# CUET UG Chemistry Sample Paper - 9

**Duration: 1 Hour** **Maximum Marks: 250**

## Instructions

- This paper contains a total of 50 Multiple Choice Questions.
- Each correct answer carries **+5 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

**Q1.** At a specific temperature, the vapor pressure of pure benzene is 640 mm Hg and that of toluene is 470 mm Hg. In a solution where the mole fraction of benzene is 0.4, the partial pressure of toluene in the vapor phase is:

(A) 256 mm Hg

(B) 282 mm Hg

(C) 188 mm Hg

(D) 384 mm Hg

**Q2.** Which of the following 0.1 M aqueous solutions will exhibit the highest boiling point?

(A) Glucose

(B) $NaCl$

(C) $CaCl_2$

(D) $Al_2(SO_4)_3$

**Q3.** For a cell reaction $Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$, the Nernst equation for the cell potential $E_{cell}$ is represented as:

(A) $E_{cell} = E^\circ_{cell} - \frac{0.059}{2} \log \frac{[Mg^{2+}]}{[Cu^{2+}]}$

(B) $E_{cell} = E^{\circ}_{cell} - \frac{0.059}{2} \log \frac{[Cu^{2+}]}{[Mg^{2+}]}$

(C) $E_{cell} = E^{\circ}_{cell} + \frac{0.059}{2} \log \frac{[Mg^{2+}]}{[Cu^{2+}]}$

(D) $E_{cell} = E^{\circ}_{cell} - \frac{0.059}{1} \log \frac{[Mg^{2+}]}{[Cu^{2+}]}$

**Q4.** The limiting molar conductivities for $NaCl$, $HCl$, and $CH_3COONa$ are 126.4, 425.9, and 91.0 S cm$^2$ mol$^{-1}$ respectively. The $\Lambda^{\circ}_m$ for $CH_3COOH$ is:

(A) 290.5 S cm$^2$ mol$^{-1}$

(B) 390.5 S cm$^2$ mol$^{-1}$

(C) 425.5 S cm$^2$ mol$^{-1}$

(D) 516.9 S cm$^2$ mol$^{-1}$

**Q5.** For a first-order reaction, if the time taken for 50% completion is 20 minutes, the time required for 75% completion of the same reaction is:

(A) 30 minutes

(B) 40 minutes

(C) 60 minutes

(D) 80 minutes

**Q6.** If the rate constant $k$ for a reaction is $2.5 \times 10^{-4}$ mol L$^{-1}$ s$^{-1}$, the order of the reaction is:

(A) Zero order

(B) First order

(C) Second order

(D) Third order

**Q7.** Which of the following ions has the highest magnetic moment (spin-only)?

(A) $Ti^{3+}$

(B) $Mn^{2+}$

(C) $Fe^{2+}$

(D) $Cu^{2+}$

**Q8.** The reason for the gradual decrease in the atomic sizes of lanthanoids with increasing atomic number (Lanthanoid Contraction) is:

(A) Increase in nuclear charge and poor shielding by $4f$ electrons

(B) Decrease in nuclear charge

(C) Effective shielding by $4f$ electrons

(D) Increase in the number of $5d$ electrons

**Q9.** The IUPAC name for the coordination compound $[Co(NH_3)_5(CO_3)]Cl$ is:

(A) Pentaamminecarbonatocobalt(III) chloride

(B) Pentaamminecarbonatocobalt(II) chloride

(C) Carbonatopentaamminecobalt(III) chloride

(D) Pentaamminecobalt(III) carbonate chloride

**Q10.** According to Crystal Field Theory (CFT), for a $d^4$ ion in an octahedral field, if $\Delta_o < P$ (where $P$ is pairing energy), the electronic configuration will be:

(A) $t_{2g}^4 e_g^0$

(B) $t_{2g}^3 e_g^1$

(C) $t_{2g}^2 e_g^2$

(D) $t_{2g}^0 e_g^4$

**Q11.** Which of the following statements is incorrect regarding the $S_N2$ mechanism?

(A) The reaction proceeds with complete inversion of configuration.

(B) The rate of reaction depends on the concentration of both the substrate and the nucleophile.

(C) The reaction involves the formation of a carbocation intermediate.

(D) Polar aprotic solvents generally favor this mechanism.

**Q12.** When Chlorobenzene is treated with sodium metal in dry ether, the product formed is Biphenyl. This reaction is known as:

(A) Wurtz Reaction

(B) Wurtz-Fittig Reaction

(C) Fittig Reaction

(D) Sandmeyer Reaction

**Q13.** The correct order of acid strength for the following compounds is: (I) Phenol (II) p-Nitrophenol (III) p-Methylphenol (IV) Ethanol

(A) IV < III < I < II

(B) IV < I < III < II

(C) II < I < III < IV

(D) I < II < III < IV

**Q14.** Propan-1-ol and Propan-2-ol can be best distinguished chemically by:

(A) Reimer-Tiemann Reaction

(B) Lucas Test

(C) Fehling's Test

(D) Cannizzaro Reaction

**Q15.** Which of the following compounds will undergo the Cannizzaro reaction?

(A) Acetaldehyde ($CH_3CHO$)

(B) Propionaldehyde ($CH_3CH_2CHO$)

(C) Benzaldehyde ($C_6H_5CHO$)

(D) Acetone ($CH_3COCH_3$)

**Q16.** The major product obtained when Acetophenone reacts with $Zn-Hg/conc.HCl$ (Clemmensen Reduction) is:

(A) Ethylbenzene

(B) Benzene

(C) Toluene

(D) Acetyl chloride

**Q17.** The correct decreasing order of basic strength of the following amines in aqueous solution is:

(A) $(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3$

(B) $(CH_3)_3N > (CH_3)_2NH > CH_3NH_2 > NH_3$

(C) $NH_3 > CH_3NH_2 > (CH_3)_2NH > (CH_3)_3N$

(D) $(CH_3)_2NH > (CH_3)_3N > CH_3NH_2 > NH_3$

**Q18.** Which of the following reagents is used in the Gabriel Phthalimide synthesis to prepare primary amines?

(A) Potassium Phthalimide and Alkyl Halide

(B) Benzene and Ammonia

(C) Aniline and Chloroform

(D) Phthalic acid and Sodium Hydroxide

**Q19.** Which of the following is a non-reducing sugar?

(A) Glucose

(B) Fructose

(C) Maltose

(D) Sucrose

**Q20.** Denaturation of proteins leads to the loss of its biological activity. This occurs due to the disruption of:

(A) Primary structure only
(B) Secondary and Tertiary structures
(C) Peptide bonds
(D) Amino acid sequence

**Q21.** The Henry's law constant for the solubility of $N_2$ gas in water at 298 K is $1.0 \times 10^5$ atm. The mole fraction of $N_2$ in air is 0.8. The number of moles of $N_2$ from air dissolved in 10 moles of water at 298 K and 5 atm pressure is:

(A) $4.0 \times 10^{-4}$
(B) $4.0 \times 10^{-5}$
(C) $5.0 \times 10^{-4}$
(D) $4.0 \times 10^{-6}$

**Q22.** An aqueous solution of a non-volatile solute freezes at $-0.186°\text{C}$. If $K_f = 1.86$ K kg mol$^{-1}$ and $K_b = 0.52$ K kg mol$^{-1}$, the elevation in boiling point for the same solution is:

(A) 0.052°C
(B) 0.52°C
(C) 0.0186°C
(D) 0.186°C

**Q23.** The amount of electricity required to deposit 1 mol of Aluminum from a solution of $AlCl_3$ is:

(A) 1 F

(B) 2 F

(C) 3 F

(D) 4 F

**Q24.** Which of the following statements regarding a Fuel Cell (Hydrogen-Oxygen) is incorrect?

(A) The electrodes used are made of porous carbon containing catalysts.

(B) The overall reaction is $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$.

(C) It is highly efficient compared to thermal power plants.

(D) It produces $CO_2$ as a major byproduct, contributing to the greenhouse effect.

**Q25.** For the reaction $2A+B \rightarrow 3C$, the rate of appearance of $C$ is $1.2\times10^{-2}$ mol L$^{-1}$ s$^{-1}$. The rate of disappearance of $A$ is:

(A) $1.2 \times 10^{-2}$ mol L$^{-1}$ s$^{-1}$

(B) $0.8 \times 10^{-2}$ mol L$^{-1}$ s$^{-1}$

(C) $1.8 \times 10^{-2}$ mol L$^{-1}$ s$^{-1}$

(D) $0.4 \times 10^{-2}$ mol L$^{-1}$ s$^{-1}$

**Q26.** According to the Arrhenius equation, a plot of $\log k$ versus $1/T$ gives a straight line with a slope equal to:

(A) $-E_a/R$

(B) $-E_a/2.303R$

(C) $E_a/2.303R$

(D) $-2.303R/E_a$

**Q27.** The correct formula for the brown ring complex formed in the test for nitrates is:

(A) $[Fe(H_2O)_5(NO)]^{2+}$

(B) $[Fe(H_2O)_5(NO)]^{3+}$

(C) $[Fe(H_2O)_4(NO)_2]^{2+}$

(D) $[Fe(CN)_5(NO)]^{2-}$

**Q28.** Which of the following pairs shows the same magnetic moment?

(A) $Mn^{2+}$ and $Fe^{3+}$

(B) $Fe^{2+}$ and $Co^{2+}$

(C) $Cr^{3+}$ and $Fe^{3+}$

(D) $Ti^{3+}$ and $V^{3+}$

**Q29.** The number of geometrical isomers possible for the complex $[Co(NH_3)_3(NO_2)_3]$ is:

(A) 2 (facial and meridional)

(B) 3

(C) 4

(D) 0

**Q30.** Which of the following complexes is expected to be diamagnetic?

(A) $[FeF_6]^{3-}$

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

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

(D) $[NiCl_4]^{2-}$

**Q31.** An organic compound 'A' with molecular formula $C_4H_9Br$ undergoes $S_N1$ reaction with aqueous $KOH$ to form an optically inactive product. The compound 'A' is most likely:

(A) n-Butyl bromide

(B) s-Butyl bromide

(C) t-Butyl bromide

(D) Isobutyl bromide

**Q32.** The reaction of Ethanol with conc. $H_2SO_4$ at 413 K yields:

(A) Ethene

(B) Ethoxyethane

(C) Ethyl hydrogen sulphate

(D) Diethyl sulphate

**Q33.** Identify the product 'Z' in the following sequence: $Phenol \xrightarrow{Zn,\text{heat}} X \xrightarrow{CH_3Cl,AlCl_3} Y \xrightarrow{KMnO_4,OH^-} Z$

(A) Benzaldehyde

(B) Benzoic acid

(C) Benzene

(D) Toluene

**Q34.** Which of the following carboxylic acids does not undergo the Hell-Volhard-Zelinsky (HVZ) reaction?

(A) $CH_3COOH$

(B) $(CH_3)_2CHCOOH$

(C) $C_6H_5COOH$

(D) $CH_3CH_2COOH$

**Q35.** The correct order of reactivity towards nucleophilic addition reactions among the following is:

(A) $HCHO > CH_3CHO > C_6H_5CHO > CH_3COCH_3$

(B) $CH_3COCH_3 > C_6H_5CHO > CH_3CHO > HCHO$

(C) $HCHO > C_6H_5CHO > CH_3CHO > CH_3COCH_3$

(D) $CH_3CHO > HCHO > CH_3COCH_3 > C_6H_5CHO$

**Q36.** When Aniline is treated with $NaNO_2$ and $HCl$ at $0 - 5°C$, followed by boiling with water, the final product is:

(A) Chlorobenzene

(B) Benzene

(C) Phenol

(D) Nitrobenzene

**Q37.** Hoffmann Bromamide Degradation reaction is used to convert:

(A) Amide to Amine with the same number of Carbon atoms.

(B) Amide to Amine with one Carbon atom less.

(C) Amine to Amide with one Carbon atom more.

(D) Nitrile to Amine.

**Q38.** Which of the following vitamins is water-soluble and cannot be stored in the body?

(A) Vitamin A

(B) Vitamin D

(C) Vitamin C

(D) Vitamin K

**Q39.** The linkage that holds the two monosaccharide units together in a disaccharide like Lactose is:

(A) Peptide linkage

(B) Glycosidic linkage

(C) Phosphodiester linkage

(D) Hydrogen bonding

**Q40.** Alpha-helix and Beta-pleated sheet structures of proteins are classified under:

(A) Primary structure

(B) Secondary structure

(C) Tertiary structure

(D) Quaternary structure

**Q41.** An ideal solution is formed by mixing two volatile liquids A and B. Which of the following conditions is incorrect for an ideal solution?

(A) $\Delta H_{mixing} = 0$

(B) $\Delta V_{mixing} = 0$

(C) $\Delta S_{mixing} = 0$

(D) $P_{total} = P^\circ_A \chi_A + P^\circ_B \chi_B$

**Q42.** The molar conductivity of a 0.05 M $BaCl_2$ solution is 220 S cm$^2$ mol$^{-1}$. Its conductivity ($\kappa$) is:

(A) 0.011 S cm$^{-1}$

(B) 0.11 S cm$^{-1}$

(C) 0.0011 S cm$^{-1}$

(D) 1.1 S cm$^{-1}$

**Q43.** Which of the following acts as a protective shield for the cell against the corrosive action of the electrolyte in a Lead Storage Battery?

(A) Pb

(B) $PbO_2$

(C) $H_2SO_4$

(D) Hard rubber container

**Q44.** The unit of the rate constant for a second-order reaction is:

(A) $\mathrm{s^{-1}}$

(B) $\mathrm{mol\ L^{-1}\ s^{-1}}$

(C) $\mathrm{L\ mol^{-1}\ s^{-1}}$

(D) $\mathrm{L^2\ mol^{-2}\ s^{-1}}$

**Q45.** The catalyst used in the Manufacture of Sulphuric acid by the Contact process is:

(A) $Fe$

(B) $V_2O_5$

(C) $Pt$

(D) $Ni$

**Q46.** Among the following, which element of the $3d$ series does not show a variable oxidation state?

(A) $Ti$

(B) $Sc$

(C) $Cu$

(D) $Zn$

**Q47.** The primary valence and secondary valence of Cobalt in $[Co(NH_3)_5Cl]Cl_2$ are respectively:

(A) 3 and 6

(B) 2 and 5

(C) 3 and 5

(D) 2 and 6

**Q48.** In the Williamson ether synthesis, the reaction follows which mechanism?

(A) $S_N1$

(B) $S_N2$

(C) $E1$

(D) Electrophilic addition

**Q49.** Which of the following tests is used to distinguish between Aldehydes and Ketones?

(A) Molisch Test

(B) Biuret Test

(C) Tollen's Test

(D) Ninhydrin Test

**Q50.** The base that is found in RNA but not in DNA is:

(A) Adenine

(B) Guanine

(C) Cytosine

(D) Uracil

## Detailed Solutions

## Q1.

### Solution

**Concept:**

According to **Raoult's Law**, the partial vapor pressure of a volatile component in a solution is directly proportional to its mole fraction in the liquid phase. For a binary solution of components A (Benzene) and B (Toluene):

$$P_A = P_A^\circ \cdot \chi_A$$

$$P_B = P_B^\circ \cdot \chi_B$$

where $P^\circ$ is the vapor pressure of the pure component and $\chi$ is the mole fraction in the solution.

**Solution:**

1. Given data: - Vapor pressure of pure benzene ($P_B^\circ$) = 640 mm Hg - Vapor pressure of pure toluene ($P_T^\circ$) = 470 mm Hg - Mole fraction of benzene ($\chi_B$) = 0.4

2. Calculate the mole fraction of toluene ($\chi_T$): Since $\chi_B + \chi_T = 1$:

$$\chi_T = 1 - 0.4 = 0.6$$

3. Calculate the partial pressure of toluene in the vapor phase ($P_T$): Using Raoult's Law:

$$P_T = P_T^\circ \times \chi_T$$

$$P_T = 470 \times 0.6 = 282 \text{ mm Hg}$$

**Answer: (B)**

## Q2.

### Solution

**Concept:**

The **Boiling Point Elevation ($\Delta T_b$)** is a colligative property, meaning it depends solely on the number of solute particles in the solution. It is defined by the formula:

$$\Delta T_b = i \cdot K_b \cdot m$$

Where: * $i$ = **van't Hoff factor** (number of ions/particles per formula unit). * $K_b$ = Molal elevation constant. * $m$ = Molality (concentration).

For a fixed concentration, the solution with the **highest $i$ value** will have the highest boiling point.

**Solution:**

We calculate the van't Hoff factor ($i$) for each 0.1 M solution assuming complete dissociation:

(A) **Glucose:** A non-electrolyte; does not ionize.
$i = 1$

(B) $\boldsymbol{NaCl}$: Dissociates into $\boldsymbol{Na^+}$ and $\boldsymbol{Cl^-}$.
$\boldsymbol{i = 2}$

(C) $\boldsymbol{CaCl_2}$: Dissociates into $\boldsymbol{Ca^{2+}}$ and $\boldsymbol{2Cl^-}$.
$\boldsymbol{i = 1 + 2 = 3}$

(D) $\boldsymbol{Al_2(SO_4)_3}$: Dissociates into $\boldsymbol{2Al^{3+}}$ and $\boldsymbol{3SO_4^{2-}}$.
$\boldsymbol{i = 2 + 3 = 5}$

**Conclusion:** Since **$Al_2(SO_4)_3$** produces the maximum number of particles ($i = 5$), it results in the greatest elevation of the boiling point. Therefore, it will exhibit the highest boiling point among the given options.

**Answer: (D)**

# Q3.

## Solution

**Concept:**

The **Nernst Equation** relates the reduction potential of an electrochemical cell to the standard electrode potential, temperature, and activities of the chemical species. For a general reaction: $aA + bB \rightarrow cC + dD$

$$E_{cell} = E^{\circ}_{cell} - \frac{2.303RT}{nF} \log Q$$

At 298 K, this simplifies to:

$$E_{cell} = E^{\circ}_{cell} - \frac{0.059}{n} \log \frac{[\text{Products}]}{[\text{Reactants}]}$$

**Solution:**

1. Identify the half-reactions: - Oxidation (Anode): $Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$ - Reduction (Cathode): $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

2. Determine $n$: The number of electrons exchanged is $n = 2$.

3. Set up the Reaction Quotient ($Q$): Pure solids ($Mg$ and $Cu$) have an activity of 1.

$$Q = \frac{[Mg^{2+}]}{[Cu^{2+}]}$$

4. Final Equation:

$$E_{cell} = E^{\circ}_{cell} - \frac{0.059}{2} \log \frac{[Mg^{2+}]}{[Cu^{2+}]}$$

**Answer: (A)**

## Q4.

### 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 the anion and cation. For Acetic acid ($CH_3COOH$), which is a weak electrolyte:

$$\Lambda_m^\circ(CH_3COOH) = \lambda^\circ(CH_3COO^-) + \lambda^\circ(H^+)$$

**Solution:**

To find the value for $CH_3COOH$, we use strong electrolytes $CH_3COONa$, $HCl$, and $NaCl$:

$$\Lambda_m^\circ(CH_3COOH) = \Lambda_m^\circ(CH_3COONa) + \Lambda_m^\circ(HCl) - \Lambda_m^\circ(NaCl)$$

Substitute the given values:

$$\Lambda_m^\circ(CH_3COOH) = 91.0 + 425.9 - 126.4$$

$$\Lambda_m^\circ(CH_3COOH) = 516.9 - 126.4 = 390.5 \text{ S cm}^2 \text{ mol}^{-1}$$

**Answer: (B)**

## Q5.

### Solution

**Concept:**

For a **First-Order Reaction**, the time required for a certain percentage of completion is given by:

$$t = \frac{2.303}{k} \log \frac{[R]_0}{[R]}$$

Where: - $t_{50\%}$ (half-life) = $\frac{0.693}{k}$. - A key characteristic of 1st order reactions is that the time taken for 75% completion ($t_{75\%}$) is exactly twice the half-life ($t_{50\%}$).

**Solution:**

1. Given $t_{50\%} = 20$ minutes. 2. For 75% completion, the remaining concentration is 25% (1/4 of original). 3. Relationship:

$$t_{75\%} = 2 \times t_{50\%}$$

(Alternatively, after one half-life 504. Calculation:

$$t_{75\%} = 2 \times 20 = 40 \text{ minutes}$$

**Answer: (B)**

## Q6.

### Solution

**Concept:**

The **Order of a Reaction** can be determined by inspecting the units of the **Rate Constant ($k$)**. The general formula for the units of $k$ for a reaction of order $n$ is:

$$\text{Units of } k = (\text{mol L}^{-1})^{1-n}\ \text{s}^{-1}$$

**Solution:**

1. **Analyze the given value:** The rate constant is given as $k = 2.5 \times 10^{-4}$ mol L$^{-1}$ s$^{-1}$. 2. **Compare with the general formula:** Set the units equal to the general expression:

$$(\text{mol L}^{-1})^{1-n}\ \text{s}^{-1} = (\text{mol L}^{-1})^{1}\ \text{s}^{-1}$$

3. **Solve for $n$:** Matching the exponents:

$$1 - n = 1$$

$$n = 0$$

4. **Conclusion:** Since the units are mol L$^{-1}$ s$^{-1}$ (Concentration/Time), the reaction rate is independent of the concentration of reactants, which is the definition of a **Zero Order Reaction**.

**Answer: (A)**

# Q7.

## Solution

**Concept:**

The **Magnetic Moment ($\mu$)** of transition metal ions is calculated using the "spin-only" formula, which depends on the number of **unpaired electrons ($n$)**:

$$\mu = \sqrt{n(n+2)} \text{ Bohr Magnetons (BM)}$$

A higher number of unpaired electrons results in a higher magnetic moment.

**Solution:**

We determine the electronic configuration and number of unpaired electrons for each ion:

- **(A)** $Ti^{3+}$**:** Atomic No. 22 ($[Ar]3d^2 4s^2$). $Ti^{3+}$ is $3d^1$.
  Unpaired electrons ($n$) = 1. $\mu = \sqrt{1(3)} = 1.73$ BM.
- **(B)** $Mn^{2+}$**:** Atomic No. 25 ($[Ar]3d^5 4s^2$). $Mn^{2+}$ is $3d^5$.
  Unpaired electrons ($n$) = 5. $\mu = \sqrt{5(7)} = 5.92$ BM.
- **(C)** $Fe^{2+}$**:** Atomic No. 26 ($[Ar]3d^6 4s^2$). $Fe^{2+}$ is $3d^6$.
  Unpaired electrons ($n$) = 4. $\mu = \sqrt{4(6)} = 4.90$ BM.
- **(D)** $Cu^{2+}$**:** Atomic No. 29 ($[Ar]3d^{10} 4s^1$). $Cu^{2+}$ is $3d^9$.
  Unpaired electrons ($n$) = 1. $\mu = \sqrt{1(3)} = 1.73$ BM.

Since **$Mn^{2+}$** has the maximum number of unpaired electrons ($n = 5$), it possesses the highest magnetic moment.

**Answer: (B)**

## Q8.

### Solution

**Concept:**

The phenomenon of **Lanthanoid Contraction** describes the steady decrease in the atomic and ionic radii of the lanthanoid elements (from $Z = 58$ to $Z = 71$) as the atomic number increases. This effect is a cornerstone of the chemistry of the $f$-block elements and has significant consequences on the properties of the subsequent $5d$ transition series.

**Solution:**

The contraction is primarily caused by the following factors:

1. **Increasing Nuclear Charge:** As we move across the series from Cerium to Lutetium, each successive element adds one proton to the nucleus, steadily increasing the positive nuclear charge.

2. **Poor Shielding Effect of 4f Electrons:** The additional electrons enter the $4f$ subshell. Unlike $s$ or $p$ orbitals, $4f$ orbitals are very diffuse and have a complex shape. This results in a **very poor shielding effect**, meaning the $4f$ electrons do not effectively "block" the outer electrons from the pull of the nucleus.

3. **Net Result:** Because the shielding is ineffective, the **Effective Nuclear Charge ($Z_{eff}$)** experienced by the outer electrons increases significantly with each added proton. This stronger electrostatic attraction pulls the electron cloud closer to the nucleus, causing:

- A gradual decrease in atomic size.
- A gradual decrease in ionic size ($M^{3+}$ ions).

**Conclusion:** The primary cause is the combination of increasing nuclear charge and the uniquely poor shielding provided by the $4f$ electrons.

**Answer: (A)**

# Q9.

## Solution

**Concept:**

IUPAC nomenclature for coordination compounds follows these priority rules: 1. **Ligands** are named first in alphabetical order. 2. **Oxidation State** of the metal is indicated by a Roman numeral in parentheses. 3. **Anionic ligands** end in '-o' (e.g., carbonato). 4. **Neutral ligands** use special names ($NH_3$ is ammine).

**Solution:**

1. **Identify Ligands:** There are 5 ammine ($NH_3$) and 1 carbonato ($CO_3^{2-}$) ligands. Alphabetically: **pentaamminecarbonato**. 2. **Calculate Oxidation State of Cobalt ($x$):** The complex is $[Co(NH_3)_5(CO_3)]Cl$. The counter ion $Cl$ has a charge of $-1$, so the coordination sphere has a charge of $+1$.

$$x + 5(0) + 1(-2) = +1$$

$$x - 2 = 1 \implies x = +3$$

3. **Assemble the Name:** Metal is Cobalt(III). The counter ion is chloride. **Name:** Pentaamminecarbonatocobalt(III) chloride.

**Answer: (A)**

# Q10.

## Solution

**Concept:**

In an octahedral coordination entity, the five degenerate $d$-orbitals of the central metal ion split into two sets due to the electrostatic field of the ligands:

- $t_{2g}$ **set:** Three orbitals of lower energy ($d_{xy}, d_{yz}, d_{zx}$).
- $e_g$ **set:** Two orbitals of higher energy ($d_{x^2-y^2}, d_{z^2}$).

The distribution of electrons in these orbitals depends on the relative magnitude of the **Crystal Field Splitting Energy ($\Delta_o$)** and the **Pairing Energy ($P$)**.

**Solution:**

For a $d^4$ configuration (4 electrons in the $d$-subshell), the first three electrons occupy the lower energy $t_{2g}$ orbitals singly in accordance with Hund's rule ($t_{2g}^3$). The placement of the fourth electron depends on the following energy criteria:

1. **Case 1** ($\Delta_o > P$)**:** If the splitting energy is greater than the pairing energy (Strong Field), the fourth electron will pair up in the $t_{2g}$ level, resulting in $t_{2g}^4 e_g^0$. 2. **Case 2** ($\Delta_o < P$)**:** If the splitting energy is less than the pairing energy (Weak Field), the fourth electron will find it energetically "cheaper" to jump to the higher $e_g$ level rather than pairing up in the $t_{2g}$ level.

**Application to the Question:** Given the condition $\boldsymbol{\Delta_o < P}$:

- The 4th electron enters the $\boldsymbol{e_g}$ orbital.
- This results in a **High Spin** complex.
- Final electronic distribution: $\boldsymbol{t_{2g}^3 e_g^1}$.

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

# Q11.

## Solution

**Concept:**

The **$S_N2$ (Substitution Nucleophilic Bimolecular)** reaction is a fundamental organic mechanism. Its key characteristics are:

- **Kinetics:** It is a second-order reaction, meaning the rate depends on the concentration of both the substrate and the nucleophile: Rate $= k[\text{Substrate}][\text{Nu}^-]$.
- **Mechanism:** It occurs in a single, concerted step. There is no intermediate; instead, a high-energy **pentacoordinate transition state** is formed.
- **Stereochemistry:** The nucleophile attacks from the side opposite to the leaving group (back-side attack), leading to a 100% **Walden Inversion** of configuration.

**Solution:**

Let's evaluate the given statements based on the $S_N2$ mechanism:

- **(A) It occurs with inversion of configuration:** This is **correct**. The back-side attack forces the other three groups to "flip" like an umbrella in a strong wind.
- **(B) The rate depends on the concentration of both reactants:** This is **correct**. Being bimolecular, both species are involved in the rate-determining step.
- **(C) The reaction involves the formation of a carbocation intermediate:** This is **incorrect**. Carbocations are formed in $S_N1$ reactions, where the leaving group departs *before* the nucleophile attacks. $S_N2$ avoids intermediates entirely.
- **(D) It is favored by polar aprotic solvents:** This is **correct**. Solvents like Acetone or DMSO do not solvate the nucleophile strongly, leaving it free to attack the substrate.

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

# Q12.

## Solution

**Concept:**
Aryl halides ($Ar - X$) are relatively unreactive toward nucleophilic substitution but undergo coupling reactions in the presence of active metals.

- **Wurtz Reaction:** Two alkyl halides react with $Na$ to form an alkane ($R - R$).
- **Fittig Reaction:** Two aryl halides react with $Na$ to form a diaryl/biphenyl ($Ar - Ar$).
- **Wurtz-Fittig Reaction:** One alkyl halide and one aryl halide react with $Na$ to form an alkylarene ($Ar - R$).

**Solution:**
1. **Identify the Reactants:** The starting material is **Chlorobenzene** ($C_6H_5Cl$), which is an aryl halide. The reagent is **Sodium metal** in the presence of **Dry Ether**. 2. **The Reaction:** Two molecules of chlorobenzene couple together as the sodium removes the chlorine atoms.

$$2C_6H_5Cl + 2Na \xrightarrow{\text{Dry Ether}} C_6H_5 - C_6H_5 + 2NaCl$$

3. **Product:** The product is **Biphenyl**. 4. **Classification:** Since the reaction involves only aryl halides coupling with sodium, it is specifically the **Fittig Reaction**.

**Answer: (C)**

## Q13.

### Solution

**Concept:**
The acidity of a compound is determined by the stability of its **conjugate base**. For phenols, this is the phenoxide ion.

- **Resonance:** Phenoxide ions are more stable than alkoxide ions (from alcohols) due to delocalization of the negative charge into the benzene ring.
- **Inductive/Mesomeric Effects:**
  - **EWG (Electron Withdrawing Groups):** Like $-NO_2$, increase acidity by dispersing the negative charge.
  - **EDG (Electron Donating Groups):** Like $-CH_3$, decrease acidity by intensifying the negative charge on the oxygen.

**Solution:**
Let's rank the given compounds from least to most acidic:

(a) **Ethanol (IV):** An aliphatic alcohol. Its conjugate base (ethoxide) has no resonance stabilization. **Least acidic**.

(b) **p-Methylphenol (III):** The $-CH_3$ group is electron-donating (+I and hyperconjugation), which destabilizes the phenoxide ion compared to phenol.

(c) **Phenol (I):** Standard resonance stabilization of the phenoxide ion.

(d) **p-Nitrophenol (II):** The $-NO_2$ group is a strong EWG ($-I$ and $-M$ effects). It effectively pulls electron density away from the oxygen, making it the **most acidic**.

The order is: **IV < III < I < II**.

**Answer: (A)**

# Q14.

## Solution

**Concept:**

The **Lucas Test** uses **Lucas Reagent** (a mixture of concentrated $HCl$ and anhydrous $ZnCl_2$). It is used to distinguish between primary, secondary, and tertiary alcohols based on the speed at which they form insoluble alkyl chlorides (appearing as cloudiness or turbidity).

**Solution:**

The reaction follows an $S_N1$ pathway, where the rate depends on the stability of the intermediate carbocation:

- **Tertiary** (3°) **Alcohols:** Form very stable 3° carbocations. Turbidity appears **immediately**.
- **Secondary** (2°) **Alcohols:** Form 2° carbocations. Turbidity appears within **5 to 10 minutes**.
- **Primary** (1°) **Alcohols:** Form unstable 1° carbocations. Turbidity **does not appear** at room temperature (only on heating).

In this question:

- **Propan-1-ol** is a 1° alcohol (no reaction/slow).
- **Propan-2-ol** is a 2° alcohol (reacts in 5 mins).

Thus, the Lucas test is the correct method to distinguish them.

**Answer: (B)**

# Q15.

## Solution

**Concept:**

The **Cannizzaro Reaction** is a redox (disproportionation) reaction of aldehydes that **do not have an $\alpha$-hydrogen** atom. In the presence of a concentrated strong base ($NaOH$ or $KOH$):

- One molecule of aldehyde is **reduced** to the corresponding primary alcohol.
- One molecule of aldehyde is **oxidized** to the salt of the corresponding carboxylic acid.

**Solution:**

We must check each option for the presence of $\alpha$-hydrogens (hydrogens on the carbon adjacent to the $-CHO$ group):

- **(A) Acetaldehyde ($CH_3CHO$):** Has 3 $\alpha$-hydrogens. It undergoes Aldol Condensation, not Cannizzaro.
- **(B) Propionaldehyde ($CH_3CH_2CHO$):** Has 2 $\alpha$-hydrogens. It undergoes Aldol Condensation.
- **(C) Benzaldehyde ($C_6H_5CHO$):** The $-CHO$ group is attached to a benzene ring carbon that has no hydrogens. **No $\alpha$-hydrogen**. It undergoes the Cannizzaro reaction.
- **(D) Acetone ($CH_3COCH_3$):** A ketone with 6 $\alpha$-hydrogens. It undergoes Aldol Condensation.

**The reaction for Benzaldehyde:**

$$2C_6H_5CHO + \text{conc. } NaOH \rightarrow C_6H_5CH_2OH + C_6H_5COONa$$

**Answer: (C)**

## Q16.

### Solution

**Concept:**
The **Clemmensen Reduction** is a classic chemical reaction used to reduce the carbonyl group ($> C = O$) of aldehydes and ketones to a methylene group ($> CH_2$).

- **Reagents:** Zinc Amalgam ($Zn - Hg$) and concentrated Hydrochloric acid ($HCl$).
- **Selectivity:** This method is particularly effective for aryl-alkyl ketones that are stable toward strong acids.

**Solution:**
1. **Identify the substrate:** **Acetophenone** is a methyl phenyl ketone with the formula $C_6H_5COCH_3$. 2. **Apply the reaction:** Under Clemmensen conditions, the oxygen of the carbonyl group is removed and replaced by two hydrogen atoms.

$$C_6H_5 - CO - CH_3 \xrightarrow{Zn-Hg/HCl} C_6H_5 - CH_2 - CH_3$$

3. **Determine the product:** The acetyl group ($-COCH_3$) is transformed into an ethyl group ($-CH_2CH_3$). The resulting compound is **Ethylbenzene**. 4. **Comparison:** While Wolff-Kishner reduction ($NH_2NH_2/KOH$) would yield the same product, Clemmensen is the preferred choice in acidic media.

**Answer: (A)**

# Q17.

## Solution

**Concept:**
The basicity of aliphatic amines in the **aqueous phase** is determined by three competing effects:

(a) **Inductive Effect (+I):** Alkyl groups donate electrons, increasing the electron density on Nitrogen (3° > 2° > 1°).

(b) **Solvation Effect:** Water stabilizes the substituted ammonium cation via hydrogen bonding. Smaller, less hindered cations are better solvated (1° > 2° > 3°).

(c) **Steric Hindrance:** Bulky alkyl groups inhibit the approach of a proton (1° > 2° > 3°).

**Solution:**
For **Methyl-substituted amines** in water, these factors result in a specific experimental order where the secondary amine is the strongest base:

$$(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3$$

$$\text{Secondary} > \text{Primary} > \text{Tertiary} > \text{Ammonia}$$

1. **Secondary** (2°)**:** Optimal balance of +I effect and solvation stabilization. 2. **Primary** (1°)**:** Stronger than 3° because the smaller size allows for superior solvation by water molecules. 3. **Tertiary** (3°)**:** Despite having three +I methyl groups, steric crowding and poor solvation make it less basic than the primary amine in water.

**Answer: (A)**

## Q18.

### Solution

**Concept:**

The **Gabriel Phthalimide Synthesis** is a highly selective and efficient chemical method for the preparation of **pure primary aliphatic amines** ($R - NH_2$). It is a superior alternative to the direct ammonolysis of alkyl halides, as it prevents the formation of secondary and tertiary amines by "protecting" the nitrogen atom within a cyclic imide structure until the final step.

**Solution:**

The synthesis proceeds through a series of logical steps involving acid-base chemistry, nucleophilic substitution, and hydrolysis:

(a) **Formation of the Nucleophile (Potassium Phthalimide):** Phthalimide is treated with ethanolic potassium hydroxide ($KOH$). The hydrogen atom attached to the nitrogen is unusually acidic ($pK_a \approx 8.3$) because the resulting negative charge is resonance-stabilized by two adjacent electron-withdrawing carbonyl groups. This yields **Potassium Phthalimide**, a strong nucleophile.

(b) **Nucleophilic Substitution ($S_N2$ Alkylation):** The potassium phthalimide reacts with a **Primary Alkyl Halide ($R - X$)**. The phthalimide anion attacks the alkyl group, displacing the halide ion.

$$\text{Phthalimide Ion} + R - X \xrightarrow{S_N2} N\text{-Alkylphthalimide} + X^-$$

*Note: Secondary halides give poor yields due to competition with elimination ($E2$), and tertiary halides or aryl halides do not react at all.*

(c) **Cleavage (Hydrolysis or Hydrazinolysis):** The $N$-alkylphthalimide is then cleaved to release the primary amine. This is typically done using:

- **Alkaline Hydrolysis:** Using aqueous $NaOH$, which yields the amine and sodium phthalate.
- **Ing-Manske Procedure:** Using **Hydrazine** ($NH_2NH_2$), which is faster and yields the amine along with phthalylhydrazide.

**Conclusion:** The essential reagents for the alkylation step are **Potassium Phthalimide** (the nucleophile) and the **Alkyl Halide** (the substrate).

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

## Q19.

### Solution

**Concept:**

A **Reducing Sugar** is a carbohydrate that possesses a free aldehyde or ketone group (or a hemiacetal/hemiketal group that can open in solution). These sugars can reduce mild oxidizing agents like Tollen's reagent ($Ag^+$ to $Ag$) or Fehling's solution ($Cu^{2+}$ to $Cu^+$).

**Solution:**

We evaluate the structural connectivity of the given carbohydrates:

- **Glucose & Fructose:** Monosaccharides have a free (or potentially free) carbonyl group. (Reducing)
- **Maltose:** Linkage is $\alpha(1 \to 4)$. The second glucose unit has a free anomeric carbon at $C_1$. (Reducing)
- **Lactose:** Linkage is $\beta(1 \to 4)$. The glucose unit has a free anomeric carbon at $C_1$. (Reducing)
- **Sucrose:** The glycosidic bond forms between the anomeric carbon of glucose ($C_1$) and the anomeric carbon of fructose ($C_2$). Since both reducing groups are bonded together, the ring cannot open. (Non-reducing)

**Answer: (D)**

## Q20.

### Solution

**Concept:**
**Denaturation of Proteins** is a process wherein a protein loses its unique three-dimensional shape (native conformation) due to external stress or compounds, such as strong acids or bases, concentrated inorganic salts, organic solvents, or heat. This structural change leads to the loss of the protein's biological activity.
To understand this deeply, we must look at the levels of protein organization:

- **Primary Structure** (1°)**:** The specific linear sequence of amino acids held together by covalent **peptide bonds**.
- **Secondary Structure** (2°)**:** The local spatial arrangement of the polypeptide backbone (e.g., $\alpha$-helices and $\beta$-pleated sheets) stabilized by **hydrogen bonds**.
- **Tertiary Structure** (3°)**:** The overall folding of a single protein molecule, stabilized by various interactions like **disulfide bridges, salt bridges, and hydrophobic interactions**.

**Solution:**
When a protein undergoes denaturation (for example, boiling an egg or curdling milk):
1. **Disruption of Interactions:** The physical or chemical changes provide enough energy or change the environment such that the relatively weak bonds (hydrogen bonds and van der Waals forces) and even some stronger ones (disulfide linkages) are broken. 2. **Unfolding:** As these stabilizing forces are lost, the complex coils and folds of the protein "unroll." The globules unfold and the helices get uncoiled. 3. **Structural Loss:** Specifically, the **Secondary** (2°) and **Tertiary** (3°**)** structures are destroyed. This transforms the organized, functional protein into a random, disordered string.
4. **The Exception:** Crucially, the **Primary (1°) structure** remains **intact**. The covalent peptide bonds between amino acids are strong enough to withstand standard denaturing conditions; therefore, the amino acid sequence does not change.
**Conclusion:** During denaturation, the protein loses its 2° and 3° structures while the 1° structure is preserved.

**Answer: (B)**

## Q21.

### Solution

**Concept:**

**Henry's Law** states that the partial pressure of a gas in the vapor phase ($P$) is proportional to the mole fraction of the gas in the solution ($\chi$). Formula:

$$P = K_H \cdot \chi$$

According to **Dalton's Law of Partial Pressures**, the partial pressure of a gas in a mixture is:

$$P_{gas} = \text{Total Pressure} \times \text{Mole fraction of gas in air}$$

**Solution:**

1. **Calculate Partial Pressure of $N_2$ ($P_{N_2}$):** Total pressure = 5 atm. Mole fraction of $N_2$ in air = 0.8.

$$P_{N_2} = 5 \times 0.8 = 4 \text{ atm}$$

2. **Calculate Mole Fraction of $N_2$ in water ($\chi_{N_2}$):** Given $K_H = 1.0 \times 10^5$ atm.

$$\chi_{N_2} = \frac{P_{N_2}}{K_H} = \frac{4}{1.0 \times 10^5} = 4.0 \times 10^{-5}$$

3. **Calculate Number of Moles of $N_2$ ($n_{N_2}$):** Mole fraction formula: $\chi_{N_2} = \frac{n_{N_2}}{n_{N_2}+n_{H_2O}}$. Since $n_{N_2}$ is very small compared to $n_{H_2O}$, we approximate:

$$\chi_{N_2} \approx \frac{n_{N_2}}{n_{H_2O}}$$

Given $n_{H_2O} = 10$ moles:

$$n_{N_2} = \chi_{N_2} \times 10 = 4.0 \times 10^{-5} \times 10 = 4.0 \times 10^{-4} \text{ moles}$$

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

## Q22.

### Solution

**Concept:**

Colligative properties like **Depression in Freezing Point** ($\Delta T_f$) and **Elevation in Boiling Point** ($\Delta T_b$) are proportional to the molality ($m$) of the solution:

$$\Delta T_f = K_f \cdot m$$

$$\Delta T_b = K_b \cdot m$$

For the same solution (same molality), we can relate the two properties:

$$\frac{\Delta T_b}{\Delta T_f} = \frac{K_b}{K_f}$$

**Solution:**

1. **Calculate Depression in Freezing Point ($\Delta T_f$):** Pure water freezes at 0°C. Solution freezes at $-0.186$°C.

$$\Delta T_f = 0 - (-0.186) = 0.186^\circ\text{C}$$

2. **Setup Relationship:** Using the ratio:

$$\Delta T_b = \Delta T_f \times \frac{K_b}{K_f}$$

3. **Substitute given values:** - $K_f = 1.86$ K kg mol$^{-1}$ - $K_b = 0.52$ K kg mol$^{-1}$

$$\Delta T_b = 0.186 \times \frac{0.52}{1.86}$$

$$\Delta T_b = 0.1 \times 0.52 = 0.052^\circ\text{C}$$

The elevation in boiling point is 0.052°C.

**Answer: (A)**

# Q23.

## Solution

**Concept:**

According to **Faraday's First Law of Electrolysis**, the amount of substance deposited is proportional to the quantity of electricity passed. One **Faraday (1 F)** is the charge carried by one mole of electrons (96500 C). The stoichiometry of the electrode reaction determines the relationship:

$$M^{n+} + ne^- \longrightarrow M(s)$$

To deposit 1 mole of metal $M$, $n$ moles of electrons (or $n$ Faradays) are required.

**Solution:**

1. **Identify the ion:** In $AlCl_3$, Aluminum exists as the $Al^{3+}$ ion.

2. **Write the reduction half-reaction:**

$$Al^{3+}(aq) + 3e^- \longrightarrow Al(s)$$

3. **Calculate electricity:** From the equation, 1 mole of $Al$ requires 3 moles of electrons. Since 1 mole of electrons = 1 F: Electricity required = 3 F.

**Answer: (C)**

# Q24.

## Solution

**Concept:**
A **Fuel Cell** is a galvanic cell that is designed to convert the chemical energy from a fuel (most commonly **Hydrogen**) and an oxidizing agent (most commonly **Oxygen**) directly into electrical energy through a redox reaction. Unlike conventional batteries, fuel cells do not "die" or require recharging; they produce electricity as long as fuel and oxygen are supplied.
The most successful and common type is the **Hydrogen-Oxygen ($H_2 - O_2$) Fuel Cell**, which was famously used in the Apollo space program.

**Solution:**
Let's break down the mechanics and features of the $H_2 - O_2$ fuel cell to evaluate the statements:
1. **Electrodes and Electrolyte:** The cell consists of porous carbon electrodes impregnated with finely divided platinum or palladium catalysts. A concentrated aqueous solution of potassium hydroxide ($KOH$) or sodium hydroxide ($NaOH$) is generally used as the electrolyte. 2. **Electrode Reactions:**

- **At Anode (Oxidation):** $2H_2(g) + 4OH^-(aq) \rightarrow 4H_2O(l) + 4e^-$
- **At Cathode (Reduction):** $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$
- **Overall Reaction:** $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

3. **Efficiency:** Fuel cells are highly efficient ($\approx 70\%$) compared to thermal power plants ($\approx 40\%$), which must first convert heat to mechanical work and then to electricity. 4. **Environmental Impact:** The only byproduct of the $H_2 - O_2$ fuel cell is **water ($H_2O$)**, making it an eco-friendly, pollution-free source of energy.
**Conclusion:** Statement (D) is **incorrect** because the major byproduct is pure water, not carbon dioxide ($CO_2$). This makes the cell a "green" energy technology.

**Answer: (D)**

## Q25.

### Solution

**Concept:**

For a general chemical reaction $aA + bB \longrightarrow cC + dD$, the **Rate of Reaction** is defined as:

$$\text{Rate} = -\frac{1}{a}\frac{d[A]}{dt} = -\frac{1}{b}\frac{d[B]}{dt} = +\frac{1}{c}\frac{d[C]}{dt}$$

The rate of disappearance of a reactant or appearance of a product is linked through their stoichiometric coefficients.

**Solution:**

1. **Reaction:** $2A + B \longrightarrow 3C$ 2. **Rate relation:**

$$\text{Rate} = -\frac{1}{2}\frac{d[A]}{dt} = +\frac{1}{3}\frac{d[C]}{dt}$$

3. **Given:** Rate of appearance of $C$ ($\frac{d[C]}{dt}$) $= 1.2 \times 10^{-2}$ mol L$^{-1}$ s$^{-1}$. 4. **Calculate rate of disappearance of $A$ ($-\frac{d[A]}{dt}$):**

$$-\frac{d[A]}{dt} = \frac{2}{3}\left(\frac{d[C]}{dt}\right)$$

$$-\frac{d[A]}{dt} = \frac{2}{3} \times (1.2 \times 10^{-2}) = 0.8 \times 10^{-2} \text{ mol L}^{-1} \text{ s}^{-1}$$

**Answer: (B)**

## Q26.

### Solution

**Concept:**

The **Arrhenius Equation** describes the temperature dependence of reaction rates:

$$k = A \cdot e^{-E_a/RT}$$

Taking the natural logarithm (ln) on both sides:

$$\ln k = \ln A - \frac{E_a}{RT}$$

To convert to common logarithm ($\log_{10}$), we divide by 2.303:

$$\log k = \log A - \frac{E_a}{2.303RT}$$

**Solution:**

1. The equation is in the form of a straight line $y = mx + c$. 2. Comparing $\log k = \left(-\frac{E_a}{2.303R}\right)\frac{1}{T} + \log A$: - $y = \log k$ - $x = 1/T$ - $m$(slope) $= -\frac{E_a}{2.303R}$ - $c$(intercept) $= \log A$

The slope of the plot $\log k$ vs $1/T$ is $-E_a/2.303R$.

**Answer: (B)**

# Q27.

## Solution

**Concept:**

The **Brown Ring Test** is a classic qualitative laboratory test used to confirm the presence of the **Nitrate ion ($NO_3^-$)** in a sample. The test depends on the ability of $Fe^{2+}$ to reduce the nitrate ion to nitric oxide ($NO$), which then reacts with the excess ferrous ions to form a characteristic brown-colored complex.

**Solution:**

The formation of the brown ring occurs at the junction of the two layers (concentrated $H_2SO_4$ and the aqueous solution) through the following chemical steps:

1. **Reduction of Nitrate:** In the presence of acidic medium (from $H_2SO_4$), the nitrate ion is reduced by $Fe^{2+}$:

$$NO_3^- + 3Fe^{2+} + 4H^+ \rightarrow NO + 3Fe^{3+} + 2H_2O$$

2. **Complex Formation:** The generated nitric oxide ($NO$) coordinates with the hydrated ferrous ion $[Fe(H_2O)_6]^{2+}$ to form the brown complex:

$$[Fe(H_2O)_6]^{2+} + NO \rightarrow [Fe(H_2O)_5(NO)]^{2+} + H_2O$$

3. **Structural Details:** In the complex **$[Fe(H_2O)_5(NO)]^{2+}$**, an electron transfer occurs from $NO$ to $Fe^{2+}$, resulting in $Fe$ being in the **+1 oxidation state** and $NO$ being the **nitrosonium ion ($NO^+$)**. This unique electronic state is responsible for the deep brown color.

**Answer: (A)**

# Q28.

## Solution

**Concept:**

The **Magnetic Moment ($\mu$)** of a transition metal ion is primarily determined by the number of **unpaired electrons ($n$)** in its $d$-orbitals. According to the "spin-only" formula:

$$\mu = \sqrt{n(n+2)} \text{ Bohr Magnetons (BM)}$$

Ions with the same number of unpaired electrons will exhibit the same magnetic moment.

**Solution:**

We evaluate the electronic configurations of the pairs of ions (Atomic numbers: $Ti = 22, V = 23, Cr = 24, Mn = 25, Fe = 26, Co = 27$):

- **Pair (A): $Mn^{2+}$ and $Fe^{3+}$**
  - $Mn^{2+}(Z = 25) : [Ar]3d^5$. All 5 electrons are unpaired. **$n = 5$**.
  - $Fe^{3+}(Z = 26) : [Ar]3d^6 \longrightarrow [Ar]3d^5$. All 5 electrons are unpaired. **$n = 5$**.
  - Both have $n = 5$, so $\mu = \sqrt{5(5+2)} = 5.92$ BM.
- **Pair (B): $Fe^{2+}$ and $Co^{2+}$**
  - $Fe^{2+} : [Ar]3d^6$. Unpaired electrons: **$n = 4$**.
  - $Co^{2+} : [Ar]3d^7$. Unpaired electrons: **$n = 3$**. (Different)
- **Pair (C): $Cr^{3+}$ and $Fe^{3+}$**
  - $Cr^{3+} : [Ar]3d^3$. Unpaired electrons: **$n = 3$**.
  - $Fe^{3+} : [Ar]3d^5$. Unpaired electrons: **$n = 5$**. (Different)

**Conclusion:** Because both $Mn^{2+}$ and $Fe^{3+}$ possess exactly 5 unpaired electrons, they will have the same magnetic moment.

**Answer: (A)**

## Q29.

### Solution

**Concept:**
Octahedral complexes of the general formula **$[Ma_3b_3]$** (where $M$ is the metal and $a, b$ are monodentate ligands) exhibit a specific type of **Geometrical Isomerism**. These isomers are classified as **facial ($fac$)** and **meridional ($mer$)**.

**Solution:**
For the complex $[Co(NH_3)_3(NO_2)_3]$, the two geometrical isomers are:

1. **Facial (fac) Isomer:** This occurs when the three identical ligands ($NH_3$) occupy three adjacent corners of an octahedral face. In this arrangement, all three ligands are **cis** to each other.

2. **Meridional (mer) Isomer:** This occurs when the three identical ligands ($NH_3$) occupy positions around the "meridian" (the equator) of the octahedron. In this case, two ligands are **trans** to each other, and the third is **cis** to both.

**Note on Optical Activity:** Since both isomers possess a plane of symmetry, neither is optically active. Therefore, the total number of stereoisomers for this complex is exactly 2.

**Answer: (A)**

## Q30.

### Solution

**Concept:**
The magnetic behavior of a complex is governed by the strength of the ligands (Crystal Field Theory).

- **Strong Field Ligands (e.g., $CN^-, CO$):** Cause large splitting ($\Delta_o$) and force electrons to pair up, often leading to **diamagnetic** (no unpaired electrons) complexes.
- **Weak Field Ligands (e.g., $Cl^-, F^-$):** Cause small splitting, allowing electrons to remain unpaired, leading to **paramagnetic** behavior.

**Solution:**
Let's examine the electronic configuration of Nickel ($Ni, Z = 28 : [Ar]3d^8 4s^2$) in its +2 state ($3d^8$):

1. **$[Ni(CN)_4]^{2-}$:** $CN^-$ is a very strong field ligand. For $Ni^{2+}$ ($d^8$), the splitting is so large that it adopts a **Square Planar** geometry ($dsp^2$ hybridization). The 8 electrons pair up completely in the four lower-energy $d$-orbitals. Number of unpaired electrons = **0**. Therefore, it is **Diamagnetic**.

2. **$[NiCl_4]^{2-}$:** $Cl^-$ is a weak field ligand. The complex adopts a **Tetrahedral** geometry ($sp^3$ hybridization). According to Hund's rule, the 8 electrons result in **2 unpaired electrons**. Therefore, it is **Paramagnetic**.

3. **$[FeF_6]^{3-}$ and $[CoF_6]^{3-}$:** $F^-$ is a weak field ligand; these are high-spin octahedral complexes with multiple unpaired electrons. Therefore, they are **Paramagnetic**.

**Answer: (C)**

## Q31.

### Solution

**Concept:**

The **$S_N1$ (Substitution Nucleophilic Unimolecular)** reaction is a two-step mechanism.

(a) **Step 1 (Slow/RDS):** The leaving group ($Br^-$) departs, forming a flat, $sp^2$-hybridized **carbocation intermediate**.

(b) **Step 2 (Fast):** The nucleophile attacks the planar carbocation from either side (front or back) with equal probability.

The reactivity order for $S_N1$ is determined by the stability of the carbocation:

$$\text{Tertiary }(3^\circ) > \text{Secondary }(2^\circ) > \text{Primary }(1^\circ) > \text{Methyl}$$

**Solution:**

We evaluate the given $C_4H_9Br$ isomers based on their ability to form a stable carbocation and the symmetry of the resulting product:

- **(A) n-Butyl bromide:** A 1° halide. Forms an unstable 1° carbocation. Unlikely to undergo $S_N1$.
- **(B) s-Butyl bromide:** A 2° halide. It is chiral. Under $S_N1$, it forms a 2° carbocation. Attack from both sides leads to a **racemic mixture** (50% R and 50% S), which is optically inactive.
- **(C) t-Butyl bromide:** A 3° halide. It forms the most stable tertiary carbocation due to +I effect and hyperconjugation from three methyl groups. This is the **most reactive** substrate for $S_N1$. The product, t-butyl alcohol, is achiral and thus optically inactive.
- **(D) Isobutyl bromide:** A 1° halide. Forms an unstable 1° carbocation.

In standard chemical logic, **t-Butyl bromide** is the classic answer for $S_N1$ reactivity because of its maximum carbocation stability.

**Answer: (C)**

## Q32.

### Solution

**Concept:**

The dehydration of ethanol with concentrated $H_2SO_4$ is a competitive reaction where the major product is determined strictly by the **reaction temperature**. Concentrated $H_2SO_4$ acts as both a catalyst (protonating the alcohol) and a dehydrating agent.

**Solution:**

Let's look at the mechanism at the two critical temperatures:

(a) **At** 443 **K (High Temp): Intramolecular dehydration** occurs. The ethanol molecule undergoes $\beta$-elimination.

$$CH_3 - CH_2 - OH \xrightarrow{H_2SO_4, 443K} CH_2 = CH_2 + H_2O$$

The product is **Ethene**.

(b) **At** 413 **K (Low Temp): Intermolecular dehydration** occurs. One molecule of ethanol is protonated and then attacked by a second *unprotonated* ethanol molecule (nucleophilic substitution).

$$CH_3CH_2OH + HOCH_2CH_3 \xrightarrow{H_2SO_4, 413K} CH_3CH_2 - O - CH_2CH_3 + H_2O$$

The product is **Ethoxyethane** (also known as Diethyl ether).

Since the question specifies **413 K**, the product is the ether.

**Answer: (B)**

## Q33.

### Solution

**Concept:**
This three-step sequence involves the reduction of a phenol, the alkylation of an aromatic ring, and the complete oxidation of an alkyl side chain.

**Solution:**

- **Step 1 (Phenol → X):** Phenol is heated with **Zinc dust**. Zinc acts as a reducing agent, removing the oxygen atom to form benzene.

$$C_6H_5OH + Zn \xrightarrow{\Delta} C_6H_5(Benzene) + ZnO \implies \textbf{X} = \textbf{Benzene}$$

- **Step 2 (X → Y):** Benzene reacts with Methyl chloride ($CH_3Cl$) in the presence of anhydrous $AlCl_3$. This is a **Friedel-Crafts Alkylation**. The $CH_3^+$ electrophile replaces a hydrogen on the ring.

$$C_6H_6 + CH_3Cl \xrightarrow{AlCl_3} C_6H_5CH_3(Toluene) \implies \textbf{Y} = \textbf{Toluene}$$

- **Step 3 (Y → Z):** Toluene is treated with alkaline $KMnO_4$, a powerful oxidizing agent. Regardless of the length of the alkyl chain (as long as it has an $\alpha$-hydrogen), the entire chain is oxidized to a carboxyl group.

$$C_6H_5CH_3 \xrightarrow{[O]} C_6H_5COOK \xrightarrow{H_3O^+} C_6H_5COOH \implies \textbf{Z} = \textbf{BenzoicAcid}$$

**Answer: (B)**

# Q34.

## Solution

**Concept:**

The **Hell-Volhard-Zelinsky (HVZ)** reaction is used to substitute a halogen (chlorine or bromine) for a hydrogen atom on the **$\alpha$-carbon** of a carboxylic acid.

- **Reagents:** $X_2$ (where $X = Cl, Br$) and a small amount of Red Phosphorus.
- **Requirement:** The acid must possess at least one **$\alpha$-hydrogen**.

[Image of Hell-Volhard-Zelinsky reaction mechanism]

**Solution:**

We examine the structure of each carboxylic acid to identify the $\alpha$-hydrogens:

- **(A) Acetic acid ($CH_3 - COOH$):** The $\alpha$-carbon is the methyl carbon. It has 3 $\alpha$-hydrogens. (Undergoes HVZ)
- **(B) Isobutyric acid ($(CH_3)_2CH - COOH$):** The $\alpha$-carbon is attached to one hydrogen. (Undergoes HVZ)
- **(C) Benzoic acid ($C_6H_5 - COOH$):** The carboxyl group is attached to a benzene ring carbon. This carbon is already bonded to three other carbons in the ring. It has **zero hydrogens**. (Does NOT undergo HVZ)
- **(D) Propionic acid ($CH_3CH_2 - COOH$):** The $\alpha$-carbon has 2 hydrogens. (Undergoes HVZ)

**Answer: (C)**

## Q35.

### Solution

**Concept:**

The reactivity of carbonyl compounds ($> C = O$) toward **Nucleophilic Addition** is governed by two factors:

(a) **Electronic Factor:** Electron-donating groups (+I) reduce the positive charge on the carbonyl carbon, making it less attractive to nucleophiles.

(b) **Steric Factor:** Bulkier groups around the carbonyl carbon hinder the approach of the nucleophile.

**Solution:**

Let's rank the reactivity based on these factors:

(a) **Formaldehyde (HCHO):** No alkyl groups. Least steric hindrance and no +I effect. **Most Reactive**.

(b) **Acetaldehyde ($CH_3CHO$):** One methyl group. Small steric hindrance and one +I effect.

(c) **Benzaldehyde ($C_6H_5CHO$):** The carbonyl group is in resonance with the benzene ring, which significantly stabilizes the carbon and reduces its electrophilicity.

(d) **Acetone ($CH_3COCH_3$):** Two methyl groups. Significant steric hindrance and two +I effects. **Least Reactive**.

The correct order of reactivity is: **HCHO** > $CH_3CHO$ > $C_6H_5CHO$ > $CH_3COCH_3$.

**Answer: (A)**

# Q36.

## Solution

**Concept:**

Conversion of primary aromatic amines to phenols occurs via **Diazotization** followed by hydrolysis.

**Solution:**

1. **Diazotization:** Aniline reacts with nitrous acid (generated from $NaNO_2 + HCl$) at low temperatures (273 – 278 K).

$$C_6H_5NH_2 \xrightarrow{NaNO_2, HCl, 0-5^\circ C} C_6H_5N_2^+Cl^- (Benzenediazoniumchloride)$$

2. **Hydrolysis:** When the diazonium salt solution is warmed or boiled with water, the diazonium group is replaced by a hydroxyl group, releasing nitrogen gas.

$$C_6H_5N_2^+Cl^- + H_2O \xrightarrow{\text{boil}} C_6H_5OH + N_2 + HCl$$

3. The final product is **Phenol**.

**Answer: (C)**

# Q37.

## Solution

**Concept:**
The **Basicity of Amines** in the aqueous phase is determined by the availability of the lone pair of electrons on the Nitrogen atom for protonation. For aromatic amines, this availability is influenced by:

(a) **Resonance Effect:** The lone pair on the $N$ atom of aniline is delocalized into the benzene ring, making it less available for donation.

(b) **Electronic Effects of Substituents:**

- **Electron Donating Groups (EDG):** Like $-CH_3$, $-OCH_3$, $-NH_2$, increase basicity by increasing electron density on Nitrogen.
- **Electron Withdrawing Groups (EWG):** Like $-NO_2$, $-CN$, $-X$, decrease basicity by pulling electron density away.

**Solution:**
Let's evaluate the given compounds:

- **(A) Aniline** ($C_6H_5NH_2$)**:** Standard resonance delocalization. Base case.
- **(B) p-Nitroaniline:** The $-NO_2$ group is a strong EWG ($-M$ and $-I$ effects). It drastically reduces the electron density on Nitrogen. **Least basic**.
- **(C) p-Toluidine** ($p - CH_3C_6H_4NH_2$)**:** The $-CH_3$ group is an EDG (+I and hyperconjugation). It pushes electron density toward the ring and the amino group. **Most basic**.

The order of basic strength is: **p-Toluidine > Aniline > p-Nitroaniline**.

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

## Q38.

### Solution

**Concept:**
**Hinsberg's Reagent** (Benzenesulphonyl chloride, $C_6H_5SO_2Cl$) is used to distinguish between primary, secondary, and tertiary amines based on their reaction products and their solubility in alkali ($NaOH$).
**Solution:**
The reaction behavior for each type of amine is as follows:

(a) **Primary** (1°) **Amines:** React to form an N-alkylbenzenesulphonamide. This product contains an acidic hydrogen on the Nitrogen atom (due to the strong electron-withdrawing $SO_2$ group), making it **soluble in alkali**.

(b) **Secondary** (2°) **Amines:** React to form an N,N-dialkylbenzenesulphonamide. This product has no acidic hydrogen on Nitrogen, so it is **insoluble in alkali**.

(c) **Tertiary** (3°) **Amines:** Do not react with Hinsberg's reagent under ordinary conditions because they lack a replaceable hydrogen on the Nitrogen atom.

The question asks for the amine whose product is **insoluble in alkali**, which corresponds to a secondary amine.

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

## Q39.

### Solution

**Concept:**
**Vitamins** are classified into two broad categories based on their solubility:

(a) **Fat-soluble Vitamins:** Vitamins **A, D, E, and K**. These are stored in the liver and adipose (fat-storing) tissues. They are not readily excreted.

(b) **Water-soluble Vitamins:** Vitamins of the **B-group** and **Vitamin C**. These must be supplied regularly in the diet because they are readily excreted in urine and cannot be stored in the body (except Vitamin $B_{12}$).

**Solution:**
1. **Vitamin A:** Fat-soluble. 2. **Vitamin D:** Fat-soluble. 3. **Vitamin C (Ascorbic acid):** Water-soluble. It is essential for collagen synthesis and immune function but is quickly flushed out of the system. 4. **Vitamin K:** Fat-soluble.
Therefore, Vitamin C is the one that is water-soluble.

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

## Q40.

### Solution

**Concept:**

**Nucleic Acids** (DNA and RNA) are polymers made of nucleotides. Each nucleotide consists of a pentose sugar, a phosphoric acid group, and a nitrogenous base.

- **Purines:** Adenine (A) and Guanine (G) — present in both DNA and RNA.
- **Pyrimidines:** Cytosine (C), Thymine (T), and Uracil (U).

**Solution:**

The distribution of pyrimidine bases is the key difference between the two types of nucleic acids:

- **DNA:** Contains Adenine, Guanine, Cytosine, and **Thymine**.
- **RNA:** Contains Adenine, Guanine, Cytosine, and **Uracil**.

The base **Uracil** is unique to RNA and is not found in DNA (where it is replaced by Thymine).

**Answer: (D)**

## Q41.

### Solution

**Concept:**

The **Order of a Reaction** is an experimental quantity that defines the dependence of the reaction rate on the concentration of reactants. It is the sum of the exponents of the concentration terms in the rate law expression.

$$\text{Rate} = k[A]^x[B]^y \implies \text{Order} = x + y$$

**Solution:**

Let's evaluate the characteristics of the reaction order:

- **Experimental Nature:** The order cannot be determined simply by looking at the balanced chemical equation (stoichiometry); it must be determined experimentally.
- **Values:** The order of a reaction can be a whole number (0, 1, 2, 3), a fraction (e.g., 1.5 for certain decomposition reactions), or even negative in rare cases.
- **Zero Order:** A reaction where the rate is independent of the reactant concentration is called a zero-order reaction.
- **Molecularity vs. Order:** While molecularity must be a positive integer (it counts reacting molecules), the **order can be fractional**.

**Answer: (C)**

## Q42.

### Solution

**Concept:**

**Adsorption** is a surface phenomenon where molecules of a substance (adsorbate) concentrate at the surface of a solid or liquid (adsorbent).

- **Physisorption:** Weak van der Waals forces, reversible, low enthalpy of adsorption.
- **Chemisorption:** Strong chemical bonds, irreversible, high enthalpy of adsorption, and often requires activation energy.

**Solution:**

According to the **Le Chatelier's Principle**, since adsorption is generally an exothermic process ($\Delta H < 0$): 1. **Physisorption:** As temperature increases, the kinetic energy of the adsorbate increases, overcoming the weak van der Waals forces. Thus, physisorption **decreases** with increasing temperature. 2. **Chemisorption:** Initially, an increase in temperature provides the necessary **activation energy** for the chemical bond formation. Therefore, chemisorption first **increases** with temperature and then decreases as the increased thermal energy begins to break the chemical bonds.

**Answer: (B)**

## Q43.

### Solution

**Concept:**

The **Extraction of Iron** takes place in a **Blast Furnace**. The ore (Haematite, $Fe_2O_3$), coke, and limestone ($CaCO_3$) are fed from the top, while a blast of hot air is blown from the bottom.

**Solution:**

In the lower, hotter regions of the furnace, several chemical transformations occur: 1. **Combustion:** Coke burns to produce $CO_2$ and heat. 2. **Formation of Reducing Agent:** $CO_2$ reacts with red-hot coke to form Carbon Monoxide ($CO$).

$$CO_2 + C \rightarrow 2CO$$

3. **Slag Formation:** Limestone decomposes to Calcium Oxide ($CaO$), which reacts with the acidic impurity (silica, $SiO_2$) to form molten slag.

$$CaO(s) + SiO_2(s) \rightarrow CaSiO_3(l) \text{ (Calcium Silicate)}$$

The slag is lighter than molten iron and floats on top, protecting the iron from re-oxidation.

**Answer: (A)**

## Q44.

### Solution

**Concept:**

The **Boiling Point** of hydrides of Group 16 elements ($H_2O, H_2S, H_2Se, H_2Te$) generally increases down the group due to the increase in molecular size and van der Waals forces. However, **Water ($H_2O$)** is a significant exception.

**Solution:**

1. **Electronegativity:** Oxygen is the second most electronegative element. 2. **Hydrogen Bonding:** Due to the high electronegativity of Oxygen and its small size, water molecules form strong **Intermolecular Hydrogen Bonds**. 3. **Result:** A large amount of energy is required to break these bonds to convert liquid water into vapor. This gives $H_2O$ an abnormally high boiling point compared to $H_2S$, $H_2Se$, and $H_2Te$, which only experience weak van der Waals forces.

**Answer: (A)**

## Q45.

### Solution

**Concept:**

The **Interhalogen Compounds** are molecules formed by the combination of two different halogen atoms ($XX'_n$). These compounds are generally more reactive than the individual halogens (except Fluorine).

**Solution:**

1. **Bond Polarity:** In an interhalogen $X - X'$, the bond is polar because of the difference in electronegativity between the two different halogens. 2. **Bond Strength:** The $X - X'$ bond in interhalogens is **weaker** than the $X - X$ bond in pure halogens (except the $F - F$ bond). 3. **Reactivity:** Because the $X - X'$ bond is weaker and polar, it breaks more easily during a chemical reaction. Therefore, interhalogen compounds are **more reactive** than the parent halogens.

**Answer: (B)**

## Q46.

### Solution

**Concept:**
The **Reimer-Tiemann Reaction** is a classic organic reaction used for the ortho-formylation of phenols.

- **Reagents:** Chloroform ($CHCl_3$) and aqueous Sodium Hydroxide ($NaOH$).
- **Product:** Salicylaldehyde (2-hydroxybenzaldehyde).

**Solution:**
The reaction proceeds through a unique electrophilic substitution: 1. **Generation of Intermediate:** $NaOH$ reacts with $CHCl_3$ to produce the reactive electrophile **Dichlorocarbene ($: CCl_2$)**. 2. **Attack:** The phenoxide ion (formed from phenol in base) attacks the carbene at the ortho position. 3. **Hydrolysis:** Subsequent hydrolysis and acidification yield **Salicylaldehyde**.

$$C_6H_5OH + CHCl_3 + 3NaOH \rightarrow o - C_6H_4(OH)CHO + 3NaCl + 2H_2O$$

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

## Q47.

### Solution

**Concept:**
The **Aldol Condensation** is a reaction involving aldehydes or ketones that possess at least one **$\alpha$-hydrogen**.

- **Reagent:** Dilute alkali (e.g., $NaOH, Ba(OH)_2$).
- **Product:** $\beta$-hydroxy aldehyde (aldol) or $\beta$-hydroxy ketone (ketol).

**Solution:**
We must look for the presence of a hydrogen atom on the carbon adjacent to the carbonyl group:

- **(A) Methanal (Formaldehyde, $HCHO$):** No $\alpha$-carbon, hence no $\alpha$-hydrogen. (Undergoes Cannizzaro)
- **(B) Ethanal (Acetaldehyde, $CH_3CHO$):** Has 3 $\alpha$-hydrogens on the methyl group. **Undergoes Aldol Condensation**.
- **(C) Benzaldehyde ($C_6H_5CHO$):** The $\alpha$-carbon is part of the benzene ring and has no hydrogen. (Undergoes Cannizzaro)
- **(D) Trichloroethanal (Chloral, $CCl_3CHO$):** The $\alpha$-carbon is attached to 3 chlorines, no hydrogens.

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

## Q48.

### Solution

**Concept:**

The **Hoffmann Bromamide Degradation** is a method used to convert a primary amide into a primary amine with **one less carbon atom** than the starting amide.

- **Reagents:** Bromine ($Br_2$) and aqueous or ethanolic Sodium Hydroxide ($NaOH$).

**Solution:**

The general reaction is:

$$R - CONH_2 + Br_2 + 4NaOH \rightarrow R - NH_2 + Na_2CO_3 + 2NaBr + 2H_2O$$

For **Ethanamide** ($CH_3CONH_2$): 1. The amide has 2 carbons. 2. The carbonyl carbon is lost as carbonate ($CO_3^{2-}$). 3. The remaining methyl group stays attached to the nitrogen. 4. Product: **Methanamine** ($CH_3NH_2$), which has 1 carbon.

**Answer: (A)**

## Q49.

### Solution

**Concept:**

**Vitamins** are essential micronutrients. **Vitamin $B_{12}$** (Cyanocobalamin) is unique because it is the only vitamin that contains a metal ion as an integral part of its complex ring structure (a corrin ring, similar to porphyrin).

**Solution:**

1. **Magnesium ($Mg$):** Found in Chlorophyll. 2. **Iron ($Fe$):** Found in Haemoglobin and Myoglobin. 3. **Cobalt ($Co$):** Found in **Vitamin $B_{12}$**. The cobalt atom is at the center of the complex and is essential for the vitamin's biological activity in DNA synthesis and nerve function. 4. **Zinc ($Zn$):** Found in various enzymes like carbonic anhydrase.

**Answer: (C)**

# Q50.

## Solution

**Concept:**

The **Order of a Reaction** is defined by the rate law. For a zero-order reaction:

$$\text{Rate} = k[A]^0 = k$$

This means the rate of the reaction is constant and independent of the concentration of the reactants.

**Solution:**

1. **Integrated Rate Equation:** For $[A]_0 \rightarrow [A]$, the equation is $[A] = [A]_0 - kt$. 2. **Half-life ($t_{1/2}$):** This is the time required for the concentration to drop to half its initial value ($[A] = [A]_0/2$).

$$\frac{[A]_0}{2} = [A]_0 - k \cdot t_{1/2}$$

$$k \cdot t_{1/2} = \frac{[A]_0}{2}$$

$$t_{1/2} = \frac{[A]_0}{2k}$$

3. **Conclusion:** In a zero-order reaction, the half-life is **directly proportional** to the initial concentration of the reactant ($[A]_0$).

**Answer: (A)**

# Answer Key

| Q | Ans | Q | Ans | Q | Ans | Q | Ans | Q | Ans |
|---|---|---|---|---|---|---|---|---|---|
| 1 | B | 2 | D | 3 | A | 4 | B | 5 | B |
| 6 | A | 7 | B | 8 | A | 9 | A | 10 | B |
| 11 | C | 12 | C | 13 | A | 14 | B | 15 | C |
| 16 | A | 17 | A | 18 | A | 19 | D | 20 | B |
| 21 | A | 22 | A | 23 | C | 24 | D | 25 | B |
| 26 | B | 27 | A | 28 | A | 29 | A | 30 | C |
| 31 | C | 32 | B | 33 | B | 34 | C | 35 | A |
| 36 | C | 37 | C | 38 | B | 39 | C | 40 | D |
| 41 | C | 42 | B | 43 | A | 44 | A | 45 | B |
| 46 | A | 47 | B | 48 | A | 49 | C | 50 | A |