5 + 0 = 5 \implies sp^3d \text{ hybridization (Trigonal bipyramidal geometry)}$$

Step 3: Consequently, only BrF_5 features a central atom with sp^3d^2 hybridization, resulting in an octahedral electron-pair geometry and a square pyramidal molecular architecture.



Square Pyramidal Geometry of BrF_5 (sp^3d^2)

Final Answer: $\boxed{\text{B}}$

Answer: (B)

Go Back to Question 24

Q25.

Solution

Concept:
Joule expansion refers to the adiabatic expansion of an ideal gas into an evacuated chamber (a complete vacuum). Because the expansion takes place against zero external resisting pressure ($P_{\text{ext}} = 0$), the process is classified as free expansion. We can determine the state modifications by applying the first law of thermodynamics:

$$\Delta U = q + w$$

Solution:
Step 1: Evaluate the work done (w) during the free expansion. Since the external pressure is zero, no opposing force is encountered:

$$w = -P_{\text{ext}}\Delta V = -0 \times \Delta V = 0$$

Step 2: Evaluate the heat exchanged (q). The problem states that the expansion is adiabatic, meaning the system is thermally isolated from its environment:

$$q = 0$$

Step 3: Calculate the change in internal energy (ΔU) using the first law of thermodynamics:

$$\Delta U = q + w = 0 + 0 = 0$$

Step 4: Analyze the temperature change (ΔT). For an ideal gas, internal energy is a function of temperature alone ($U = f(T)$). Since $\Delta U = 0$, the temperature of the ideal gas must remain invariant throughout the process:

$$\Delta T = 0$$

Step 5: Group the derived parameters together into the correct corresponding set:

$$w = 0, \quad \Delta T = 0, \quad \Delta U = 0$$

Final Answer: $\boxed{w = 0, \Delta T = 0, \Delta U = 0}$

Answer: (B)

Go Back to Question 25

Q26.

Solution

Concept:
When a weak acid (CH_3COOH) is mixed with a strong base (NaOH), they react to form a salt (CH_3COONa) and water. If the weak acid is present in excess, the resulting solution contains both the unreacted weak acid and its conjugate base (salt), forming an acidic buffer solution. The pH of an acidic buffer is calculated using the Henderson-Hasselbalch equation:

$$\text{pH} = \text{p}K_a + \log\frac{[\text{Salt}]}{[\text{Acid}]}$$

Solution:
Step 1: Calculate the initial millimoles (mmol) of the reactants, assuming equal volumes (V mL) of both solutions are mixed:

$$\text{Initial mmol of } CH_3COOH = 0.2\text{ M} \times V\text{ mL} = 0.2V\text{ mmol}$$

$$\text{Initial mmol of NaOH} = 0.1\text{ M} \times V\text{ mL} = 0.1V\text{ mmol}$$

Step 2: Set up the stoichiometric reaction table to determine the equilibrium quantities:

Reaction:	CH_3COOH	+	NaOH	$\rightarrow$	$CH_3COONa + H_2O$
Initial (mmol):	$0.2V$		$0.1V$		0
Change (mmol):	$-0.1V$		$-0.1V$		$+0.1V$
Final (mmol):	$0.1V$		0		$0.1V$

Step 3: Determine the final concentrations of the weak acid and its salt in the total solution volume ($2V$ mL):

$$[\text{Acid}] = [CH_3COOH] = \frac{0.1V}{2V} = 0.05\text{ M}$$

$$[\text{Salt}] = [CH_3COONa] = \frac{0.1V}{2V} = 0.05\text{ M}$$

Step 4: Substitute these concentrations into the Henderson-Hasselbalch equation:

$$\text{pH} = \text{p}K_a + \log\left(\frac{0.05}{0.05}\right) = \text{p}K_a + \log(1)$$

Step 5: Evaluate the logarithmic term. Since $\log(1) = 0$:

$$\text{pH} = \text{p}K_a$$

Final Answer: $\boxed{\text{p}K_a}$

Answer: (A)

Go Back to Question 26

Q27.

Solution

Concept:

A pseudo-first-order reaction is a higher-order chemical reaction that behaves as a first-order reaction due to the presence of one or more reactants in vast excess. For a bimolecular reaction A + B $\rightarrow$ Products where $[B] \gg [A]$, the concentration of reactant B remains virtually constant throughout the reaction cycle ($[B]_t \approx [B]_0$). The rate law simplifies to Rate $= k'[A]$, where $k' = k[B]_0$ is the pseudo-first-order rate constant.

Solution:

Step 1: Write down the simplified rate expression for the pseudo-first-order system:

$$\text{Rate} = k'[\text{A}] \quad \text{where} \quad k' = k[\text{B}]_0$$

Step 2: Recall the half-life equation ($t_{1/2}$) for standard first-order and pseudo-first-order kinetics:

$$t_{1/2} = \frac{\ln 2}{k'} = \frac{0.693}{k'}$$

Step 3: Analyze the components of the half-life formula. The term $\frac{0.693}{k'}$ depends solely on the pseudo-rate constant k' and does not include the initial concentration term of reactant A ($[A]_0$).

Step 4: Evaluate the functional behavior of the half-life. Because $[A]_0$ is absent from the equation, the time required to reduce the concentration of A to half of its initial value is completely independent of its own initial concentration.

Final Answer: $\boxed{\text{Independent of the initial concentration of A}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 27

Q28.

Solution

Concept:

Boric acid (H_3BO_3 or $B(OH)_3$) is a structural exception among mineral acids. It is not a protic acid in the classical Arrhenius or Brønsted-Lowry sense, because it does not dissociate to release hydronium ions directly from its own framework. Instead, the central boron atom is electron-deficient with an incomplete octet (six valence electrons), allowing it to behave as a Lewis acid by accepting an electron pair from a water molecule.

Solution:

Step 1: Analyze the electronic environment of the central boron atom in $B(OH)_3$. Boron forms three σ-bonds with hydroxyl groups, leaving an empty p-orbital that can accommodate a lone pair of electrons.

Step 2: Trace the chemical interaction when boric acid is dissolved in an aqueous medium. It reacts with a water molecule, acting as a Lewis acid by accepting a lone pair from the oxygen atom of a hydroxyl ion (OH^-):

$$B(OH)_3 + 2H_2O \rightleftharpoons [B(OH)_4]^- + H_3O^+$$

Step 3: Account for the source of acidity in the solution. The generation of hydronium ions (H_3O^+) is a direct consequence of the ionization of water molecules after the abstraction of OH^- by boric acid, rather than the direct deprotonation of the H_3BO_3 molecule itself.

Step 4: Formulate the primary role of the acid. It functions explicitly as a Lewis acid by accepting a hydroxyl ion (OH^-) from a water molecule.

Final Answer: $\boxed{\text{A Lewis acid by accepting a hydroxyl ion } (OH^-) \text{ from a water molecule}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 28

Q29.

Solution

Concept:
The thermal stability of alkaline earth metal carbonates (MCO_3) increases systematically down the group. This periodic trend can be rationalized by the polarizing power of the metal cation (Fajans' rules). Small, highly charged cations have a high charge density, which heavily polarizes the large, unstable carbonate anion (CO_3^{2-}). Polarization weakens the carbon-oxygen bonds within the anion, lowering the activation energy required for thermal decomposition into a metal oxide and carbon dioxide gas.

Solution:
Step 1: List the alkaline earth metal cations in order of increasing ionic radius down Group 2:

$$Mg^{2+} < Ca^{2+} < Sr^{2+} < Ba^{2+}$$

Step 2: Relate ionic size to ionic charge density and polarizing capability. The smaller Mg^{2+} ion features the highest charge density and strongest polarizing effect, severely distorting the carbonate electron cloud and making $MgCO_3$ easy to decompose at lower temperatures.

Step 3: Analyze the properties of the barium cation (Ba^{2+}). Because Ba^{2+} has the largest ionic radius in this series, it possesses the lowest ionic charge density and the weakest polarizing power.

Step 4: Conclude the relative thermal stability of the carbonates. Since the carbonate cloud undergoes minimal distortion when paired with the large Ba^{2+} cation, the $BaCO_3$ lattice remains highly stable and requires the highest thermal energy to undergo decomposition.

Final Answer: $\boxed{BaCO_3}$

Answer: (D)

Go Back to Question 29

Q30.

Solution

Concept:

For an organic molecule to exhibit optical isomerism and exist as a non-superimposable pair of enantiomers, it must be chiral. In alkanes and haloalkanes, molecular chirality is typically generated by the presence of at least one asymmetric carbon atom, also known as a stereocenter or chiral center. A chiral carbon atom is a tetrahedral carbon atom covalently bonded to four entirely distinct groups or substituents ($-R_1 \neq -R_2 \neq -R_3 \neq -R_4$).

Solution:

Step 1: Evaluate 1-chlorobutane structurally: $CH_3 - CH_2 - CH_2 - CH_2 - Cl$. Every carbon in this molecule is bonded to at least two identical hydrogen atoms, meaning it contains no chiral centers.

Step 2: Evaluate 2-chloropropane structurally: $CH_3 - CH(Cl) - CH_3$. The central carbon is bonded to a hydrogen atom, a chlorine atom, and two identical methyl ($-CH_3$) groups, making it achiral.

Step 3: Evaluate 2-methylpropane structurally: $CH_3 - CH(CH_3) - CH_3$. The central carbon is bonded to three identical methyl groups and one hydrogen, making it achiral.

Step 4: Evaluate 2-chlorobutane structurally and identify the substituents on Carbon-2:

$$CH_3 - \overset{*}{C}H(Cl) - CH_2 - CH_3$$

The Carbon-2 atom is bonded to four distinct chemical groups: a hydrogen atom ($-H$), a chlorine atom ($-Cl$), a methyl group ($-CH_3$), and an ethyl group ($-CH_2CH_3$).

Step 5: Conclude the optical activity status. Because Carbon-2 is a valid asymmetric stereocenter, 2-chlorobutane is a chiral molecule that can exist as a pair of enantiomers.

Final Answer: $\boxed{\text{2-Chlorobutane}}$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 30

Q31.

Solution

Concept:

The standard Gibbs free energy change (ΔG°) of an electrochemical cell reaction is linked directly to its standard cell potential (E°_{cell}) by the fundamental thermodynamic equation $\Delta G^\circ = -nFE^\circ_{\text{cell}}$, where n represents the total number of moles of electrons transferred in the balanced redox equation, and F is Faraday's constant (96500 C mol^{-1}). The standard cell potential is computed as:

$$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$$

Solution:

Step 1: Breakdown the overall cell reaction into its separate oxidation and reduction half-reactions:
Reduction (Cathode): $2\text{Fe}^{3+}(aq) + 2e^- \rightarrow 2\text{Fe}^{2+}(aq) \quad [E^\circ = +0.77\text{ V}]$
Oxidation (Anode): $2\text{I}^-(aq) \rightarrow \text{I}_2(s) + 2e^- \quad [E^\circ = +0.54\text{ V}]$

Step 2: Determine the value of n from the balanced half-reactions. The total number of transferred electrons is:

$$n = 2$$

Step 3: Calculate the standard net potential (E°_{cell}) of the electrochemical cell:

$$E^\circ_{\text{cell}} = E^\circ(\text{Fe}^{3+}/\text{Fe}^{2+}) - E^\circ(\text{I}_2/\text{I}^-) = +0.77\text{ V} - 0.54\text{ V} = +0.23\text{ V}$$

Step 4: Substitute the values of n, F, and E°_{cell} into the standard Gibbs free energy equation:

$$\Delta G^\circ = -2 \times 96500\text{ C mol}^{-1} \times 0.23\text{ V}$$

$$\Delta G^\circ = -44390\text{ J} = -44.39\text{ kJ} \approx -44.4\text{ kJ}$$

Final Answer: $\boxed{-44.4\text{ kJ}}$

Answer: (A)

Go Back to Question 31

Q32.

Solution

Concept:

The depression in freezing point (ΔT_f) of a solution containing a non-volatile, non-electrolyte solute is a colligative property defined by the relation $\Delta T_f = K_f \cdot m$, where K_f is the molal depression constant of the solvent, and m is the molality. Rearranging this relationship allows the experimental molar mass (M_2) of the unknown solute to be determined.

Solution:

Step 1: State the variables given in the text:

Mass of non-electrolyte solute (w_2) = 1.00 g

Mass of benzene solvent (w_1) = 50.0 g

Depression in freezing point (ΔT_f) = 0.40 K

Molal depression constant (K_f) = 5.12 K kg mol^{-1}

Step 2: Express the mathematical equation for the freezing point depression in terms of solute weight and molar mass:

$$\Delta T_f = \frac{K_f \times w_2 \times 1000}{M_2 \times w_1}$$

Step 3: Isolate the molar mass variable (M_2) algebraically:

$$M_2 = \frac{K_f \times w_2 \times 1000}{\Delta T_f \times w_1}$$

Step 4: Substitute the given values to solve for M_2:

$$M_2 = \frac{5.12 \times 1.00 \times 1000}{0.40 \times 50.0} = \frac{5120}{20} = 256 \text{ g mol}^{-1}$$

Final Answer: $\boxed{256}$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 32

Q33.

Solution

Concept:
Dinitrogen gas (N_2) can be prepared through several chemical pathways, including the thermal decomposition of nitrogen-rich salts (like azides and dichromates) or the controlled oxidation of ammonia. Conversely, binary compounds of phosphorus and alkaline earth metals react with protic solvents via non-redox pathways to yield phosphorus hydrides rather than nitrogen gas.

Solution:
Step 1: Evaluate the thermal decomposition of ammonium dichromate:

$$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_2 \uparrow + Cr_2O_3 + 4H_2O$$

This reaction produces nitrogen gas, so it is an incorrect option.

Step 2: Evaluate the thermal decomposition of sodium azide:

$$2NaN_3 \xrightarrow{\Delta} 2Na + 3N_2 \uparrow$$

This reaction produces highly pure nitrogen gas, so it is an incorrect option.

Step 3: Evaluate the reaction of excess ammonia with chlorine gas:

$$8NH_3 \text{ (excess)} + 3Cl_2 \longrightarrow 6NH_4Cl + N_2 \uparrow$$

This reaction produces nitrogen gas, so it is an incorrect option.

Step 4: Evaluate the reaction of calcium phosphide (Ca_3P_2) with water. This is a hydrolysis reaction of a phosphide salt:

$$Ca_3P_2 + 6H_2O \longrightarrow 3Ca(OH)_2 + 2PH_3 \uparrow$$

This pathway yields phosphine gas (PH_3) instead of nitrogen gas (N_2).

Final Answer: $\boxed{\text{Reaction of calcium phosphide with water}}$

$\boxed{\textbf{Answer: (D)}}$

Go Back to Question 33

Q34.

Solution

Concept:

The functional profile of an organic molecule can be deduced from its characteristic chemical tests:

1. Reaction with hydroxylamine (NH_2OH) to form an oxime indicates the presence of a carbonyl group ($C = O$).

2. A negative Tollen's test confirms the absence of an aldehyde group, meaning the compound must be a ketone.

3. A positive iodoform test ($I_2/NaOH$) confirms the presence of a methyl ketone group ($CH_3{-}CO{-}$).

Solution:

Step 1: Identify the functional class from the molecular formula C_4H_8O. The compound has one degree of unsaturation. Because it forms an oxime but does not reduce Tollen's reagent, it must be an aliphatic ketone rather than an aldehyde.

Step 2: Apply the structural constraint from the iodoform test. A positive iodoform test requires the presence of a terminal methyl carbonyl unit:

$$CH_3 - C(=O)-$$

Step 3: Assemble the remaining alkyl group from the total formula. Subtracting the methyl ketone fragment (C_2H_3O) from C_4H_8O leaves an ethyl group ($-CH_2CH_3$). Combining these components gives:

$$CH_3 - CO - CH_2 - CH_3$$

Step 4: Assign the IUPAC name to this four-carbon ketone chain. The systematic name is butan-2-one.

Final Answer: $\boxed{\text{Butan-2-one}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 34

Q35.

Solution

Concept:
Atomic and ionic radii typically increase down a vertical group in the periodic table due to the addition of new principal electronic shells. However, the atomic radius of the $5d$ transition series elements (like hafnium) is nearly identical to that of the preceding $4d$ transition series elements (like zirconium). This anomaly is caused by the filling of the $4f$ subshell, which occurs before the $5d$ subshell.

Solution:
Step 1: Analyze the electronic configuration of the $5d$ transition elements. Before entering the $5d$ subshell, electrons fill the inner $4f$ orbitals (from $Z = 58$ to $Z = 71$).

Step 2: Assess the shielding capacity of the $4f$ electrons. The f-orbitals have a highly diffuse shape, which results in exceptionally poor shielding of the outer electrons from the nuclear charge.

Step 3: Analyze the effect on the effective nuclear charge (Z_{eff}). Because the diffuse $4f$ electrons fail to shield the outer shell effectively, the increasing nuclear charge exerts a stronger pull on the outer electrons. This steady contraction in atomic size across the inner transition series is known as the lanthanoid contraction.

Step 4: Correlate this contraction with the size similarity between zirconium and hafnium. The lanthanoid contraction down the group counteracts the expected increase in size from the additional electronic shell, making the atomic radii of Zr and Hf virtually identical.

Final Answer: $\boxed{\text{Lanthanoid contraction}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 35

Q36.

Solution

Concept:

The temperature dependence of a chemical reaction rate is governed by the Arrhenius equation $k = A \cdot e^{-E_a/RT}$. Increasing the temperature increases the kinetic energy of molecules, thereby increasing the rate constants (k) of both forward and reverse reactions. For a reversible exothermic reaction ($\Delta H < 0$), the activation energy of the reverse reaction is greater than that of the forward reaction ($E_{a,r} > E_{a,f}$). Consequently, the reverse rate constant (k_r) increases more rapidly with temperature than the forward rate constant (k_f), causing the equilibrium constant ($K_{\text{eq}} = k_f/k_r$) to decrease.

Solution:

Step 1: Analyze Statement A ("The rate constant of the forward reaction increases while that of the reverse reaction decreases"). This is incorrect because an increase in temperature increases the rate constants of both forward and reverse reactions.

Step 2: Analyze Statement B ("The rate constants of both forward and reverse reactions increase"). According to the Arrhenius model, an increase in temperature increases the fraction of collisions with energy greater than the activation energy, thus elevating both k_f and k_r. Hence, Statement B is a correct option.

Step 3: Analyze Statement C ("The activation energy of the reaction changes with temperature"). Activation energy (E_a) is determined by the reaction pathway and molecular structure, and it remains essentially independent of temperature variations. This is incorrect.

Step 4: Analyze Statement D ("The equilibrium constant (K_{eq}) for an exothermic reaction decreases as temperature increases"). According to Le Chatelier's principle, heating an exothermic reaction shifts the equilibrium toward the reactants, which mathematically corresponds to a reduction in the value of K_{eq}. Hence, Statement D is a correct option.

Final Answer: $\boxed{\text{B and D}}$

$\boxed{\textbf{Answer: (B, D)}}$

Go Back to Question 36

Q37.

Solution

Concept:

Non-ideal solutions are those that do not obey Raoult's law over the entire composition range because the intermolecular attractive forces between the solute and solvent molecules (A – B) differ significantly from the forces present in the pure components (A – A and B – B). For non-ideal solutions, the enthalpy change of mixing ($\Delta H_{\text{mix}} \neq 0$) and the volume change of mixing ($\Delta V_{\text{mix}} \neq 0$).

Solution:

Step 1: Evaluate the Benzene + Toluene mixture (Option A). Both compounds are structurally similar, non-polar aromatic hydrocarbons. Their intermolecular interactions are nearly identical (A – B ≈ A – A ≈ B – B), forming a near-ideal solution where $\Delta H_{\text{mix}} \approx 0$ and $\Delta V_{\text{mix}} \approx 0$. This is not a non-ideal solution.

Step 2: Evaluate the Acetone + Chloroform mixture (Option B). When mixed, a strong hydrogen bond forms between the carbonyl oxygen of acetone and the acidic hydrogen of chloroform. This makes the A – B interactions stronger than the original A – A and B – B forces, causing a negative deviation from Raoult's law ($\Delta H_{\text{mix}} < 0, \Delta V_{\text{mix}} < 0$). This is a non-ideal solution.

Step 3: Evaluate the Ethanol + Acetone mixture (Option C). Pure ethanol contains strong hydrogen bonding networks. The addition of acetone molecules breaks some of these hydrogen bonds, meaning the new A – B interactions are weaker than the original forces. This results in a positive deviation from Raoult's law ($\Delta H_{\text{mix}} > 0, \Delta V_{\text{mix}} > 0$). This is a non-ideal solution.

Step 4: Identify the correct options. Since both Option B and Option C represent non-ideal systems with non-zero thermodynamic parameters of mixing, both are correct solutions.

Final Answer: $\boxed{\text{B and C}}$

$\boxed{\textbf{Answer: (B, C)}}$

Go Back to Question 37

Q38.

Solution

Concept:
Geometric isomerism (cis/trans or E/Z) occurs when rotation about a carbon-carbon double bond ($C = C$) is restricted, and each individual carbon atom of the double bond is attached to two entirely distinct atoms or groups. If either of the double-bonded carbons is attached to two identical substituents, the molecule cannot exhibit geometric isomerism.

Solution:
Step 1: Examine 1,1-dichloroprop-1-ene (Option A): $Cl_2C = CH - CH_3$. Carbon-1 is bonded to two identical chlorine atoms. Swapping these groups creates an identical structure, so it does not exhibit geometric isomerism.

Step 2: Examine 1,2-dichlorobut-2-ene (Option B): $ClCH_2 - C(Cl) = CH - CH_3$. The first double-bonded carbon (C_2) is attached to $-CH_2Cl$ and $-Cl$ (two different groups). The second double-bonded carbon (C_3) is attached to $-H$ and $-CH_3$ (two different groups). Therefore, it exhibits geometric isomerism (cis/trans forms). This is a correct option.

Step 3: Examine pent-2-ene (Option C): $CH_3 - CH = CH - CH_2CH_3$. The first double-bonded carbon (C_2) is attached to $-H$ and $-CH_3$. The second double-bonded carbon (C_3) is attached to $-H$ and $-CH_2CH_3$. Because each carbon carries two distinct groups, it exhibits geometric isomerism. This is a correct option.

Step 4: Examine 2-methylbut-2-ene (Option D): $(CH_3)_2C = CH - CH_3$. One of the double-bonded carbons is attached to two identical methyl ($-CH_3$) groups, so it cannot show geometric isomerism.

Final Answer: $\boxed{\text{B and C}}$

$\boxed{\textbf{Answer: (B, C)}}$

Go Back to Question 38

Q39.

Solution

Concept:

The boiling point of an organic compound depends on the strength of its intermolecular forces. For compounds with similar molecular masses, the boiling point follows the order: Hydrogen bonding (Alcohols) > Dipole-dipole interactions (Aldehydes/Ketones) > Weak dipole/dispersion forces (Ethers) > London dispersion forces (Alkanes).

Solution:

Step 1: Analyze the intermolecular forces of the given structural options:

A. Butanal ($CH_3CH_2CH_2CHO$) has a polar carbonyl group that participates in dipole-dipole interactions.

B. Butan-1-ol ($CH_3CH_2CH_2CH_2OH$) possesses a highly polar $-OH$ group, allowing for extensive intermolecular hydrogen bonding.

C. Ethoxyethane ($CH_3CH_2OCH_2CH_3$) is an ether with weak dipole-dipole interactions.

D. Butane ($CH_3CH_2CH_2CH_3$) is a non-polar alkane experiencing only weak London dispersion forces.

Step 2: Compare the magnitudes of these interactions. Intermolecular hydrogen bonding is significantly stronger than dipole-dipole and dispersion forces.

Step 3: Correlate interaction strength with physical properties. Because the intermolecular hydrogen bonds in butan-1-ol require the highest thermal energy to break, it exhibits a significantly higher boiling point than the other three compounds. Therefore, only Option B is correct.

Final Answer: $\boxed{\text{B}}$

$\boxed{\textbf{Answer: (B)}}$

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Q40.

Solution

Concept:

The structural and physical properties of primary subatomic particles are characterized by their resting mass values:

Mass of a neutron $(m_n) \approx 1.675 \times 10^{-27}$ kg

Mass of a proton $(m_p) \approx 1.673 \times 10^{-27}$ kg

Mass of an electron $(m_e) \approx 9.109 \times 10^{-31}$ kg

Solution:

Step 1: Evaluate Statement A ("Neutrons are heavier than protons"). Comparing the values shows that 1.675×10^{-27} kg $> 1.673 \times 10^{-27}$ kg. Thus, a neutron is slightly heavier than a proton, making Statement A correct.

Step 2: Evaluate Statement B ("Electrons have the least mass among the three particles"). The rest mass of an electron (9.109×10^{-31} kg) is roughly $1/1836$ of the mass of a proton, confirming it is the lightest particle. Thus, Statement B is correct.

Step 3: Evaluate Statement C ("Protons and electrons have the same mass"). Protons are much heavier than electrons ($m_p \approx 1836 \cdot m_e$), so this statement is incorrect.

Step 4: Evaluate Statement D ("Neutrons are the lightest particles"). Neutrons are the heaviest of the three primary subatomic particles, so this statement is incorrect.

Final Answer: $\boxed{\text{A and B}}$

$\boxed{\textbf{Answer: (A, B)}}$

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	D	2	A	3	A	4	A	5	A
6	A	7	B	8	B	9	A	10	C
11	B	12	A	13	A	14	C	15	B
16	B	17	B	18	C	19	A	20	B
21	B	22	B	23	A	24	B	25	B
26	A	27	B	28	C	29	D	30	A
31	A	32	A	33	D	34	B	35	C
36	B, D	37	B, C	38	B, C	39	B	40	A, B

Note: Section C (Q36–Q40): One or more correct options may be correct. Full marks only if all correct options are marked. Partial marking is not applicable.