CUET UG Chemistry Sample Paper - 1

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. Which of the following 0.10 m aqueous solutions will exhibit the largest freezing point depression?

(A) KCl

(B) $C_6H_{12}O_6$

(C) $Al_2(SO_4)_3$

(D) K_2SO_4

Q2. The value of Van't Hoff factor (i) for $K_4[Fe(CN)_6]$ assuming 100% dissociation is:

(A) 4

(B) 5

(C) 2

(D) 3

Q3. According to Raoult's law, the relative lowering of vapour pressure for a solution containing a non-volatile solute is equal to:

(A) Mole fraction of solvent

(B) Mole fraction of solute

(C) Molality

(D) Molarity

Q4. If two liquids A and B form an ideal solution, then:

(A) $\Delta H_{mix} > 0$

(B) $\Delta V_{mix} < 0$

(C) $\Delta H_{mix} = 0$

(D) $\Delta S_{mix} = 0$

Q5. An aqueous solution of glucose is made by dissolving 18g of glucose $(C_6H_{12}O_6)$ in 90g of water. The mole fraction of glucose is:

(A) 0.1

(B) 0.02

(C) 0.05

(D) 0.2

Q6. The limiting molar conductivity of an electrolyte A_2B is given by:

(A) $2\lambda_A^0 + \lambda_B^0$

(B) $\lambda_A^0 + \lambda_B^0$

(C) $\lambda_A^0 + 2\lambda_B^0$

(D) $1/2\lambda_A^0 + \lambda_B^0$

Q7. The amount of electricity required to deposit 1 mole of Aluminium from a solution of $AlCl_3$ is:

(A) 1 F

(B) 2 F

(C) 3 F

(D) 4 F

Q8. In the Nernst equation, the constant value of $2.303RT/F$ at 298 K is:

(A) 0.0591

(B) 0.591

(C) 0.0295

(D) 0.118

Q9. Which of the following is used in a dry cell (Leclanché cell) as the electrolyte?

(A) $KOH + ZnO$

(B) $NH_4Cl + ZnCl_2$

(C) H_2SO_4

(D) $NaOH$

Q10. For the cell reaction $Cu(s) + 2Ag^+(aq) \to Cu^{2+}(aq) + 2Ag(s)$, the equilibrium constant K_c is related to E^0_{cell} by:

(A) $E^0 = \frac{0.059}{2} \log K_c$

(B) $E^0 = \frac{0.059}{1} \log K_c$

(C) $E^0 = 0.059 \log K_c$

(D) $E^0 = \frac{2}{0.059} \log K_c$

Q11. What is the fuel used in the fuel cell used in the Apollo space program?

(A) $CH_4 - O_2$

(B) $H_2 - O_2$

(C) $NH_3 - O_2$

(D) $CO - O_2$

Q12. The unit of rate constant for a zero-order reaction is:

(A) s^{-1}

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

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

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

Q13. A first-order reaction has a rate constant $1.15 \times 10^{-3} s^{-1}$. How long will 5g of this reactant take to reduce to 3g?

(A) 444 s

(B) 600 s

(C) 300 s

(D) 100 s

Q14. The activation energy of a reaction can be determined from the slope of which graph?

(A) $\ln k$ vs T

(B) $\ln k$ vs $1/T$

(C) k vs T

(D) $\log k$ vs T

Q15. If the concentration of the reactant is increased by 4 times and the rate of reaction doubles, the order of the reaction is:

(A) 1

(B) 2

(C) 0.5

(D) 0

Q16. For a reaction $A + B \rightarrow C$, the rate law is $Rate = k[A]^2[B]$. What is the overall order?

(A) 1

(B) 2

(C) 3

(D) 0

Q17. Which of the following ions has the highest magnetic moment?

(A) Cu^{2+}

(B) Ni^{2+}

(C) Co^{2+}

(D) Fe^{3+}

Q18. Lanthanoid contraction is due to:

(A) Perfect shielding of 4f electrons

(B) Poor shielding of 4f electrons

(C) Increase in nuclear charge

(D) Both (B) and (C)

Q19. When $KMnO_4$ acts as an oxidizing agent in acidic medium, the oxidation state of Mn changes from +7 to:

(A) +4

(B) +2

(C) +6

(D) +3

Q20. The colour of $K_2Cr_2O_7$ crystals is:

(A) Orange

(B) Yellow

(C) Green

(D) Pink

Q21. The IUPAC name of $[Pt(NH_3)_2Cl(NO_2)]$ is:

(A) Diamminechloridonitritoplatinum(II)

(B) Diamminechloridonitroplatinum(IV)

(C) Diamminechloridonitritoplatinum(IV)

(D) Chloridonitritoplatinum(II)

Q22. Which of the following complexes is square planar in shape?

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

(B) $[Ni(CO)_4]$

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

(D) $[MnCl_4]^{2-}$

Q23. The number of geometrical isomers for the complex $[Co(NH_3)_4Cl_2]^+$ is:

(A) 2

(B) 3

(C) 4

(D) 1

Q24. According to Crystal Field Theory, the sequence of d-orbital splitting in an octahedral field is:

(A) t_{2g} is lower, e_g is higher

(B) e_g is lower, t_{2g} is higher

(C) All d-orbitals remain degenerate

(D) None of these

Q25. The spin-only magnetic moment of $[Fe(H_2O)_6]^{2+}$ is (in BM):

(A) 1.73

(B) 4.90

(C) 5.92

(D) 2.84

Q26. Which of the following is an outer orbital complex?

(A) $[Co(NH_3)_6]^{3+}$

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

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

(D) $[Mn(CN)_6]^{3-}$

Q27. Which of the following will undergo S_N2 reaction fastest?

(A) $CH_3 - CH_2 - Br$

(B) $CH_3 - CH(Br) - CH_3$

(C) $(CH_3)_3C - Br$

(D) $CH_3 - Br$

Q28. The reaction of methyl bromide with AgF to give methyl fluoride is known as:

(A) Finkelstein reaction

(B) Swarts reaction

(C) Wurtz reaction

(D) Sandmeyer reaction

Q29. Chlorobenzene is formed from Benzene diazonium chloride by reacting with $CuCl/HCl$. This is:

(A) Gattermann reaction

(B) Sandmeyer reaction

(C) Wurtz-Fittig

(D) Friedel-Crafts

Q30. In S_N1 reaction, the intermediate formed is a:

(A) Carbocation

(B) Carbanion

(C) Free radical

(D) Carbene

Q31. Lucas reagent is a mixture of:

(A) Conc. HCl+ anhydrous $ZnCl_2$

(B) Conc. HNO_3+ anhydrous $ZnCl_2$

(C) Conc. HCl+ Hydrated $ZnCl_2$

(D) Conc. H_2SO_4+ anhydrous $ZnCl_2$

Q32. Phenol is more acidic than ethanol because:

(A) Phenoxide ion is more stable than ethoxide ion

(B) Phenoxide ion is resonance stabilized

(C) Phenol has a higher molecular weight

(D) Ethanol has hydrogen bonding

Q33. Identify the product of Reimer-Tiemann reaction:

(A) Salicylic acid

(B) Salicylaldehyde

(C) Benzene

(D) Benzoic acid

Q34. Propan-2-ol on oxidation with PCC gives:

(A) Propanal

(B) Propanone

(C) Propanoic acid

(D) Ethanol

Q35. The reaction of sodium phenoxide with CO_2 followed by acidification yields Salicylic acid. This is:

(A) Kolbe's reaction

(B) Reimer-Tiemann

(C) Etard reaction

(D) Stephen reaction

Q36. Which of the following does NOT give Tollens' test?

(A) CH_3CHO

(B) $HCHO$

(C) CH_3COCH_3

(D) C_6H_5CHO

Q37. Cannizzaro reaction is given by:

(A) Acetaldehyde

(B) Acetone

(C) Benzaldehyde

(D) Propanal

Q38. The strongest acid among the following is:

(A) CH_3COOH

(B) $ClCH_2COOH$

(C) $Cl_2CHCOOH$

(D) Cl_3CCOOH

Q39. Nucleophilic addition reaction is most favored in:

(A) CH_3CHO

(B) CH_3COCH_3

(C) $HCHO$

(D) $C_6H_5COCH_3$

Q40. Cross Aldol condensation between Benzaldehyde and Acetophenone gives:

(A) 1,3-diphenylprop-2-en-1-one

(B) Benzyl alcohol

(C) Benzoic acid

(D) Phenol

Q41. Hell-Volhard-Zelinsky (HVZ) reaction is used to prepare:

(A) α-halo acids

(B) β-halo acids

(C) Alcohols

(D) Amines

Q42. Which of the following is the strongest base in the gas phase?

(A) CH_3NH_2

(B) $(CH_3)_2NH$

(C) $(CH_3)_3N$

(D) NH_3

Q43. Gabriel Phthalimide synthesis is used for the preparation of:

(A) 1° Aliphatic amine

(B) 2° Aliphatic amine

(C) 1° Aromatic amine

(D) 3° Amine

Q44. Hinsberg's reagent is:

(A) Benzene sulphonyl chloride

(B) Benzene sulphonic acid

(C) Phenyl isocyanide

(D) Thionyl chloride

Q45. Aniline reacts with $NaNO_2 + HCl$ at $0 - 5^\circ C$ to give:

(A) Chlorobenzene

(B) Benzene diazonium chloride

(C) Nitrobenzene

(D) Phenol

Q46. Which of the following is a non-reducing sugar?

(A) Glucose

(B) Fructose

(C) Sucrose

(D) Lactose

Q47. The linkage present between two amino acids in a protein is:

(A) Glycosidic linkage

(B) Peptide linkage

(C) Phosphodieater linkage

(D) Hydrogen bond

Q48. Deficiency of Vitamin C causes:

(A) Rickets

(B) Scurvy

(C) Night blindness

(D) Beri-beri

Q49. On complete hydrolysis, DNA yields:

(A) Pentose sugar, Nitrogenous base, and Phosphate

(B) Glucose, base, and acid

(C) Amino acids only

(D) Ribose sugar and base

Q50. Denaturation of protein leads to loss of its biological activity due to the destruction of:

(A) Primary structure

(B) Secondary and Tertiary structures

(C) Peptide bonds

(D) Amino acid sequence

Detailed Solutions

Q1.

Solution

Concept: Colligative properties, such as the depression of freezing point (ΔT_f), depend solely on the total number of solute particles (ions or molecules) present in the solution, regardless of their nature.

Solution: The relationship for freezing point depression is given by:

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

Where i is the Van't Hoff factor, K_f is the cryoscopic constant, and m is the molality. Since m is constant (0.10 m) for all options, $\Delta T_f \propto i$.

- **KCl:** Dissociates into K^+ and $Cl^- \implies i = 2$
- $C_6H_{12}O_6$**:** Does not dissociate (non-electrolyte) $\implies i = 1$
- $Al_2(SO_4)_3$**:** Dissociates into $2Al^{3+}$ and $3SO_4^{2-} \implies i = 2 + 3 = 5$
- K_2SO_4**:** Dissociates into $2K^+$ and $SO_4^{2-} \implies i = 2 + 1 = 3$

$Al_2(SO_4)_3$ has the highest Van't Hoff factor ($i = 5$), producing the most particles, and thus exhibits the largest freezing point depression.

Answer: (C)

Q2.

Solution

Concept: The Van't Hoff factor (i) represents the extent of dissociation or association of a solute in a solvent. For 100% dissociation, i is equal to the total number of ions produced per formula unit.

Solution: Potassium ferrocyanide, $K_4[Fe(CN)_6]$, is a complex salt. In aqueous solution, the counter ions (potassium) dissociate from the coordination entity (the square bracket), but the coordination entity remains intact.

$$K_4[Fe(CN)_6] \xrightarrow{H_2O} 4K^+ + [Fe(CN)_6]^{4-}$$

Counting the particles:

(a) 4 Potassium ions ($4K^+$)

(b) 1 Ferrocyanide complex ion ($[Fe(CN)_6]^{4-}$)

Total number of ions $(n) = 4 + 1 = 5$. Since dissociation is 100%, $i = n = 5$.

Answer: (B)

Q3.

Solution

Concept: Raoult's Law for a solution containing a non-volatile solute states that the addition of the solute lowers the vapor pressure of the solvent.
Solution: The mathematical expression for Raoult's Law regarding the relative lowering of vapour pressure is:

$$\frac{P^\circ - P_s}{P^\circ} = \chi_{solute}$$

Where:

- P° = Vapour pressure of the pure solvent.
- P_s = Vapour pressure of the solution.
- $(P^\circ - P_s)$ = Lowering of vapour pressure.
- $\frac{P^\circ - P_s}{P^\circ}$ = Relative lowering of vapour pressure.
- χ_{solute} = Mole fraction of the solute.

Thus, the relative lowering is equal to the mole fraction of the solute.

Answer: (B)

Q4.

Solution

Concept: An ideal solution is a mixture where the solute-solute and solvent-solvent intermolecular forces are nearly identical to the solute-solvent interactions.
Solution: For a solution of liquids A and B to be "Ideal," it must satisfy the following thermodynamic criteria upon mixing:

(a) **Enthalpy of mixing (ΔH_{mix}):** No heat is absorbed or evolved, so $\Delta H_{mix} = 0$.

(b) **Volume of mixing (ΔV_{mix}):** The total volume is the sum of the individual volumes, so $\Delta V_{mix} = 0$.

(c) **Entropy of mixing (ΔS_{mix}):** Mixing increases randomness, so $\Delta S_{mix} > 0$.

(d) **Gibbs Free Energy (ΔG_{mix}):** For spontaneous mixing, $\Delta G_{mix} < 0$.

Based on the choices provided, the correct condition is $\Delta H_{mix} = 0$.

Answer: (C)

Q5.

Solution

Concept: The mole fraction (χ) of a component in a mixture is the number of moles of that component divided by the total number of moles of all components.

Solution: Step 1: Calculate moles of glucose ($n_{glucose}$) Molar mass of $C_6H_{12}O_6 = (6 \times 12) + (12 \times 1) + (6 \times 16) = 180$ g/mol.

$$n_{glucose} = \frac{\text{Given mass}}{\text{Molar mass}} = \frac{18 \text{ g}}{180 \text{ g/mol}} = 0.1 \text{ mol}$$

Step 2: Calculate moles of water (n_{water}) Molar mass of $H_2O = (2 \times 1) + (16) = 18$ g/mol.

$$n_{water} = \frac{90 \text{ g}}{18 \text{ g/mol}} = 5.0 \text{ mol}$$

Step 3: Calculate mole fraction of glucose ($\chi_{glucose}$)

$$\chi_{glucose} = \frac{n_{glucose}}{n_{glucose} + n_{water}} = \frac{0.1}{0.1 + 5.0} = \frac{0.1}{5.1} \approx 0.0196$$

Rounding to significant figures provided in options, we get 0.02.

Answer: (B)

Q6.

Solution

Concept: Kohlrausch's Law of Independent Migration of Ions states that at infinite dilution, the limiting molar conductivity of an electrolyte is the sum of the limiting molar conductivities of its constituent ions, each multiplied by the number of ions present in the formula unit.

Solution: Consider the electrolyte A_2B. Upon complete dissociation in water:

$$A_2B \rightarrow 2A^+ + B^{2-}$$

According to Kohlrausch's Law, the limiting molar conductivity (Λ_m°) is calculated as:

$$\Lambda_m^\circ(A_2B) = \nu_A\lambda_A^\circ + \nu_B\lambda_B^\circ$$

Where ν represents the stoichiometric coefficients of the ions.

- Number of A ions (ν_A) = 2
- Number of B ions (ν_B) = 1

Therefore, $\Lambda_m^\circ = 2\lambda_A^\circ + \lambda_B^\circ$.

Answer: (A)

Q7.

Solution

Concept: According to Faraday's Laws, the charge required to deposit or liberate one mole of a substance is equal to $n \times F$, where n is the number of electrons involved in the redox half-reaction and F is the Faraday constant.
Solution: In an aqueous solution of $AlCl_3$, Aluminium exists in the +3 oxidation state (Al^{3+}). To deposit solid Aluminium at the cathode, the following reduction reaction occurs:

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

From the balanced equation:

- To deposit 1 mole of Al atoms, 3 moles of electrons are required.
- The charge of 1 mole of electrons is defined as 1 Faraday (1 F).
- Therefore, 3 moles of electrons = 3 Faradays (3 F).

The amount of electricity required is 3 F.

Answer: (C)

Q8.

Solution

Concept: The Nernst equation describes the relationship between the cell potential and the concentration of species. It involves a constant derived from the Gas constant (R), Temperature (T), and Faraday's constant (F).
Solution: The term in the Nernst equation is $\frac{RT}{F}\ln(Q)$. Converting the natural log (ln) to base-10 log (log), we multiply by 2.303, giving the term: $\frac{2.303RT}{F}$. At the standard biological/laboratory temperature of 298 K:

- R (Universal Gas Constant) = 8.314 J K^{-1} mol^{-1}
- T (Temperature) = 298 K
- F (Faraday Constant) = 96485 C mol^{-1}

Calculation:

$$\text{Value} = \frac{2.303 \times 8.314 \times 298}{96485} \approx 0.05915 \text{ V}$$

In most chemistry applications and textbook problems, this is rounded to 0.0591.

Answer: (A)

Q9.

Solution

Concept: A dry cell (Leclanché cell) consists of a zinc container (anode) and a carbon/graphite rod (cathode) surrounded by powdered manganese dioxide and carbon. The space between the electrodes is filled with a moist electrolyte paste.
Solution: In a Leclanché cell, the electrolyte is not a liquid but a moist paste to prevent leakage, making it "dry." This paste consists of:

- **Ammonium chloride (NH_4Cl):** Acts as the primary electrolyte providing ions for the reaction.
- **Zinc chloride ($ZnCl_2$):** Helps maintain moisture and combines with the ammonia gas produced during the reaction to form a complex $[Zn(NH_3)_2]Cl_2$, preventing pressure buildup.

Therefore, the electrolyte used is a mixture of NH_4Cl and $ZnCl_2$.

Answer: (B)

Q10.

Solution

Concept: The relationship between the standard cell potential (E°_{cell}) and the equilibrium constant (K_c) is derived from the Nernst equation at equilibrium, where $E_{cell} = 0$.
Solution: The Nernst equation is: $E_{cell} = E^\circ_{cell} - \frac{0.059}{n} \log Q$. At equilibrium, $E_{cell} = 0$ and the reaction quotient Q becomes the equilibrium constant K_c. For the given reaction: $Cu(s) + 2Ag^+(aq) \to Cu^{2+}(aq) + 2Ag(s)$

(a) **Identify n:** The number of electrons transferred is 2 ($Cu \to Cu^{2+} + 2e^-$ and $2Ag^+ + 2e^- \to 2Ag$). Thus, $n = 2$.

(b) **Substitute into the equation:**

$$0 = E^\circ_{cell} - \frac{0.059}{2} \log K_c$$

$$E^\circ_{cell} = \frac{0.059}{2} \log K_c$$

Answer: (A)

Q11.

Solution

Concept: Fuel cells are galvanic cells that convert the chemical energy of spontaneous combustion of fuels directly into electrical energy.
Solution: The fuel cell used in the Apollo space program was the **Hydrogen-Oxygen** $(H_2 - O_2)$ **fuel cell**.

- In this cell, hydrogen and oxygen are bubbled through porous carbon electrodes into a concentrated aqueous sodium hydroxide or potassium hydroxide solution.
- This specific cell was chosen because it is highly efficient, compact, and the byproduct (water vapor) was condensed and used as drinking water by the astronauts.

Answer: (B)

Q12.

Solution

Concept: The units of the rate constant (k) depend on the overall order of the reaction (n). The general formula for the units of k is $(mol\,L^{-1})^{1-n}\,s^{-1}$.
Solution: For a zero-order reaction, the value of n is 0. The rate law is expressed as:

$$Rate = k[A]^0 = k$$

Since the rate of a reaction is defined as the change in concentration over time, its unit is:

$$\text{Unit of Rate} = \frac{\text{Concentration}}{\text{Time}} = \frac{mol\,L^{-1}}{s} = mol\,L^{-1}s^{-1}$$

Since $Rate = k$, the unit of k for a zero-order reaction is also $mol\,L^{-1}s^{-1}$.

Answer: (B)

Q13.

Solution

Concept: For a first-order reaction, the time required for a change in concentration is calculated using the integrated rate equation: $t = \frac{2.303}{k} \log \frac{[R]_0}{[R]}$.

Solution: Step 1: Identify given values

- Initial mass $[R]_0 = 5$ g
- Final mass $[R] = 3$ g
- Rate constant $k = 1.15 \times 10^{-3}$ s^{-1}

Step 2: Plug into the formula

$$t = \frac{2.303}{1.15 \times 10^{-3}} \log \left(\frac{5}{3} \right)$$

$$t = \frac{2.303}{1.15 \times 10^{-3}} \log(1.666)$$

$$t = \frac{2.303}{1.15 \times 10^{-3}} \times 0.2218$$

$$t \approx 2002.6 \times 0.2218 \approx 444 \text{ s}$$

Answer: (A)

Q14.

Solution

Concept: The Arrhenius equation describes the dependence of the rate constant (k) on temperature (T) and activation energy (E_a): $k = Ae^{-E_a/RT}$.

Solution: Taking the natural logarithm (ln) on both sides of the Arrhenius equation:

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

This equation is in the form of a straight line, $y = mx + c$:

- $y = \ln k$
- $x = 1/T$
- $m(\text{slope}) = -E_a/R$
- $c(\text{intercept}) = \ln A$

Thus, by plotting $\ln k$ **vs** $1/T$, a straight line is obtained where the slope (E_a/R) allows us to calculate the activation energy.

Answer: (B)

Q15.

Solution

Concept: The order of a reaction with respect to a reactant determines how the rate changes when the concentration of that reactant is varied: $Rate \propto [C]^n$.
Solution: Let the rate law be $r_1 = k[C]^n$. According to the problem:

(a) The concentration is increased by 4 times: $[C'] = 4[C]$

(b) The rate doubles: $r_2 = 2r_1$

Substituting these into the rate equation:

$$2r_1 = k(4[C])^n$$

Dividing the new rate equation by the original ($2r_1/r_1 = k(4C)^n/kC^n$):

$$2 = 4^n$$

$$2^1 = (2^2)^n \implies 2^1 = 2^{2n}$$

Equating powers: $1 = 2n \implies n = 0.5$.

Answer: (C)

Q16.

Solution

Concept: The overall order of a chemical reaction is defined as the sum of the exponents (powers) of the concentration terms of the reactants in the rate law expression.
Solution: Given the rate law:

$$Rate = k[A]^2[B]^1$$

To find the overall order (n):

- Order with respect to $A = 2$
- Order with respect to $B = 1$

Sum of the orders: $n = 2 + 1 = 3$. The reaction is a third-order reaction.

Answer: (C)

Q17.

Solution

Concept: The magnetic moment (μ) of an ion depends on the number of unpaired electrons (n) present in its d-orbitals, calculated using the spin-only formula: $\mu = \sqrt{n(n+2)}$ Bohr Magnetons (BM).

Solution: We determine the number of unpaired electrons for each ion:

- Cu^{2+}**:** Electronic configuration $[Ar]3d^9$. It has 1 unpaired electron.
- Ni^{2+}**:** Electronic configuration $[Ar]3d^8$. It has 2 unpaired electrons.
- Co^{2+}**:** Electronic configuration $[Ar]3d^7$. It has 3 unpaired electrons.
- Fe^{3+}**:** Electronic configuration $[Ar]3d^5$. It has 5 unpaired electrons.

Since Fe^{3+} has the maximum number of unpaired electrons ($n = 5$), it will have the highest magnetic moment ($\mu = \sqrt{5(5+2)} = \sqrt{35} \approx 5.92$ BM).

Answer: (D)

Q18.

Solution

Concept: Lanthanoid contraction refers to the steady decrease in the atomic and ionic radii of the Lanthanoids as the atomic number increases.

Solution: This phenomenon occurs due to two primary factors working together:

(a) **Poor Shielding Effect:** The $4f$ electrons have a very diffused shape, which results in poor shielding of the outer electrons from the nuclear charge.

(b) **Increase in Nuclear Charge:** As we move along the series, the nuclear charge increases by one unit at each step.

Because the shielding provided by $4f$ electrons is insufficient to compensate for the increasing nuclear charge, the effective nuclear charge increases, pulling the electron cloud closer to the nucleus and causing a contraction.

Answer: (D)

Q19.

Solution

Concept: Potassium permanganate ($KMnO_4$) is a powerful oxidizing agent. Its reduction product depends on the pH of the medium.
Solution: In an acidic medium (usually H_2SO_4), the MnO_4^- ion accepts 5 electrons to be reduced. The ionic half-reaction is:

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$

- In MnO_4^-, the oxidation state of Manganese (Mn) is **+7**.
- In the product Mn^{2+}, the oxidation state is **+2**.

Therefore, the oxidation state changes from +7 to +2.

Answer: (B)

Q20.

Solution

Concept: Potassium dichromate ($K_2Cr_2O_7$) is an important inorganic reagent. Its characteristic color arises from charge transfer spectra rather than d-d transitions.
Solution: Potassium dichromate exists as bright **orange** colored crystals.

- In aqueous solution, the color depends on pH due to the equilibrium between chromate (CrO_4^{2-}, yellow) and dichromate ($Cr_2O_7^{2-}$, orange).
- In its solid crystalline state, it is distinctly orange.

Answer: (A)

Q21.

Solution

Concept: IUPAC nomenclature for coordination compounds requires naming ligands in alphabetical order followed by the central metal and its oxidation state in Roman numerals.
Solution: Analysis of $[Pt(NH_3)_2Cl(NO_2)]$:

- **Ligands:** Two ammine (NH_3), one chlorido (Cl), and one nitrito-N or nitro (NO_2). Alphabetically: ammine, then chlorido, then nitrito.
- **Oxidation State:** Let Pt be x. $x + 2(0) + (-1) + (-1) = 0 \implies x = +2$.
- **Name:** Diamminechloridonitritoplatinum(II).

Note: "Nitrito" is used for NO_2^- when it coordinates through Nitrogen (often specified as nitrito-N).

Answer: (A)

Q22.

Solution

Concept: The geometry of a complex depends on the hybridization of the central metal ion, which is influenced by the strength of the ligands (spectrochemical series).
Solution: We examine $[Ni(CN)_4]^{2-}$:

(a) Ni^{2+} has a $3d^8$ configuration.

(b) CN^- is a **strong field ligand**, which causes the electrons in the $3d$ orbitals to pair up.

(c) This leaves one $3d$ orbital vacant, allowing for dsp^2 **hybridization**.

(d) dsp^2 hybridization always results in a **square planar** geometry.

In contrast, $[NiCl_4]^{2-}$ and $[Ni(CO)_4]$ are tetrahedral (sp^3) because Cl^- is a weak field ligand and $Ni(0)$ in $[Ni(CO)_4]$ fills the $4p$ orbitals.

Answer: (C)

Q23.

Solution

Concept: Geometrical isomerism (cis/trans) occurs in octahedral complexes of the type $[MA_4B_2]$ due to different spatial arrangements of the ligands.
Solution: For the complex $[Co(NH_3)_4Cl_2]^+$, there are two possible geometrical arrangements:

(a) **cis-isomer:** The two chloride (Cl^-) ligands are adjacent to each other (at a 90° angle).

(b) **trans-isomer:** The two chloride (Cl^-) ligands are opposite to each other (at a 180° angle).

Thus, there are 2 geometrical isomers.

Answer: (A)

Q24.

Solution

Concept: Crystal Field Theory (CFT) explains that when ligands approach a central metal ion, the degeneracy of the d-orbitals is lifted, causing them to split into different energy levels.
Solution: In an octahedral field, the ligands approach along the x, y, and z axes:

- The $d_{x^2-y^2}$ and d_{z^2} orbitals (called the e_g **set**) point directly toward the ligands and experience more repulsion, shifting to a **higher energy level**.
- The d_{xy}, d_{yz}, and d_{zx} orbitals (called the t_{2g} **set**) point between the axes and experience less repulsion, shifting to a **lower energy level**.

Therefore, the t_{2g} set is lower in energy and the e_g set is higher.

Answer: (A)

Q25.

Solution

Concept: The spin-only magnetic moment is calculated as $\mu = \sqrt{n(n+2)}$, where n is the number of unpaired electrons.
Solution: Analysis of $[Fe(H_2O)_6]^{2+}$:

(a) Iron is in the +2 oxidation state (Fe^{2+}).

(b) Fe^{2+} electronic configuration is $[Ar]3d^6$.

(c) H_2O is a **weak field ligand**, so it does not cause electron pairing (High Spin complex).

(d) The 6 electrons are distributed as: 4 in t_{2g} and 2 in e_g ($t_{2g}^4 e_g^2$).

(e) This results in **4 unpaired electrons** ($n = 4$).

(f) $\mu = \sqrt{4(4+2)} = \sqrt{24} \approx 4.899 \approx 4.90$ BM.

Answer: (B)

Q26.

Solution

Concept: Coordination complexes are classified based on the hybridization of the central metal. An **outer orbital complex** uses the outer d-orbitals (nd, e.g., $4d$) for hybridization (sp^3d^2), which typically occurs when the ligand is too weak to pair up the inner $(n-1)d$ electrons.
Solution: We examine the electronic configuration and ligand field strength of each complex:

(a) $[Co(NH_3)_6]^{3+}$**:** Co^{3+} is $3d^6$. NH_3 is a strong field ligand (SFL) that pairs electrons, allowing d^2sp^3 (inner).

(b) $[Fe(CN)_6]^{3-}$**:** Fe^{3+} is $3d^5$. CN^- is a very strong ligand that pairs electrons, allowing d^2sp^3 (inner).

(c) $[CoF_6]^{3-}$**:** The central metal is Co^{3+} ($3d^6$). The fluoride ion (F^-) is a **weak field ligand** (WFL). According to Crystal Field Theory, the crystal field splitting (Δ_o) is less than the pairing energy (P). Consequently, electrons do not pair up and remain in the $3d$ orbitals. The metal must use the vacant $4s$, $4p$, and **outer** $4d$ orbitals for bonding, resulting in sp^3d^2 hybridization.

(d) $[Mn(CN)_6]^{3-}$**:** Mn^{3+} is $3d^4$. CN^- is an SFL, leading to d^2sp^3 (inner).

Thus, $[CoF_6]^{3-}$ is the outer orbital complex.

Answer: (C)

Q27.

Solution

Concept: The S_N2 (Substitution Nucleophilic Bimolecular) mechanism involves a single-step concerted process where the nucleophile attacks from the side opposite to the leaving group. The rate is governed by **steric hindrance**.

Solution: In the S_N2 transition state, the carbon atom is pentacoordinated and very crowded. Any bulky groups attached to this carbon block the approach of the nucleophile. Therefore, the reactivity order is:

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

Comparing the given alkyl bromides:

- $CH_3 - Br$**:** Methyl bromide (No alkyl groups, zero steric hindrance).
- $CH_3 - CH_2 - Br$**:** Ethyl bromide (1° alkyl halide, low hindrance).
- $CH_3 - CH(Br) - CH_3$**:** Isopropyl bromide (2° alkyl halide, moderate hindrance).
- $(CH_3)_3C - Br$**:** tert-Butyl bromide (3° alkyl halide, extreme hindrance; usually undergoes S_N1 or $E2$).

Since $CH_3 - Br$ has the least steric hindrance, it undergoes the S_N2 reaction fastest.

Answer: (D)

Q28.

Solution

Concept: The synthesis of alkyl fluorides is often difficult via direct halogenation. Halogen exchange reactions are utilized to substitute a chloride or bromide with a fluoride using inorganic fluorides.

Solution: The specific reaction of an alkyl bromide (or chloride) with metallic fluorides such as AgF, Hg_2F_2, CoF_2, or SbF_3 is known as the **Swarts reaction**.

$$CH_3 - Br + AgF \rightarrow CH_3 - F + AgBr$$

Comparison with other reactions:

- **Finkelstein reaction:** Halogen exchange using NaI in dry acetone to prepare alkyl iodides.
- **Wurtz reaction:** Reaction of alkyl halides with sodium in dry ether to form higher alkanes.
- **Sandmeyer reaction:** Synthesis of aryl halides from diazonium salts using cuprous halides.

Answer: (B)

Q29.

Solution

Concept: The replacement of the diazonium group $(-N_2^+Cl^-)$ in benzene diazonium chloride by a halide or cyanide using copper(I) salts is a classic method for preparing haloarenes.

Solution: When a freshly prepared solution of benzene diazonium chloride is mixed with **cuprous chloride ($CuCl$ or Cu_2Cl_2)** dissolved in HCl, the diazonium group is replaced by a chlorine atom, evolving nitrogen gas.

$$C_6H_5N_2Cl \xrightarrow{CuCl/HCl} C_6H_5Cl + N_2$$

This specific procedure, utilizing cuprous salts as catalysts, is known as the **Sandmeyer reaction**.

- If copper powder were used instead of cuprous salts, it would be the Gattermann reaction.
- Wurtz-Fittig involves alkyl and aryl halide coupling with sodium.
- Friedel-Crafts involves alkylation or acylation of the benzene ring.

Answer: (B)

Q30.

Solution

Concept: The S_N1 (Substitution Nucleophilic Unimolecular) reaction occurs in two distinct steps. The rate-determining step involves the ionization of the substrate.

Solution: The mechanism of S_N1 is as follows:

(a) **Step 1 (Slow):** The bond between the carbon and the leaving group breaks heterolytically. The leaving group takes both electrons, leaving the carbon with a formal positive charge. This species is a **carbocation**.

(b) **Step 2 (Fast):** The carbocation, which is sp^2 hybridized and planar, is attacked by a nucleophile from either side.

Because the intermediate is a carbocation, the reaction rate is highly dependent on the stability of that carbocation (Tertiary > Secondary > Primary).

Answer: (A)

Q31.

Solution

Concept: The Lucas test is a qualitative laboratory procedure used to distinguish between primary, secondary, and tertiary alcohols. It relies on the differing rates of formation of alkyl chlorides.

Solution: Lucas reagent is a solution of **concentrated hydrochloric acid** (HCl) and **anhydrous zinc chloride** ($ZnCl_2$).

- The $ZnCl_2$ acts as a Lewis acid catalyst to facilitate the breaking of the $C - OH$ bond.
- **Tertiary alcohols** react immediately to form an oily layer/turbidity of alkyl chloride.
- **Secondary alcohols** produce turbidity within 5–10 minutes.
- **Primary alcohols** do not produce turbidity at room temperature unless heated.

Answer: (A)

Q32.

Solution

Concept: Acidity is proportional to the stability of the conjugate base formed after the loss of a proton (H^+).

Solution: When Phenol and Ethanol act as acids, they form the **phenoxide ion** ($C_6H_5O^-$) and **ethoxide ion** ($C_2H_5O^-$), respectively.

(a) **Phenoxide Ion:** The lone pair on the oxygen atom is in conjugation with the π-system of the benzene ring. The negative charge is delocalized over the ortho and para positions through **resonance**. This delocalization stabilizes the ion significantly.

(b) **Ethoxide Ion:** The negative charge is localized on the oxygen atom. Furthermore, the ethyl group is an electron-donating group ($+I$ effect), which pushes electron density toward the already negative oxygen, destabilizing the ion.

Because the phenoxide ion is resonance-stabilized, phenol loses its proton much more readily than ethanol.

Answer: (B)

Q33.

Solution

Concept: The Reimer-Tiemann reaction is an electrophilic aromatic substitution reaction used to introduce a formyl group ($-CHO$) onto a phenol ring.
Solution: In this reaction, phenol is treated with **chloroform ($CHCl_3$)** in the presence of aqueous **sodium hydroxide ($NaOH$)**.

- The reaction generates a reactive intermediate called dichlorocarbene ($: CCl_2$).
- This intermediate attacks the benzene ring at the ortho position.
- After hydrolysis and acidification, the final product is **Salicylaldehyde** (2-hydroxybenzaldehyde).

If carbon tetrachloride (CCl_4) were used instead of chloroform, the product would be salicylic acid.

Answer: (B)

Q34.

Solution

Concept: Pyridinium chlorochromate (PCC) is a specialized oxidizing agent used in organic chemistry to oxidize alcohols to carbonyl compounds. It is known for its mildness and selectivity.
Solution: The product of oxidation depends on the type of alcohol:

- **Primary Alcohols:** Oxidized to aldehydes (PCC prevents further oxidation to carboxylic acids).
- **Secondary Alcohols:** Oxidized to **ketones**.

Propan-2-ol ($CH_3 - CH(OH) - CH_3$) is a **secondary (2°) alcohol**. Upon treatment with PCC, the hydroxyl group is converted into a carbonyl group ($C = O$), resulting in the formation of **Propanone** (commonly known as acetone).

$$CH_3CH(OH)CH_3 \xrightarrow{PCC} CH_3COCH_3$$

Answer: (B)

Q35.

Solution

Concept: The synthesis of phenolic acids can be achieved through the carboxylation of phenoxide ions using carbon dioxide.
Solution: When phenol is treated with $NaOH$, it forms sodium phenoxide. This salt is then reacted with **carbon dioxide (CO_2)** at high temperature (400 K) and pressure (4–7 atm). The resulting intermediate is acidified to produce **Salicylic acid** (2-hydroxybenzoic acid). This reaction is known as **Kolbe's reaction** (or the Kolbe-Schmitt reaction).

- **Etard reaction** is the oxidation of toluene to benzaldehyde.
- **Stephen reaction** is the reduction of nitriles to aldehydes.
- **Reimer-Tiemann** produces Salicylaldehyde.

Answer: (A)

Q36.

Solution

Concept: Tollens' test is a chemical reaction used to distinguish between aldehydes and ketones. Tollens' reagent (ammoniacal silver nitrate) is a mild oxidizing agent.
Solution: Tollens' reagent can oxidize **aldehydes** to their corresponding carboxylate ions while being reduced to metallic silver, which forms a "silver mirror" on the test tube.

- **Aliphatic Aldehydes ($CH_3CHO, HCHO$):** Give a positive test.
- **Aromatic Aldehydes (C_6H_5CHO):** Give a positive test.
- **Ketones (CH_3COCH_3):** Since ketones lack the hydrogen atom attached to the carbonyl carbon, they are resistant to mild oxidation and do **not** react with Tollens' reagent.

Propanone (CH_3COCH_3) is a ketone and therefore does not give the Tollens' test.

Answer: (C)

Q37.

Solution

Concept: The Cannizzaro reaction is a disproportionation (self-oxidation and reduction) reaction. It is specifically undergone by aldehydes that **do not possess any α-hydrogen atoms** when they are treated with a concentrated alkali (such as 50% $NaOH$ or KOH).
Solution: To identify the correct aldehyde, we must look for the absence of α-hydrogens (hydrogen atoms attached to the carbon adjacent to the carbonyl group):

- **Acetaldehyde (CH_3CHO):** Contains 3 α-hydrogens. It undergoes Aldol condensation.
- **Acetone (CH_3COCH_3):** A ketone with 6 α-hydrogens. It undergoes Aldol condensation.
- **Propanal (CH_3CH_2CHO):** Contains 2 α-hydrogens. It undergoes Aldol condensation.
- **Benzaldehyde (C_6H_5CHO):** The carbonyl group is attached to a benzene ring carbon that is already bonded to three other carbons. Thus, there is **no α-hydrogen**.

In the reaction, one molecule of Benzaldehyde is reduced to Benzyl alcohol ($C_6H_5CH_2OH$) and another is oxidized to Sodium benzoate (C_6H_5COONa).

Answer: (C)

Q38.

Solution

Concept: The acidity of carboxylic acids is determined by the stability of the carboxylate ion ($RCOO^-$) formed after losing a proton. Electron-withdrawing groups (EWGs) like Chlorine increase acidity through the **negative inductive effect ($-I$ effect)**.
Solution: An EWG pulls electron density away from the $O-H$ bond, making it more polar and easier to break. It also disperses the negative charge on the carboxylate ion, stabilizing it. The strength of this effect increases with the number of EWGs:

(a) **Acetic acid (CH_3COOH):** No EWG; standard acidity.

(b) **Monochloroacetic acid ($ClCH_2COOH$):** One Cl atom exerts a $-I$ effect.

(c) **Dichloroacetic acid ($Cl_2CHCOOH$):** Two Cl atoms exert a stronger cumulative effect.

(d) **Trichloroacetic acid (Cl_3CCOOH):** Three Cl atoms exert the **maximum possible $-I$ effect** in this series.

As the number of chlorine atoms increases, the K_a value increases significantly. Thus, Cl_3CCOOH is the strongest acid.

Answer: (D)

Q39.

Solution

Concept: The reactivity of a carbonyl compound toward nucleophilic addition is governed by **electronic factors** (the magnitude of the positive charge on the carbonyl carbon) and **steric factors** (the physical size of the groups surrounding that carbon).

Solution: A nucleophile attacks the electrophilic carbon of the $C = O$ group. Reactivity is highest when:

(a) **Electronic:** There are fewer electron-donating groups (alkyl groups). Alkyl groups have a $+I$ effect, which reduces the partial positive charge ($\delta+$) on the carbon, making it less attractive to nucleophiles.

(b) **Steric:** The groups attached to the carbonyl carbon are small, allowing the nucleophile easy access.

Comparing the choices:

- **Formaldehyde ($HCHO$):** Has two small hydrogen atoms (minimal hindrance) and no $+I$ groups.
- **Acetaldehyde (CH_3CHO):** Has one $+I$ methyl group.
- **Acetone (CH_3COCH_3):** Has two $+I$ methyl groups.
- **Acetophenone ($C_6H_5COCH_3$):** Has a bulky phenyl ring and an alkyl group.

Therefore, **Formaldehyde** ($HCHO$) is the most reactive and favored for nucleophilic addition.

Answer: (C)

Q40.

Solution

Concept: Cross Aldol condensation is a reaction between two different carbonyl compounds where one acts as the nucleophile (forming an enolate) and the other as the electrophile.

Solution: In the reaction between Benzaldehyde and Acetophenone:

(a) **Enolate Formation:** Benzaldehyde (C_6H_5CHO) has no α-hydrogens, so it cannot form an enolate. Acetophenone ($C_6H_5COCH_3$) has three α-hydrogens on the methyl group and forms an enolate ion in the presence of a base.

(b) **Nucleophilic Attack:** The enolate of Acetophenone attacks the carbonyl carbon of Benzaldehyde.

(c) **Dehydration:** The resulting aldol intermediate spontaneously loses a water molecule to form a stable, conjugated α, β-unsaturated ketone.

The product is **1,3-diphenylprop-2-en-1-one** (also called Benzalacetophenone or Chalcone).

$$C_6H_5CHO + CH_3COC_6H_5 \xrightarrow{OH^-} C_6H_5CH = CHCOC_6H_5 + H_2O$$

Answer: (A)

Q41.

Solution

Concept: The Hell-Volhard-Zelinsky (HVZ) reaction is a specific method used to substitute a halogen atom for a hydrogen atom at the alpha (α) position of a carboxylic acid.

Solution: Carboxylic acids that contain at least one α-hydrogen react with **Chlorine** (Cl_2) or **Bromine** (Br_2) in the presence of a catalytic amount of **red phosphorus**.

- The reaction begins by converting a small amount of the acid into an acid halide, which then undergoes enolization and halogenation at the α-carbon.
- The resulting intermediate is hydrolyzed back to the carboxylic acid, but with a halogen now attached to the α-carbon.

The product formed is an α-**halo acid** (e.g., α-chloropropanoic acid). This reaction does not occur at the β or γ positions.

Answer: (A)

Q42.

Solution

Concept: In the **gas phase**, the basicity of amines is determined solely by the electron-donating effect ($+I$ **effect**) of the alkyl groups. Unlike in aqueous solution, there is no "solvation effect" (hydrogen bonding with water) or "steric effect" to complicate the order.
Solution: The basicity of an amine depends on the availability of the lone pair of electrons on the Nitrogen atom. Alkyl groups (CH_3) are electron-releasing:

- **Trimethylamine** $(CH_3)_3N$**:** Has three methyl groups pushing electron density onto the Nitrogen.
- **Dimethylamine** $(CH_3)_2NH$**:** Has two methyl groups.
- **Methylamine** CH_3NH_2**:** Has one methyl group.
- **Ammonia** NH_3**:** Has no methyl groups.

In the gas phase, the base strength increases with the number of alkyl groups: $3° > 2° > 1° > NH_3$. Therefore, the tertiary amine $(CH_3)_3N$ is the strongest base.

Answer: (C)

Q43.

Solution

Concept: Gabriel Phthalimide synthesis is a specific laboratory method for the preparation of pure primary amines. It avoids the formation of secondary and tertiary amines that typically occurs in other methods like ammonolysis.
Solution: The mechanism involves:

(a) Treatment of phthalimide with KOH to form potassium phthalimide.

(b) Reaction with an alkyl halide (RX) to form N-alkylphthalimide via an S_N2 **mechanism**.

(c) Cleavage of the N-alkylphthalimide using $NaOH$ to yield a primary amine.

Restriction: Because the second step involves an S_N2 attack on the alkyl halide, aryl halides cannot be used (they do not undergo S_N reactions easily). Thus, the method is used only for $1°$ **aliphatic amines**. It cannot produce aromatic amines like aniline.

Answer: (A)

Q44.

Solution

Concept: Hinsberg's test is a chemical procedure used to distinguish between primary (1°), secondary (2°), and tertiary (3°) amines. It utilizes a specific reagent that reacts differently with each class.
Solution: The reagent, known as **Hinsberg's reagent**, is **Benzene sulphonyl chloride** ($C_6H_5SO_2Cl$).

- 1° **Amines:** React to form N-alkylbenzene sulphonamide. Due to the presence of an acidic hydrogen on the Nitrogen, this product **dissolves in alkali**.
- 2° **Amines:** React to form N, N-dialkylbenzene sulphonamide. Since there is no hydrogen on the Nitrogen, the product **is insoluble in alkali**.
- 3° **Amines:** Do not react with the reagent as they lack a replaceable hydrogen on the Nitrogen.

Thus, Benzene sulphonyl chloride is the fundamental component of this test.

Answer: (A)

Q45.

Solution

Concept: The reaction between a primary aromatic amine and nitrous acid at low temperatures is a fundamental organic transformation known as the Diazotization reaction. Nitrous acid (HNO_2) is highly unstable and must be prepared "in situ" within the reaction mixture.
Solution: When Aniline ($C_6H_5NH_2$) is treated with sodium nitrite ($NaNO_2$) and excess hydrochloric acid (HCl) at a controlled temperature of $273 - 278$ K ($0 - 5$°C), the following steps occur:

(a) **In situ generation of Nitrous Acid:** $NaNO_2 + HCl \rightarrow HNO_2 + NaCl$.

(b) **Formation of the Electrophile:** The HNO_2 reacts with more HCl to produce the nitrosonium ion (NO^+).

(c) **Diazotization:** The lone pair on the nitrogen of Aniline attacks the nitrosonium ion. Through a series of proton transfers and the loss of a water molecule, the amino group ($-NH_2$) is converted into a diazonium group ($-N_2^+$).

(d) **Product Stabilization:** The resulting Benzene diazonium chloride ($C_6H_5N_2^+Cl^-$) is relatively stable at this low temperature due to resonance stabilization with the benzene ring.

If the reaction mixture is allowed to warm above 5°C, the diazonium salt reacts with water (hydrolysis) to form phenol, evolving nitrogen gas.

Answer: (B)

Q46.

Solution

Concept: Carbohydrates are classified as reducing sugars if they possess a free aldehyde or ketone group (or a hemiacetal/hemiketal group that can open into an aldehyde/ketone). If these functional groups are "locked" in a glycosidic bond, the sugar is non-reducing.

Solution: We analyze the given carbohydrates based on their structural connectivity:

- **Glucose and Fructose:** These are monosaccharides. In aqueous solution, they exist in equilibrium with their open-chain forms which contain free aldehyde and ketone groups, respectively. They readily reduce Tollen's and Fehling's reagents.
- **Lactose:** A disaccharide (milk sugar) composed of glucose and galactose. The glycosidic bond involves the C1 of galactose and C4 of glucose. Since the C1 of the glucose unit is free (exists as a hemiacetal), it is a reducing sugar.
- **Sucrose:** Common table sugar is a disaccharide composed of α-D-glucose and β-D-fructose. The glycosidic linkage is formed between the **anomeric carbon of glucose (C1)** and the **anomeric carbon of fructose (C2)**.

Because both reducing centers are utilized in the formation of the glycosidic bond, sucrose cannot revert to an open-chain form with a free carbonyl group. Thus, it does not reduce mild oxidizing agents and is classified as a non-reducing sugar.

Answer: (C)

Q47.

Solution

Concept: Proteins are biological macromolecules consisting of long chains of α-amino acids. The chemical bond that links these amino acids together is formed through a dehydration synthesis (condensation) reaction.

Solution: The formation of a protein involves the following chemical process:

(a) An amino acid contains both an amino group ($-NH_2$) and a carboxyl group ($-COOH$).

(b) During protein synthesis, the carboxyl group of one amino acid reacts with the amino group of the adjacent amino acid.

(c) A molecule of water is eliminated (OH from the carboxyl group and H from the amino group).

(d) This results in the formation of a covalent amide linkage represented as $-CONH-$.

In biochemistry, this specific amide bond between amino acid residues is termed a peptide linkage.

- Glycosidic linkages are found in carbohydrates.
- Phosphodiester linkages are found in nucleic acids (DNA/RNA).
- Hydrogen bonds are responsible for the secondary and tertiary folding, but they are not the primary linkage between amino acids.

Answer: (B)

Q48.

Solution

Concept: Vitamins are organic compounds required in micro-quantities for the normal growth and maintenance of the body. Each vitamin plays a unique role, and its absence leads to a specific deficiency disease.
Solution: Vitamin C, chemically known as ascorbic acid, is a water-soluble vitamin essential for the synthesis of collagen, which acts as the "glue" for connective tissues, skin, and blood vessels.

- **Scurvy:** The primary result of Vitamin C deficiency is Scurvy. Symptoms include spongy and bleeding gums, fragile blood vessels (leading to bruising), and poor wound healing.
- **Comparison with other options:**
  - **Rickets:** Caused by a deficiency of Vitamin D (affects bone calcification).
  - **Night Blindness:** Caused by a deficiency of Vitamin A (affects the retina).
  - **Beri-beri:** Caused by a deficiency of Vitamin B1 (thiamine).

Therefore, Vitamin C is directly linked to the prevention of Scurvy.

Answer: (B)

Q49.

Solution

Concept: Nucleic acids like DNA (Deoxyribonucleic Acid) are polymers known as polynucleotides. To determine the basic building blocks of these polymers, scientists perform complete chemical hydrolysis.
Solution: When DNA undergoes complete hydrolysis using enzymes or chemical reagents, the long polymer chains are broken down into their three fundamental chemical constituents:

(a) **A Pentose Sugar:** In the case of DNA, this sugar is specifically **2-deoxy-D-ribose** (distinguished from ribose found in RNA by the absence of an oxygen at the C2 position).

(b) **Nitrogenous Bases:** DNA yields four heterocyclic bases: the purines (Adenine and Guanine) and the pyrimidines (Cytosine and Thymine).

(c) **Phosphate Groups:** This is derived from phosphoric acid (H_3PO_4), which serves to link the sugar molecules together in the backbone of the DNA strand.

Consequently, DNA is characterized by the presence of a deoxyribose sugar, nitrogenous bases, and phosphate units.

Answer: (A)

Q50.

Solution

Concept: Protein denaturation is the process wherein a protein loses its specific native three-dimensional conformation. This structural change is usually irreversible and results in the loss of the protein's biological function.

Solution: Protein structure is organized into four levels:

- **Primary Structure:** The linear sequence of amino acids joined by covalent peptide bonds.
- **Secondary and Tertiary Structures:** The folding (alpha-helices, beta-sheets) and overall 3D shape held together by relatively weak interactions like hydrogen bonds, disulfide bridges, and hydrophobic interactions.

When a protein is denatured (via heat, pH changes, or chemicals), the secondary and tertiary structures are destroyed because the weak bonds holding them together are broken. However, the primary structure remains intact because the covalent peptide bonds are much stronger and are not broken during denaturation. Since the biological activity of a protein (like an enzyme) depends on its 3D shape, the destruction of these higher-order structures renders the protein inactive.

Answer: (B)

Answer Key

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