CUET UG Chemistry Sample Paper - 16

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. The vapor pressure of pure liquid A is 100 mm Hg and that of pure liquid B is 150 mm Hg. If 2 moles of A and 3 moles of B are mixed, the total vapor pressure of the ideal solution will be:

(A) 120 mm Hg

(B) 130 mm Hg

(C) 140 mm Hg

(D) 125 mm Hg

Q2. Which of the following 0.1 M aqueous solutions will exhibit the highest boiling point? 2024

(A) Glucose

(B) $NaCl$

(C) $CaCl_2$

(D) $AlCl_3$

Q3. The value of Van't Hoff factor (i) for a dilute solution of $K_4[Fe(CN)_6]$ assuming 100% dissociation is:

(A) 4

(B) 5

(C) 3

(D) 2

Q4. According to Raoult's Law, the relative lowering of vapor pressure is equal to:

(A) Mole fraction of solvent

(B) Mole fraction of solute

(C) Molality

(D) Molarity

Q5. An azeotropic mixture of two liquids has a boiling point lower than either of the two when it:

(A) Shows negative deviation from Raoult's Law

(B) Shows positive deviation from Raoult's Law

(C) Is an ideal solution

(D) Is saturated

Q6. Using the Nernst Equation, the potential of a hydrogen electrode at $pH = 10$ is:

(A) -0.591 V

(B) 0.00 V

(C) -0.059 V

(D) 0.591 V

Q7. Limiting molar conductivity (Λ_m°) for NH_4OH can be calculated using:

(A) $\Lambda^\circ(NH_4Cl) + \Lambda^\circ(NaOH) - \Lambda^\circ(NaCl)$

(B) $\Lambda^\circ(NH_4Cl) + \Lambda^\circ(NaCl) - \Lambda^\circ(NaOH)$

(C) $\Lambda^\circ(NaOH) + \Lambda^\circ(NaCl) - \Lambda^\circ(NH_4Cl)$

(D) $\Lambda^\circ(NH_4OH) + \Lambda^\circ(NH_4Cl)$

Q8. How many Coulombs are required to reduce 1 mole of MnO_4^- to Mn^{2+}?

(A) $1F$

(B) $3F$

(C) $5F$

(D) $2F$

Q9. In a H_2-O_2 fuel cell, the reaction occurring at the cathode is:

(A) $2H_2 + 4OH^- \rightarrow 4H_2O + 4e^-$

(B) $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

(C) $H^+ + OH^- \rightarrow H_2O$

(D) $2H_2 + O_2 \rightarrow 2H_2O$

Q10. If the E_{cell}° for a reaction is negative, which of the following is true?

(A) $\Delta G^\circ > 0; K < 1$

(B) $\Delta G^\circ < 0; K > 1$

(C) $\Delta G^\circ > 0; K > 1$

(D) $\Delta G^\circ < 0; K < 1$

Q11. Resistance of a conductivity cell filled with 0.1 M KCl is 100 Ω. If the cell constant is 1.29 cm^{-1}, the conductivity is:

(A) 0.0129 S cm^{-1}

(B) 129 S cm^{-1}

(C) 1.29 S cm^{-1}

(D) 0.129 S cm^{-1}

Q12. For a first-order reaction, if the concentration of reactant is doubled, the half-life ($t_{1/2}$):

(A) Is doubled

(B) Is halved

(C) Remains constant

(D) Increases 4 times

Q13. 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) $L^2\, mol^{-2}\, s^{-1}$

Q14. A reaction is 50% complete in 2 hours and 75% complete in 4 hours. The order of the reaction is:

(A) 0

(B) 1

(C) 2

(D) 3

Q15. The slope of the plot of $\ln k$ vs $1/T$ (Arrhenius plot) is:

(A) $-E_a/R$

(B) E_a/R

(C) A/R

(D) $-R/E_a$

Q16. For the reaction $2A + B \rightarrow C$, the rate law is $Rate = k[A][B]^2$. If $[B]$ is doubled while $[A]$ is kept constant, the rate will:

(A) Double

(B) Quadruple

(C) Remain same

(D) Triple

Q17. The cause of Lanthanoid contraction is:

(A) Poor shielding by $4f$ electrons

(B) Good shielding by $4f$ electrons

(C) Increase in nuclear charge

(D) Both A and C

Q18. Which of the following ions is paramagnetic?

(A) Zn^{2+}

(B) Sc^{3+}

(C) Ti^{4+}

(D) Cu^{2+}

Q19. $KMnO_4$ acts as an oxidizing agent in acidic medium and is reduced to:

(A) MnO_2

(B) Mn^{2+}

(C) MnO_4^{2-}

(D) Mn_2O_3

Q20. The highest oxidation state shown by any transition element (like Os or Ru) is:

(A) +6

(B) +7

(C) +8

(D) +5

Q21. The IUPAC name of $[Co(NH_3)_5Cl]Cl_2$ is:

(A) Pentaamminechloridocobalt(III) chloride

(B) Pentaamminechlorocobalt(II) chloride

(C) Chloropentaamminecobalt(III) chloride

(D) Pentaamminecobalt(III) trichloride

Q22. The hybridization of Ni in $[Ni(CN)_4]^{2-}$ is:

(A) sp^3

(B) dsp^2

(C) d^2sp^3

(D) sp^3d^2

Q23. Which of the following shows linkage isomerism?

(A) $[Co(NH_3)_5(NO_2)]Cl_2$

(B) $[Co(NH_3)_6]Cl_3$

(C) $[Pt(NH_3)_2Cl_2]$

(D) $[Cu(NH_3)_4]SO_4$

Q24. The spin-only magnetic moment of $[Fe(H_2O)_6]^{2+}$ is approximately:

(A) 4.90 BM

(B) 5.92 BM

(C) 1.73 BM

(D) 2.83 BM

Q25. According to CFT, for a d^4 ion in an octahedral field with high spin, the configuration is:

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

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

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

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

Q26. Which ligand is a bidentate ligand?

(A) NH_3

(B) CN^-

(C) Ethylenediamine (en)

(D) Cl^-

Q27. Which of the following reacts fastest by S_N1 mechanism?

(A) Methyl chloride

(B) Ethyl chloride

(C) Isopropyl chloride

(D) Tert-butyl chloride

Q28. S_N2 reaction involves:

(A) Inversion of configuration

(B) Retention of configuration

(C) Racemization

(D) Formation of carbocation

Q29. Finkelstein reaction is used to prepare:

(A) Alkyl fluorides

(B) Alkyl iodides

(C) Alkyl chlorides

(D) Alkyl bromides

Q30. Chlorobenzene is less reactive than methyl chloride towards nucleophilic substitution due to:

(A) Resonance stabilization

(B) sp^2 hybridization of C-Cl carbon

(C) Partial double bond character

(D) All of the above

Q31. Lucas test is used to distinguish between:

(A) $1°, 2°, 3°$ Alcohols

(B) Alcohols and Phenols

(C) Phenols and Ethers

(D) Aldehydes and Ketones

Q32. Reimer-Tiemann reaction converts Phenol to:

(A) Salicylic acid

(B) Salicylaldehyde

(C) Benzene

(D) Picric acid

Q33. Phenol is more acidic than Ethanol because:

(A) Phenoxide ion is resonance stabilized

(B) Ethoxide ion is resonance stabilized

(C) Phenol has a higher molecular weight

(D) Ethanol shows hydrogen bonding

Q34. Kolbe's reaction involves the treatment of Phenol with $NaOH$ and CO_2 followed by acidification to give:

(A) Salicylaldehyde

(B) Salicylic acid

(C) Anisole

(D) Quinol

Q35. Acid catalyzed dehydration of secondary alcohols usually follows:

(A) $E1$ mechanism

(B) $E2$ mechanism

(C) S_N1 mechanism

(D) S_N2 mechanism

Q36. Which of the following does not undergo Aldol condensation?

(A) Acetaldehyde

(B) Acetone

(C) Formaldehyde

(D) Propanaldehyde

Q37. Cannizzaro reaction is given by:

(A) Benzaldehyde

(B) Acetaldehyde

(C) Acetone

(D) Ethyl methyl ketone

Q38. The strongest acid among the following is:

(A) CH_3COOH

(B) $ClCH_2COOH$

(C) $Cl_2CHCOOH$

(D) Cl_3CCOOH

Q39. Propanone on reaction with Methylmagnesium bromide followed by hydrolysis gives:

(A) 2-Methylpropan-2-ol

(B) Butan-2-ol

(C) Propan-2-ol

(D) Butan-1-ol

Q40. Which reagent reduces Carboxylic acid to primary alcohol?

(A) $NaBH_4$

(B) $LiAlH_4$

(C) H_2/Ni

(D) PCC

Q41. Tollen's reagent is:

(A) Ammoniacal silver nitrate

(B) Alkaline $CuSO_4$

(C) Acidified $K_2Cr_2O_7$

(D) $I_2/NaOH$

Q42. The correct order of basic strength 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) $(CH_3)_2NH > (CH_3)_3N > CH_3NH_2 > NH_3$

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

(A) Primary aromatic amines

(B) Primary aliphatic amines

(C) Secondary amines

(D) Tertiary amines

Q44. Aniline reacts with $NaNO_2$ and HCl at $0-5°C$ to give:

(A) Chlorobenzene

(B) Benzene diazonium chloride

(C) Phenol

(D) Nitrobenzene

Q45. Hoffmann Bromamide degradation reaction of Acetamide gives:

(A) Ethylamine

(B) Methylamine

(C) Aniline

(D) Ammonia

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

(A) Glucose

(B) Fructose

(C) Maltose

(D) Sucrose

Q47. Denaturation of proteins leads to the loss of:

(A) Primary structure

(B) Secondary and tertiary structure

(C) Peptide bonds

(D) Sequence of amino acids

Q48. Which vitamin is water-soluble?

(A) Vitamin A

(B) Vitamin D

(C) Vitamin C

(D) Vitamin K

Q49. The two strands of DNA are held together by:

(A) Peptide bonds

(B) Glycosidic bonds

(C) Hydrogen bonds

(D) Phosphodiester bonds

Q50. Deficiency of Vitamin B_{12} causes:

(A) Scurvy

(B) Rickets

(C) Pernicious anemia

(D) Night blindness

Detailed Solutions

Q1.

Solution

Concept: For an ideal solution, Raoult's Law states:

$$P_{\text{total}} = x_A P_A^\circ + x_B P_B^\circ$$

where x_A, x_B are mole fractions and P_A°, P_B° are vapor pressures of pure components.

Solution:

Given:

$$P_A^\circ = 100 \text{ mm Hg}, \quad P_B^\circ = 150 \text{ mm Hg}$$

$$n_A = 2, \quad n_B = 3$$

Total moles:

$$n_{\text{total}} = 2 + 3 = 5$$

Mole fractions:

$$x_A = \frac{2}{5}, \quad x_B = \frac{3}{5}$$

Applying Raoult's Law:

$$P_{\text{total}} = \left(\frac{2}{5} \times 100\right) + \left(\frac{3}{5} \times 150\right)$$

$$P_{\text{total}} = 40 + 90 = 130 \text{ mm Hg}$$

$$\boxed{130 \text{ mm Hg}}$$

Answer: (B)

Q2.

Solution

Concept: Boiling point elevation is given by:

$$\Delta T_b = iK_b m$$

Thus, $\Delta T_b \propto i$. Greater the Van't Hoff factor (i), higher the boiling point.

Solution:

Glucose $\rightarrow i = 1$ (non-electrolyte)

$NaCl \rightarrow i = 2$

$CaCl_2 \rightarrow i = 3$

$AlCl_3 \rightarrow i = 4$

Thus, maximum dissociation is shown by $AlCl_3$, hence highest boiling point.

$$\boxed{AlCl_3}$$

Answer: (D)

Q3.

Solution

Concept: Van't Hoff factor (i) is equal to the total number of ions produced after complete dissociation.

$$i = \text{number of particles formed}$$

Solution:

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

Total ions formed:

$$4 + 1 = 5$$

$$\boxed{i = 5}$$

Answer: (B)

Q4.

Solution

Concept: According to Raoult's Law, the relative lowering of vapor pressure is given by:

$$\frac{\Delta P}{P^\circ} = x_{\text{solute}}$$

Solution:

Relative lowering of vapor pressure depends on the mole fraction of solute.

$$\boxed{\text{Mole fraction of solute}}$$

Answer: (B)

Q5.

Solution

Concept:

- Positive deviation from Raoult's Law $\rightarrow$ weaker intermolecular forces $\rightarrow$ higher vapor pressure $\rightarrow$ lower boiling point
- Negative deviation $\rightarrow$ stronger intermolecular forces $\rightarrow$ lower vapor pressure $\rightarrow$ higher boiling point

Solution:

An azeotropic mixture with a boiling point lower than either component is called a minimum boiling azeotrope, which shows positive deviation from Raoult's Law.

$$\boxed{\text{Shows positive deviation from Raoult's Law}}$$

Answer: (B)

Q6.

Solution

Concept: The electrode potential of a hydrogen electrode depends on the concentration of hydrogen ions (H^+) in the solution, as described by the Nernst Equation.For the reduction half-reaction:

$$H^+(aq) + e^- \rightarrow \frac{1}{2}H_2(g)$$

The Nernst equation is:

$$E = E^\circ - \frac{0.0591}{n} \log \frac{P_{H_2}^{1/2}}{[H^+]}$$

Where E° for a standard hydrogen electrode is 0.00 V and $n = 1$.

Solution: Assuming standard pressure for hydrogen gas ($P_{H_2} = 1$ atm):

$$E = 0 - \frac{0.0591}{1} \log \frac{1}{[H^+]}$$

$$E = -0.0591 \times \log[H^+]^{-1}$$

$$E = -0.0591 \times (-\log[H^+])$$

Since $pH = -\log[H^+]$, the expression simplifies to:

$$E = -0.0591 \times pH$$

Given $pH = 10$:

$$E = -0.0591 \times 10$$

$$E = -0.591 \text{ V}$$

Answer: (A)

Q7.

Solution

Concept: Using Kohlrausch's Law of independent migration of ions:

$$\Lambda_m^\circ = \lambda_{cation}^\circ + \lambda_{anion}^\circ$$

For weak electrolytes like NH_4OH, we calculate using strong electrolytes.

Solution:

$$NH_4Cl \longrightarrow NH_4^+ + Cl^-$$

$$NaOH \longrightarrow Na^+ + OH^-$$

$$NaCl \longrightarrow Na^+ + Cl^-$$

Adding first two and subtracting third:

$$\Lambda^\circ(NH_4Cl) + \Lambda^\circ(NaOH) - \Lambda^\circ(NaCl)$$

This gives:

$$(NH_4^+ + Cl^-) + (Na^+ + OH^-) - (Na^+ + Cl^-)$$

$$= NH_4^+ + OH^-$$

$$= \Lambda^\circ(NH_4OH)$$

$$\boxed{\Lambda^\circ(NH_4Cl) + \Lambda^\circ(NaOH) - \Lambda^\circ(NaCl)}$$

Answer: (A)

Q8.

Solution

Concept: Number of Coulombs required is given by:

$$Q = nF$$

where n = number of electrons transferred per mole.

Solution:

Reduction of permanganate in acidic medium:

$$MnO_4^- \rightarrow Mn^{2+}$$

Oxidation states:

$$Mn : +7 \rightarrow +2$$

Change in oxidation state:

$$= 5 \text{ electrons gained}$$

Thus, $n = 5$

$$Q = 5F$$

$$\boxed{5F}$$

Answer: (C)

Q9.

Solution

Concept: In a fuel cell:

- Oxidation occurs at anode
- Reduction occurs at cathode

At cathode, oxygen undergoes reduction.

Solution:

Cathode reaction in alkaline medium:

$$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$$

Thus, correct reaction is:

$$\boxed{O_2 + 2H_2O + 4e^- \rightarrow 4OH^-}$$

Answer: (B)

Q10.

Solution

Concept: Relationship between cell potential, Gibbs free energy, and equilibrium constant:

$$\Delta G^\circ = -nFE^\circ_{cell}$$

$$\Delta G^\circ = -RT \ln K$$

Solution:

If $E^\circ_{cell} < 0$, then:

$$\Delta G^\circ = -nF(E^\circ_{cell}) > 0$$

Also,

$$\Delta G^\circ > 0 \Rightarrow K < 1$$

$$\boxed{\Delta G^\circ > 0;\ K < 1}$$

Answer: (A)

Q11.

Solution

Concept: Conductivity (κ) is given by:

$$\kappa = \frac{\text{cell constant}}{R}$$

Solution:

Given:

$$\text{Cell constant} = 1.29\ \text{cm}^{-1}, \quad R = 100\ \Omega$$

$$\kappa = \frac{1.29}{100}$$

$$\kappa = 0.0129\ \text{S cm}^{-1}$$

$$\boxed{0.0129\ \text{S cm}^{-1}}$$

Answer: (A)

Q12.

Solution

Concept: For a first-order reaction, half-life is given by:

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

Thus, $t_{1/2}$ is independent of initial concentration.

Solution:

Even if the concentration is doubled, half-life remains unchanged.

$$\boxed{\text{Remains constant}}$$

Answer: (C)

Q13.

Solution

Concept: For a zero-order reaction:

$$\text{Rate} = k$$

Rate has units of concentration per time.

Solution:

$$\text{Rate} = \frac{\text{mol}}{L \cdot s}$$

Thus, unit of k is:

$$\boxed{mol\, L^{-1}\, s^{-1}}$$

Answer: (B)

Q14.

Solution

Concept: For a first-order reaction:

$$[A]_t = [A]_0 e^{-kt}$$

Also, half-life is constant and independent of initial concentration.

Solution:

Given:

- 50% completion in 2 hours $\Rightarrow$ half-life $t_{1/2} = 2$ hours
- After 4 hours (i.e., two half-lives), remaining concentration:

$$\left(\frac{1}{2}\right)^2 = \frac{1}{4}$$

Thus, 75% reaction completed.

This matches the behavior of a first-order reaction.

$$\boxed{\text{Order} = 1}$$

Answer: (B)

Q15.

Solution

Concept: Arrhenius equation:

$$k = Ae^{-E_a/RT}$$

Taking logarithm:

$$\ln k = \ln A - \frac{E_a}{R} \cdot \frac{1}{T}$$

This is of the form $y = mx + c$.

Solution:

Comparing with straight line equation:

$$\text{slope} = -\frac{E_a}{R}$$

$$\boxed{-\frac{E_a}{R}}$$

Answer: (A)

Q16.

Solution

Concept: Rate law:

$$\text{Rate} = k[A][B]^2$$

Rate depends on square of concentration of B.

Solution:

If $[B]$ is doubled:

$$\text{New Rate} = k[A](2[B])^2 = k[A] \cdot 4[B]^2 = 4 \times \text{Rate}$$

Thus, rate becomes four times.

$$\boxed{\text{Quadruple}}$$

Answer: (B)

Q17.

Solution

Concept: Lanthanoid contraction occurs due to:

- Increase in nuclear charge across the series
- Poor shielding effect of 4f electrons

Solution:

As we move across lanthanoids:

- Nuclear charge increases
- 4f electrons do not shield effectively
- Effective nuclear charge increases, causing decrease in atomic size

Thus, both factors are responsible.

$$\boxed{\text{Poor shielding by 4f electrons and increase in nuclear charge}}$$

Answer: (D)

Q18.

Solution

Concept: Paramagnetic species contain unpaired electrons, while diamagnetic species have all electrons paired.

Solution:

Check electronic configurations:

- Zn^{2+} : $[Ar]\,3d^{10}$ (all paired) $\Rightarrow$ Diamagnetic
- Sc^{3+} : $[Ar]$ (all paired) $\Rightarrow$ Diamagnetic
- Ti^{4+} : $[Ar]$ (all paired) $\Rightarrow$ Diamagnetic
- Cu^{2+} : $[Ar]\,3d^{9}$ (one unpaired electron) $\Rightarrow$ Paramagnetic

$$\boxed{Cu^{2+}}$$

Answer: (D)

Q19.

Solution

Concept: The reduction product of $KMnO_4$ depends on the medium:

- Acidic medium $\rightarrow Mn^{2+}$
- Neutral medium $\rightarrow MnO_2$
- Alkaline medium $\rightarrow MnO_4^{2-}$

Solution:

In acidic medium:

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

$$\boxed{Mn^{2+}}$$

Answer: (B)

Q20.

Solution

Concept: Transition elements can exhibit multiple oxidation states. The highest oxidation state is shown when all valence electrons (both ns and $(n-1)d$) participate in bonding.

Solution:

Elements like Osmium (Os) and Ruthenium (Ru) can show a maximum oxidation state of +8 (e.g., OsO_4).

$$\boxed{+8}$$

Answer: (C)

Q21.

Solution

Concept:

- Ligands are named alphabetically before the metal
- NH_3 is *ammine*, Cl^- is *chlorido*
- Oxidation state of metal must be calculated

Solution:

Given complex: $[Co(NH_3)_5Cl]Cl_2$

Let oxidation state of Co = x

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

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

Thus, cobalt is in +3 oxidation state.

Ligands in alphabetical order:

ammine (A) before chlorido (C)

Name:

Pentaamminechloridocobalt(III) chloride

Answer: (A)

Q22.

Solution

Concept:

- CN^- is a strong field ligand → causes pairing of electrons
- Square planar complexes generally have dsp^2 hybridization

Solution:
For $[Ni(CN)_4]^{2-}$:
Oxidation state of Ni:

$$x + 4(-1) = -2 \Rightarrow x = +2$$

Electronic configuration:

$$Ni^{2+} : [Ar]\,3d^8$$

Since CN^- is a strong field ligand, electrons pair up → leads to square planar geometry.
Hybridization:

$$\boxed{dsp^2}$$

Answer: (B)

Q23.

Solution

Concept: Linkage isomerism occurs when a ligand can coordinate to the metal through two different atoms (ambidentate ligand), e.g., NO_2^- can bind through N or O.

Solution:

Check the complexes:

- $[Co(NH_3)_5(NO_2)]Cl_2 \rightarrow NO_2^-$ is ambidentate $\rightarrow$ can bind via N or O $\Rightarrow$ linkage isomerism
- $[Co(NH_3)_6]Cl_3 \rightarrow$ all monodentate, no ambidentate ligand $\rightarrow$ no
- $[Pt(NH_3)_2Cl_2] \rightarrow$ only Cl^- and $NH_3 \rightarrow$ no
- $[Cu(NH_3)_4]SO_4 \rightarrow$ only $NH_3 \rightarrow$ no

$$\boxed{[Co(NH_3)_5(NO_2)]Cl_2}$$

Answer: (A)

Q24.

Solution

Concept: Spin-only magnetic moment is given by:

$$\mu_{so} = \sqrt{n(n+2)}\,\text{BM}$$

where n is the number of unpaired electrons.

Solution:

For $[Fe(H_2O)_6]^{2+}$:

$$Fe^{2+} : [Ar]\,3d^6$$

H_2O is a weak field ligand → high-spin complex → number of unpaired electrons $n = 4$

$$\mu_{so} = \sqrt{4(4+2)} = \sqrt{24} \approx 4.90\,\text{BM}$$

$$\boxed{4.90\,\text{BM}}$$

Answer: (A)

Q25.

Solution

Concept:

- In Crystal Field Theory (CFT), for an octahedral complex:

  d-orbitals split into t_{2g} (lower energy) and e_g (higher energy)

- High-spin complexes occur with weak field ligands $\rightarrow$ electrons occupy higher orbitals to maximize unpaired electrons.

Solution:

For a d^4 ion in an octahedral field (high spin):

$$t_{2g} \text{ orbitals: } 3 \text{ electrons}$$

$$e_g \text{ orbitals: } 1 \text{ electron}$$

$$\text{Configuration: } t_{2g}^3 e_g^1$$

$$\boxed{t_{2g}^3 e_g^1}$$

Answer: (B)

Q26.

Solution

Concept: A bidentate ligand has two donor atoms that can coordinate to the same metal center.

Solution:

- $NH_3 \rightarrow$ monodentate - $CN^- \rightarrow$ monodentate - Ethylenediamine (en) $\rightarrow$ two N atoms $\rightarrow$ bidentate - $Cl^- \rightarrow$ monodentate

$$\boxed{\text{Ethylenediamine (en)}}$$

Answer: (C)

Q27.

Solution

Concept: S_N1 reactions proceed via carbocation formation. The more stable the carbocation, the faster the reaction.

Solution:

Carbocation stability order:

$$\text{tertiary} > \text{secondary} > \text{primary} > \text{methyl}$$

- Methyl chloride $\rightarrow$ methyl carbocation $\rightarrow$ least stable - Ethyl chloride $\rightarrow$ primary carbocation - Isopropyl chloride $\rightarrow$ secondary carbocation - Tert-butyl chloride $\rightarrow$ tertiary carbocation $\rightarrow$ most stable $\rightarrow$ reacts fastest

$$\boxed{\text{Tert-butyl chloride}}$$

Answer: (D)

Q28.

Solution

Concept: S_N2 reactions are bimolecular nucleophilic substitutions where the nucleophile attacks the carbon from the side opposite to the leaving group.

Solution:

- Mechanism: Concerted backside attack → single step - Result: Inversion of configuration at the chiral center (Walden inversion) - Does not form carbocation

$$\boxed{\text{Inversion of configuration}}$$

Answer: (A)

Q29.

Solution

Concept: Finkelstein reaction is a halide exchange reaction, typically carried out in acetone, where a halide (usually Cl or Br) is replaced by iodide.

Solution:

$$R - X + NaI \xrightarrow{\text{acetone}} R - I + NaX$$

- Produces alkyl iodides - Example: $CH_3Cl + NaI \rightarrow CH_3I + NaCl$

$$\boxed{\text{Alkyl iodides}}$$

Answer: (B)

Q30.

Solution

Concept: Nucleophilic substitution is slower if the C–X bond is stronger or less electrophilic.

Solution:

For chlorobenzene:

1. **Resonance stabilization:** Lone pair on Cl delocalizes into the benzene ring → reduces electrophilicity of carbon. 2. **sp^2 hybridization:** Carbon attached to Cl is sp^2 → more s-character → stronger C–Cl bond. 3. **Partial double bond character:** Due to resonance → C–Cl bond is shorter and stronger.

All these factors reduce reactivity.

All of the above

Answer: (D)

Q31.

Solution

Concept: Lucas test uses Lucas reagent ($ZnCl_2 + HCl$) to classify alcohols based on their rate of reaction to form alkyl chlorides.

Solution:

- 3° alcohols → react immediately (cloudiness in seconds) - 2° alcohols → react in few minutes - 1° alcohols → react very slowly (hours) - Phenols, ethers → do not react

$1^\circ, 2^\circ, 3^\circ$ Alcohols

Answer: (A)

Q32.

Solution

Concept: Reimer-Tiemann reaction involves the reaction of phenol with chloroform in the presence of a base to form an ortho-substituted aldehyde.

Solution:

$$\text{Phenol} + CHCl_3 + \text{NaOH} \xrightarrow{\Delta} \text{o-Formylphenol (Salicylaldehyde)}$$

- The –CHO group is introduced at the ortho position of phenol.

$$\boxed{\text{Salicylaldehyde}}$$

Answer: (B)

Q33.

Solution

Concept: Acidity depends on the stability of the conjugate base. The more stable the conjugate base, the stronger the acid.

Solution:

- **Phenol:** Loses H to form phenoxide ion, which is **resonance stabilized** over the aromatic ring. - **Ethanol:** Loses H to form ethoxide ion, which has **no resonance stabilization**. - Molecular weight and hydrogen bonding are less significant factors in this comparison.

$$\boxed{\text{Phenoxide ion is resonance stabilized}}$$

Answer: (A)

Q34.

Solution

Concept: Kolbe's reaction (Kolbe-Schmitt reaction) carboxylates phenol at the ortho position using sodium hydroxide and carbon dioxide under pressure, followed by acidification.

Solution:

$$\text{Phenol}+NaOH+CO_2 \xrightarrow{\text{pressure, heat}} \text{Sodium salicylate} \xrightarrow{\text{HCl}} \text{Salicylic acid}$$

$$\boxed{\text{Salicylic acid}}$$

Answer: (B)

Q35.

Solution

Concept: Acid-catalyzed dehydration of alcohols forms alkenes. The mechanism depends on the degree of the alcohol:

- 3° and 2° alcohols $\rightarrow$ carbocation formation $\rightarrow$ **E1 mechanism** - 1° alcohols $\rightarrow$ usually E2 mechanism

Solution:

For secondary alcohols:

$$R_2CHOH \xrightarrow{H^+,\Delta} R_2C = CH_2 + H_2O$$

- Proceeds via **carbocation intermediate** $\rightarrow$ E1 mechanism.

$$\boxed{\text{E1 mechanism}}$$

Answer: (A)

Q36.

Solution

Concept: For a carbonyl compound (aldehyde or ketone) to undergo Aldol condensation, it must possess at least one α-hydrogen atom. The α-hydrogen is the hydrogen atom attached to the carbon atom immediately adjacent to the carbonyl group ($> C = O$).

Solution: Let's examine the structure of each option:

- **Acetaldehyde (CH_3CHO):** Has 3 α-hydrogens on the methyl group. (Undergoes Aldol)
- **Acetone (CH_3COCH_3):** Has 6 α-hydrogens (3 on each side). (Undergoes Aldol)
- **Formaldehyde ($HCHO$):** The carbonyl carbon is attached only to two hydrogen atoms. There is no carbon atom adjacent to the carbonyl group; therefore, it has zero α-hydrogens.
- **Propanaldehyde (CH_3CH_2CHO):** Has 2 α-hydrogens on the CH_2 group. (Undergoes Aldol)

Since formaldehyde lacks α-hydrogens, it cannot form an enolate ion and thus cannot undergo Aldol condensation. Instead, it undergoes the Cannizzaro reaction in the presence of a concentrated base.

Answer: (C)

Q37.

Solution

Concept: The Cannizzaro reaction is a chemical reaction that involves the base-induced disproportionation of an aldehyde that lacks an α-hydrogen atom.In this reaction, one molecule of the aldehyde is reduced to a primary alcohol, while another molecule is oxidized to a carboxylic acid salt.

Solution: We evaluate the presence of α-hydrogens in the given options:

- **Benzaldehyde** (C_6H_5CHO)**:** The carbonyl group is attached to a benzene ring carbon that has no hydrogens. Since it has no α-hydrogen, it undergoes the Cannizzaro reaction.
- **Acetaldehyde** (CH_3CHO)**:** Contains 3 α-hydrogens. It undergoes Aldol condensation.
- **Acetone** (CH_3COCH_3)**:** Contains 6 α-hydrogens. It undergoes Aldol condensation.
- **Ethyl methyl ketone** ($CH_3CH_2COCH_3$)**:** Contains 5 α-hydrogens. It undergoes Aldol condensation.

The general reaction for Benzaldehyde is:

$$2C_6H_5CHO + NaOH \rightarrow C_6H_5CH_2OH + C_6H_5COONa$$

Answer: (A)

Q38.

Solution

Concept: The acidity of carboxylic acids is influenced by the Inductive Effect ($-I$ effect) of substituents attached to the carboxyl group.

- Electron-withdrawing groups (like Chlorine) exert a $-I$ effect, which pulls electron density away from the $O - H$ bond.
- This stabilizes the resulting carboxylate anion ($RCOO^-$) after the loss of a proton (H^+).
- As the number of electronegative atoms increases, the $-I$ effect strengthens, making the acid stronger.

Solution: Comparing the given compounds based on the number of chlorine atoms (electron-withdrawing groups):

i. CH_3COOH **(Acetic acid):** No chlorine atoms; the methyl group actually has a slight $+I$ (electron-donating) effect, making it the weakest acid in this list.

ii. $ClCH_2COOH$ **(Chloroacetic acid):** One chlorine atom exerts a $-I$ effect.

iii. $Cl_2CHCOOH$ **(Dichloroacetic acid):** Two chlorine atoms exert a stronger cumulative $-I$ effect.

iv. Cl_3CCOOH **(Trichloroacetic acid):** Three chlorine atoms exert the maximum cumulative $-I$ effect, greatly stabilizing the Cl_3CCOO^- ion.

The acidity order is: $CH_3COOH < ClCH_2COOH < Cl_2CHCOOH < Cl_3CCOOH$. Therefore, Trichloroacetic acid is the strongest.

Answer: (D)

Q39.

Solution

Concept: The reaction involves the nucleophilic addition of a Grignard reagent ($RMgX$) to a carbonyl compound.

- Formaldehyde + Grignard → Primary (1°) alcohol
- Other Aldehydes + Grignard → Secondary (2°) alcohol
- Ketones + Grignard → Tertiary (3°) alcohol

Solution: Propanone (Acetone) is a ketone. When it reacts with Methylmagnesium bromide (CH_3MgBr), the nucleophilic methyl group (CH_3^-) attacks the carbonyl carbon.

i. **Nucleophilic Attack:** The methyl group from CH_3MgBr attacks the central carbon of propanone (CH_3COCH_3), forming an adduct:

$$(CH_3)_2C = O + CH_3MgBr \rightarrow (CH_3)_3C - OMgBr$$

ii. **Hydrolysis:** Adding water (H_2O/H^+) replaces the $-OMgBr$ group with a hydroxyl group ($-OH$):

$$(CH_3)_3C - OMgBr + H_2O \rightarrow (CH_3)_3C - OH + Mg(OH)Br$$

The resulting product is tert-butyl alcohol, which has the IUPAC name 2-Methylpropan-2-ol.

Answer: (A)

Q40.

Solution

Concept: Reducing a carboxylic acid ($R - COOH$) to a primary alcohol ($R - CH_2OH$) requires a very strong reducing agent. The carboxylic acid group is resistant to many common mild reducing agents because the carbonyl carbon is less electrophilic due to resonance stabilization with the hydroxyl group.

Solution: Below is the evaluation of each reagent provided:

- $NaBH_4$ **(Sodium borohydride):** This is a mild reducing agent. While it works well for aldehydes and ketones, it is not strong enough to reduce carboxylic acids.
- $LiAlH_4$ **(Lithium aluminum hydride):** This is a powerful hydride donor. It reacts vigorously with carboxylic acids to reduce them completely to primary alcohols. It is the standard laboratory reagent for this transformation.
- H_2/Ni **(Catalytic hydrogenation):** Generally, catalytic hydrogenation at standard temperatures and pressures does not reduce carboxylic acids. Very high pressures and specialized catalysts are usually required for industrial applications.
- PCC **(Pyridinium chlorochromate):** This is an oxidizing agent. It performs the opposite task—turning a primary alcohol into an aldehyde.

The reaction sequence involves the loss of water and the addition of four hydride equivalents:

$$RCOOH \xrightarrow[2) H_3O^+]{1) LiAlH_4/\text{ether}} RCH_2OH$$

Answer: (B)

Q41.

Solution

Concept: Tollen's reagent is an oxidizing agent used to distinguish between aldehydes and ketones. It is a coordination compound that contains the silver diamine complex $[Ag(NH_3)_2]^+$.

Solution: Let's identify the reagents listed in the options:

- **Ammoniacal silver nitrate:** This is prepared by adding a small amount of sodium hydroxide to silver nitrate followed by enough ammonia solution to dissolve the precipitate. It is Tollen's reagent.
- **Alkaline $CuSO_4$:** When mixed with sodium potassium tartrate (Rochelle salt), this is known as Fehling's solution. It is also used to detect aldehydes.
- **Acidified $K_2Cr_2O_7$:** This is a strong oxidizing agent used to oxidize alcohols to carboxylic acids.
- **$I_2/NaOH$:** This is the reagent used for the Iodoform test, which detects the presence of methyl ketones or alcohols with a $CH_3CH(OH)-$ group.

When an aldehyde is heated with Tollen's reagent, the aldehyde is oxidized to a carboxylate ion, and the Ag^+ ions are reduced to metallic silver, which deposits on the inner wall of the test tube, forming a silver mirror.

$$R-CHO + 2[Ag(NH_3)_2]^+ + 3OH^- \rightarrow R-COO^- + 2Ag\downarrow + 4NH_3 + 2H_2O$$

Answer: (A)

Q42.

Solution

Concept: Basicity in aqueous solution depends on **availability of the lone pair on nitrogen** to accept a proton.
- **Inductive effect:** Alkyl groups donate electron density $\rightarrow$ increase basicity. - **Steric effect:** Bulky groups hinder solvation $\rightarrow$ decrease basicity in water.

Solution:
1. $(CH_3)_3N$ $\rightarrow$ lone pair sterically hindered $\rightarrow$ less solvated $\rightarrow$ basicity decreases in aqueous solution 2. $(CH_3)_2NH$ $\rightarrow$ moderately hindered $\rightarrow$ highest basicity in water 3. CH_3NH_2 $\rightarrow$ less hindered $\rightarrow$ moderate basicity 4. NH_3 $\rightarrow$ least basic

$$\boxed{(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3}$$

Answer: (A)

Q43.

Solution

Concept: The Gabriel Phthalimide Synthesis is a specific chemical reaction used to prepare pure primary amines. It involves the nucleophilic substitution (S_N2) of an alkyl halide by the phthalimide anion.

Solution: The reaction proceeds through the following steps:

i. **Formation of Potassium Phthalimide:** Phthalimide reacts with ethanolic KOH to form a potassium salt.

ii. **Alkylation:** The potassium phthalimide reacts with an alkyl halide (RX) to form N-alkylphthalimide. This step is an S_N2 reaction.

iii. **Hydrolysis:** The N-alkylphthalimide is then hydrolyzed (usually with hydrazine or an alkali) to yield a primary aliphatic amine.

Why not aromatic amines?Aromatic primary amines (like aniline) cannot be prepared by this method because aryl halides (ArX) do not undergo nucleophilic substitution (S_N2) with the phthalimide anion due to the partial double-bond character of the $C - X$ bond and steric hindrance of the benzene ring.

Answer: (B)

Q44.

Solution

Concept: The reaction of a primary aromatic amine with nitrous acid ($NaNO_2 + HCl$) at low temperatures ($0 - 5°C$) is known as Diazotization. Nitrous acid is unstable, so it is prepared in situ by reacting sodium nitrite with hydrochloric acid. **Solution:**When Aniline ($C_6H_5NH_2$) reacts with $NaNO_2$ and HCl at a cold temperature:

- The amino group ($-NH_2$) is converted into a diazonium group ($-N_2^+Cl^-$).
- The low temperature ($0 - 5°C$) is critical because diazonium salts are unstable and decompose at higher temperatures to form phenol and nitrogen gas.

The chemical equation is:

$$C_6H_5NH_2 + NaNO_2 + 2HCl \xrightarrow{273-278\,K} C_6H_5N_2^+Cl^- + NaCl + 2H_2O$$

Benzene diazonium chloride is a very important intermediate in organic chemistry as it can be converted into a variety of other compounds like chlorobenzene, iodobenzene, and phenol through further reactions.

Answer: (B)

Q45.

Solution

Concept: The Hoffmann Bromamide Degradation reaction is used to convert a primary amide into a primary amine with one less carbon atom than the starting amide.The general reaction involves treating a primary amide with bromine (Br_2) in an aqueous or ethanolic solution of sodium hydroxide ($NaOH$).

Solution: Acetamide is a two-carbon amide with the formula CH_3CONH_2.During the degradation process:

i. The carbonyl group ($C = O$) of the amide is removed as a carbonate ion (CO_3^{2-}).

ii. The alkyl group (in this case, the methyl group, $-CH_3$) migrates from the carbonyl carbon to the nitrogen atom.

iii. This results in the formation of Methylamine (CH_3NH_2), which has one carbon atom.

The chemical equation for this specific reaction is:

$$CH_3CONH_2+Br_2+4NaOH \rightarrow CH_3NH_2+Na_2CO_3+2NaBr+2H_2O$$

Since the product must have one fewer carbon than the reactant, Acetamide (2C) produces Methylamine (1C).

Answer: (B)

Q46.

Solution

Concept: A non-reducing sugar is one that does not have a free aldehyde or ketone group capable of acting as a reducing agent. Reducing sugars give a positive Tollens' or Fehling's test.

Solution:

Glucose: Has a free aldehyde group → Reducing sugar. Fructose: Has a free ketone group → Reducing sugar. Maltose: Has a free hemiacetal group at the reducing end → Reducing sugar. Sucrose: The glycosidic bond is between the anomeric carbons of glucose and fructose → No free aldehyde or ketone → Non-reducing sugar.

Result: The non-reducing sugar is sucrose.

Answer: (D)

Q47.

Solution

Concept: Denaturation of proteins involves the unfolding of the protein structure due to disruption of non-covalent interactions (like hydrogen bonds, ionic bonds, hydrophobic interactions, and van der Waals forces). It does not break the peptide bonds, so the primary structure remains intact.

Solution:

Primary structure: Sequence of amino acids linked by peptide bonds → remains unchanged. Secondary structure: -helix and -pleated sheets stabilized by hydrogen bonds → disrupted. Tertiary structure: Overall 3D folding stabilized by various interactions → disrupted. Quaternary structure (if present): Subunit interactions → disrupted.

Result: Denaturation affects secondary and tertiary structures, but not the primary sequence.

Answer: (B)

Q48.

Solution

Concept: Vitamins are classified as fat-soluble or water-soluble: Fat-soluble vitamins: A, D, E, K $\rightarrow$ stored in fat and liver, soluble in organic solvents. Water-soluble vitamins: C and B-complex $\rightarrow$ dissolve in water, excreted in urine, not stored in large amounts.

Solution:

Vitamin A: Fat-soluble Vitamin D: Fat-soluble Vitamin C: Water-soluble Vitamin K: Fat-soluble

Result: The water-soluble vitamin is Vitamin C.

Answer: (C)

Q49.

Solution

Concept: DNA is a double-stranded helix where the two strands are complementary. The bases on opposite strands form specific pairs: adenine (A) with thymine (T) and guanine (G) with cytosine (C). These base pairs are stabilized by hydrogen bonds.

A–T pair: 2 hydrogen bonds G–C pair: 3 hydrogen bonds

Other bonds in DNA:

Phosphodiester bonds: Link sugars and phosphates along the backbone of each strand. Glycosidic bonds: Link each base to its sugar. Peptide bonds: Found in proteins, not DNA.

Result: The two strands of DNA are held together by hydrogen bonds.

Answer: (C)

Q50.

Solution

Concept: Vitamin 12 B 12
(Cobalamin) is essential for red blood cell formation and nervous system function. Its deficiency leads to pernicious anemia, a condition characterized by the production of abnormally large and immature red blood cells (megaloblastic anemia).

Solution:
Scurvy: Caused by Vitamin C deficiency. Rickets: Caused by Vitamin D deficiency. Pernicious anemia: Caused by Vitamin 12 B 12 deficiency. Night blindness: Caused by Vitamin A deficiency.

Result: Deficiency of Vitamin 12 B 12
causes pernicious anemia.

Answer: (C)

Answer Key

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