CUET UG Chemistry Sample Paper - 20

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 units is independent of temperature?

(A) Molarity
(B) Normality
(C) Molality
(D) Formality

Q2. The value of Henry's constant K_H is:

(A) Greater for gases with higher solubility
(B) Greater for gases with lower solubility
(C) Constant for all gases
(D) Not related to the solubility of gases

Q3. An azeotropic mixture of two liquids has a boiling point lower than either of them when it:

(A) Shows negative deviation from Raoult's Law
(B) Shows positive deviation from Raoult's Law
(C) Shows no deviation from Raoult's Law
(D) Is saturated

Q4. The osmotic pressure of a solution can be increased by:

(A) Increasing the volume

(B) Increasing the temperature

(C) Decreasing the number of solute molecules

(D) None of these

Q5. At a given temperature, which of the following will have the same osmotic pressure as 0.1 M glucose?

(A) 0.1 M $NaCl$

(B) 0.05 M $MgCl_2$

(C) 0.1 M Urea

(D) 0.1 M $Al_2(SO_4)_3$

Q6. The cell constant of a conductivity cell:

(A) Changes with the change of electrolyte

(B) Changes with change of concentration of electrolyte

(C) Changes with temperature

(D) Remains constant for a given cell

Q7. In the electrolysis of molten $NaCl$, the product obtained at the cathode is:

(A) Silver

(B) Chlorine

(C) Sodium

(D) Oxygen

Q8. Which equation represents the variation of molar conductivity with concentration for a strong electrolyte?

(A) Kohlrausch Law
(B) Debye-Huckel-Onsager Equation
(C) Nernst Equation
(D) Faraday's Law

Q9. The standard reduction potentials of three metals A, B, and C are +0.5 V, -3.0 V, and -1.2 V respectively. The reducing power of these metals is:

(A) A > B > C
(B) B > C > A
(C) C > B > A
(D) A > C > B

Q10. A device that converts the energy of combustion of fuels like hydrogen and methane directly into electrical energy is known as:

(A) Electrolytic cell
(B) Dynamo
(C) Ni-Cd cell
(D) Fuel cell

Q11. How many Coulombs are required to reduce 1 mole of MnO_4^- to Mn^{2+}?

(A) 96500 C
(B) 193000 C
(C) 482500 C
(D) 289500 C

Q12. A first-order reaction is 50% completed in 20 minutes. How much time will it take for 75% completion?

(A) 30 min

(B) 40 min

(C) 60 min

(D) 80 min

Q13. The rate constant of a reaction depends on:

(A) Time

(B) Activation Energy

(C) Concentration

(D) Temperature

Q14. For a zero-order reaction, the plot of $[A]$ vs time (t) gives a slope equal to:

(A) k

(B) $-k$

(C) $k/2.303$

(D) $-k/2.303$

Q15. The role of a catalyst is to change:

(A) Gibbs energy of reaction

(B) Enthalpy of reaction

(C) Activation energy of reaction

(D) Equilibrium constant

Q16. The molecularity of a reaction:

- (A) Can be zero
- (B) Can be a fraction
- (C) Cannot be greater than three
- (D) Is always equal to the order

Q17. Which of the following transition metal ions is colorless in aqueous solution?

- (A) Ti^{4+}
- (B) V^{4+}
- (C) Cu^{2+}
- (D) Fe^{3+}

Q18. The catalytic activity of transition metals is due to their ability to adopt:

- (A) Fixed oxidation states
- (B) Variable oxidation states
- (C) Magnetic properties
- (D) High melting points

Q19. $K_2Cr_2O_7$ acts as a strong oxidizing agent in:

- (A) Alkaline medium
- (B) Neutral medium
- (C) Acidic medium
- (D) All of these

Q20. The element with the electronic configuration $[Xe]\,4f^7\,5d^1\,6s^2$ is:

(A) Gd

(B) Eu

(C) Tb

(D) Lu

Q21. The coordination number of Co in $[Co(en)_3]^{3+}$ is:

(A) 3

(B) 4

(C) 6

(D) 2

Q22. Which of the following is an outer orbital complex?

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

(B) $[Mn(CN)_6]^{4-}$

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

(D) $[Fe(CN)_6]^{4-}$

Q23. Facial (fac) and Meridional (mer) isomerism is associated with which general formula?

(A) $[MA_4B_2]$

(B) $[MA_3B_3]$

(C) $[MA_2B_4]$

(D) $[M(AA)_3]$

Q24. The crystal field stabilization energy (CFSE) for high spin d^4 octahedral complex is:

(A) $-0.6\Delta_o$

(B) $-1.8\Delta_o$

(C) $-1.6\Delta_o + P$

(D) $-0.4\Delta_o$

Q25. In $[Ni(CO)_4]$, the oxidation state of Nickel is:

(A) 0

(B) +2

(C) +4

(D) -2

Q26. Which complex is used as an anti-cancer agent?

(A) $[Pt(NH_3)_2Cl_2]$ (cis-platin)

(B) $[TiCl_4]$

(C) $[Fe(EDTA)]$

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

Q27. Chirality is shown by:

(A) 2-chlorobutane

(B) 1-chlorobutane

(C) 2-chloropropane

(D) Isopropyl chloride

Q28. Reaction of ethyl chloride with aqueous KOH gives:

(A) Ethene

(B) Ethanol

(C) Ethane

(D) Ethyl alcohol and Ethene

Q29. Chlorobenzene is prepared commercially by:

(A) Raschig process

(B) Wurtz-Fittig reaction

(C) Friedel-Crafts reaction

(D) Deacon's process

Q30. The reaction $2C_6H_5Cl + 2Na \xrightarrow{ether} C_6H_5{-}C_6H_5 + 2NaCl$ is:

(A) Wurtz reaction

(B) Fittig reaction

(C) Wurtz-Fittig reaction

(D) Sandmeyer reaction

Q31. Aspirin is obtained by the reaction of salicylic acid with:

(A) Methanol

(B) Acetic anhydride

(C) Ethanol

(D) Ethylene glycol

Q32. Phenol reacts with Zn dust to give:

(A) Benzene

(B) Toluene

(C) Benzaldehyde

(D) Zinc phenoxide

Q33. Ortho-nitrophenol is less soluble in water than Para-nitrophenol because:

(A) Ortho-isomer has intermolecular H-bonding

(B) Ortho-isomer has intramolecular H-bonding

(C) Para-isomer has intramolecular H-bonding

(D) None of these

Q34. Which alcohol reacts fastest with conc. HCl and $ZnCl_2$?

(A) Butan-1-ol

(B) Butan-2-ol

(C) 2-methylpropan-2-ol

(D) Propan-1-ol

Q35. The product of the reaction between $CH_3CH_2OCH_3$ and HI is:

(A) $CH_3CH_2I + CH_3OH$

(B) $CH_3CH_2OH + CH_3I$

(C) $CH_3CH_2I + CH_3I$

(D) $C_2H_6 + CH_3I$

Q36. The formation of cyanohydrin from a ketone is an example of:

(A) Nucleophilic substitution

(B) Nucleophilic addition

(C) Electrophilic addition

(D) Electrophilic substitution

Q37. Which acid is strongest?

(A) $ClCH_2COOH$

(B) $Cl_2CHCOOH$

(C) Cl_3CCOOH

(D) CH_3COOH

Q38. Hell-Volhard-Zelinsky (HVZ) reaction is used for:

(A) Oxidation of aldehydes

(B) Halogenation of α-carbon of carboxylic acids

(C) Decarboxylation

(D) Esterification

Q39. Propanone and Propanal can be distinguished by:

(A) Tollen's reagent

(B) Fehling's solution

(C) Iodoform test

(D) All of these

Q40. Wolff-Kishner reduction reduces the carbonyl group to:

(A) $-CH_2OH$

(B) $-CH_2-$

(C) $-CHO$

(D) $-COOH$

Q41. Etard reaction involves the oxidation of toluene to benzaldehyde using:

(A) CrO_2Cl_2

(B) $KMnO_4$

(C) H_2/Pd

(D) $LiAlH_4$

Q42. Aniline on treatment with $NaNO_2/HCl$ at 0–5°C gives:

(A) Nitrobenzene

(B) Benzene diazonium chloride

(C) Phenol

(D) Chlorobenzene

Q43. Hoffmann bromamide degradation reaction converts:

(A) Amide to amine with same carbons

(B) Amide to amine with one less carbon

(C) Amine to amide

(D) Cyanide to amine

Q44. Which of the following is most basic in the gaseous phase?

(A) NH_3

(B) CH_3NH_2

(C) $(CH_3)_2NH$

(D) $(CH_3)_3N$

Q45. Reduction of nitrobenzene with Sn/HCl gives:

(A) Aniline

(B) Azobenzene

(C) Nitrosobenzene

(D) Hydrazobenzene

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

(A) Maltose

(B) Lactose

(C) Sucrose

(D) Glucose

Q47. The vitamin whose deficiency causes Night Blindness is:

(A) Vitamin B

(B) Vitamin C

(C) Vitamin K

(D) Vitamin A

Q48. Zwitterion is formed by:

(A) Glucose
(B) Amino acids
(C) Fatty acids
(D) Nucleotides

Q49. Denaturation of protein leads to loss of:

(A) Primary structure
(B) Secondary and tertiary structure
(C) Peptide bonds
(D) Amino acid sequence

Q50. In a DNA molecule, Cytosine pairs with Guanine through:

(A) One H-bond
(B) Two H-bonds
(C) Three H-bonds
(D) Ionic bond

Detailed Solutions

Q1.

Solution

Concept: Concentration terms based on *volume* change with temperature because volume expands or contracts. Terms based on *mass* remain unaffected by temperature. Molality is defined as moles of solute per kg of solvent (mass-based), hence it is independent of temperature.

Solution:

- Molarity (M) = moles of solute / volume of solution $\Rightarrow$ depends on temperature
- Normality (N) = equivalents / volume of solution $\Rightarrow$ depends on temperature
- Formality = formula mass units / volume of solution $\Rightarrow$ depends on temperature
- Molality (m) = moles of solute / mass of solvent $\Rightarrow$ independent of temperature

Thus, the correct answer is:

$$\boxed{\text{Molality}}$$

Answer: (C)

Q2.

Solution

Concept: Henry's law states that solubility of a gas is inversely proportional to Henry's constant:

$$p = K_H x$$

Higher $K_H \Rightarrow$ lower solubility.

Solution:

Thus, gases with lower solubility have higher Henry's constant.

$$\boxed{\text{Greater for gases with lower solubility}}$$

Answer: (B)

Q3.

Solution

Concept: Azeotropes with lower boiling point show **positive deviation** from Raoult's Law due to weaker intermolecular forces, leading to higher vapour pressure.

Solution:

Thus, such mixtures boil at lower temperature than either component.

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

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

Q4.

Solution

Concept: Osmotic pressure is given by:

$$\pi = CRT$$

It increases with temperature and concentration.

Solution:

- Increasing volume $\Rightarrow$ decreases concentration $\Rightarrow$ decreases π
- Increasing temperature $\Rightarrow$ increases π
- Decreasing solute particles $\Rightarrow$ decreases π

$$\boxed{\text{Increasing the temperature}}$$

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

Q5.

Solution

Concept: Osmotic pressure depends on number of particles:

$$\pi = iCRT$$

where i is van't Hoff factor.

Solution:

For same osmotic pressure:

$$iC = \text{constant}$$

- Glucose: $i = 1 \Rightarrow iC = 0.1$
- NaCl: $i \approx 2 \Rightarrow iC = 0.2$
- $MgCl_2$: $i \approx 3 \Rightarrow iC = 0.15$
- Urea: $i = 1 \Rightarrow iC = 0.1$
- $Al_2(SO_4)_3$: $i \approx 5 \Rightarrow iC = 0.5$

Thus, urea has same osmotic pressure as glucose.

$$\boxed{\text{0.1 M Urea}}$$

Answer: (C)

Q6.

Solution

Concept: Cell constant depends only on the geometry of the conductivity cell:

$$\text{Cell constant} = \frac{l}{A}$$

where l = distance between electrodes and A = area of cross-section. It is independent of electrolyte, concentration, and temperature for a given cell.

Solution:

Thus, for a given conductivity cell, the cell constant remains fixed.

$$\boxed{\text{Remains constant for a given cell}}$$

Answer: (D)

Q7.

Solution

Concept: In electrolysis of molten NaCl:

- At cathode: reduction occurs
- $Na^+ + e^- \longrightarrow Na$ (metal)

Solution:
Thus, sodium metal is deposited at the cathode.

$$\boxed{\text{Sodium}}$$

Answer: (C)

Q8.

Solution

Concept: For strong electrolytes, molar conductivity varies with concentration according to the Debye-Hückel-Onsager equation:

$$\Lambda_m = \Lambda_m^0 - A\sqrt{C}$$

Solution:
Thus, the correct relation describing variation is given by Debye-Hückel-Onsager equation.

$$\boxed{\text{Debye-Hückel-Onsager Equation}}$$

Answer: (B)

Q9.

Solution

Concept: The more negative the standard reduction potential (E°), the stronger is the reducing agent.
Solution:
Given:

$$A = +0.5\text{ V}, \quad B = -3.0\text{ V}, \quad C = -1.2\text{ V}$$

Order of reducing power:

$$B > C > A$$

$$\boxed{B > C > A}$$

Answer: (B)

Q10.

Solution

Concept: A fuel cell converts chemical energy of fuels directly into electrical energy through redox reactions.

Solution:

Thus, the correct device is:

$$\boxed{\text{Fuel cell}}$$

Answer: (D)

Q11.

Solution

Concept: Charge required:

$$Q = n \times F$$

where n = number of electrons and $F = 96500$ C mol^{-1}.

Reduction:

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

Oxidation state change:

$$+7 \rightarrow +2 \Rightarrow 5 \text{ electrons}$$

Solution:

$$Q = 5 \times 96500 = 482500 \text{ C}$$

$$\boxed{482500 \text{ C}}$$

Answer: (C)

Q12.

Solution

Concept: For a first-order reaction, the half-life ($t_{1/2}$) is independent of the initial concentration. The time required for 75% completion ($t_{75\%}$) is exactly twice the half-life ($t_{50\%}$) because 75% completion means the concentration has halved twice (from 100% to 50%, then 50% to 25%).

Solution: Given that the reaction is 50% complete in 20 minutes:

$$t_{1/2} = 20 \text{ min}$$

The relation between time and concentration for a first-order reaction is:

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

For 75% completion, the remaining concentration is $[A]_t = [A]_0 - 0.75[A]_0 = 0.25[A]_0$.

$$t_{75\%} = \frac{2.303}{k} \log \frac{[A]_0}{0.25[A]_0} = \frac{2.303}{k} \log 4$$

$$t_{75\%} = \frac{2.303}{k} \log(2^2) = 2 \times \left(\frac{2.303}{k} \log 2\right)$$

Since $t_{50\%} = \frac{2.303 \log 2}{k}$:

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

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

Answer: (B)

Q13.

Solution

Concept: The dependence of the rate constant (k) on various factors is given by the Arrhenius equation:

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

Where: - A is the pre-exponential factor. - E_a is the activation energy. - R is the universal gas constant. - T is the absolute temperature.

Solution: Based on the Arrhenius equation, the rate constant k is a function of: 1. **Temperature (T):** As T increases, the value of k increases exponentially. 2. **Activation Energy (E_a):** A change in E_a (e.g., by adding a catalyst) changes the value of k.

The rate constant is *independent* of the concentration of reactants and the time of the reaction. In most standard contexts, temperature is the most significant variable that modifies the rate constant for a specific reaction.

Thus, the most appropriate choice is both B and D, but usually D is the preferred answer in single-choice formats.

Answer: (D)

Q14.

Solution

Concept: For a zero-order reaction, the rate is independent of concentration. The differential rate equation is:

$$-\frac{d[A]}{dt} = k$$

Integrating this from $t = 0$ to $t = t$ gives the integrated rate law:

$$[A]_t = [A]_0 - kt$$

Solution: Comparing the integrated rate law $[A]_t = -kt + [A]_0$ with the equation of a straight line ($y = mx + c$):

- $y = [A]_t$
- $x = t$
- $m(\text{slope}) = -k$
- $c(\text{intercept}) = [A]_0$

Thus, a plot of concentration $[A]$ versus time t for a zero-order reaction results in a straight line with a slope equal to $-k$.

Answer: (B)

Q15.

Solution

Concept: A catalyst increases the rate of a chemical reaction by providing an alternative pathway with a lower activation energy (E_a). It does not affect the energy of reactants or products.

Solution: Thermodynamically, a catalyst has the following effects:

- It **lowers the activation energy** (E_a) for both forward and backward reactions.
- It **does not change** the Enthalpy of reaction (ΔH).
- It **does not change** the Gibbs free energy (ΔG).
- It **does not change** the Equilibrium constant (K_{eq}), though it helps reach equilibrium faster.

Since the catalyst directly modifies the energy barrier that reactants must overcome to form products:

$$E_{a,\text{catalyzed}} < E_{a,\text{uncatalyzed}}$$

Answer: (C)

Q16.

Solution

Concept: Molecularity is the number of reacting species taking part in an elementary reaction, which must collide simultaneously in order to bring about a chemical reaction.

- It is always a whole number (1, 2, or 3).
- It cannot be zero or a fraction.
- It is a theoretical property applicable only to elementary reactions.

Solution: Molecularity represents the number of molecules colliding at once. The simultaneous collision of more than three molecules is very rare and statistically improbable. Thus:

- **A & B:** Incorrect, as molecularity must be a positive integer.
- **D:** Incorrect, as the order of a reaction is experimental and can differ from molecularity (especially in complex reactions).
- **C:** Correct, because the chance of more than three molecules colliding simultaneously with proper orientation is nearly zero.

Answer: (C)

Q17.

Solution

Concept: Color in transition metal ions arises due to d-d electronic transitions. If the d-orbitals are either completely filled (d^{10}) or empty (d^0), no d-d transitions occur, and the ion is colorless.
Solution:

- Ti^{4+}: $3d^0 \Rightarrow$ no d electrons $\Rightarrow$ colorless
- V^{4+}: $3d^1 \Rightarrow$ colored
- Cu^{2+}: $3d^9 \Rightarrow$ colored
- Fe^{3+}: $3d^5 \Rightarrow$ colored

Thus, the colorless ion is:

$$\boxed{Ti^{4+}}$$

Answer: (A)

Q18.

Solution

Concept: Transition metals show catalytic activity mainly due to their ability to exist in *variable oxidation states*. This allows them to form intermediate compounds and facilitate different reaction pathways.

Solution:

- Fixed oxidation states ⇒ no flexibility in reactions
- Variable oxidation states ⇒ formation of intermediates ⇒ catalysis
- Magnetic properties and high melting points are not the primary reasons

Thus, the correct answer is:

$$\boxed{\text{Variable oxidation states}}$$

Answer: (B)

Q19.

Solution

Concept: $K_2Cr_2O_7$ is a strong oxidizing agent in *acidic medium* because it gets reduced from Cr^{6+} to Cr^{3+} more readily in the presence of H^+ ions.

Solution:

In acidic medium:

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$$

Thus, its oxidizing power is maximum in acidic conditions.

$$\boxed{\text{Acidic medium}}$$

Answer: (C)

Q20.

Solution

Concept: In lanthanoids, the general electronic configuration is:

$$[Xe]\ 4f^n\ 5d^{0-1}\ 6s^2$$

Extra stability is observed for half-filled $(4f^7)$ and fully filled $(4f^{14})$ subshells.

Solution:

Given configuration:

$$[Xe]\ 4f^7\ 5d^1\ 6s^2$$

This corresponds to **Gadolinium (Gd)**, which shows a half-filled $4f^7$ configuration along with one electron in $5d$.

$$\boxed{\text{Gadolinium (Gd)}}$$

Answer: (A)

Q21.

Solution

Concept: Coordination number is the number of donor atoms directly bonded to the central metal ion. Ethylenediamine (en) is a *bidentate ligand*, meaning each en ligand donates two lone pairs.

Solution:

In $[Co(en)_3]^{3+}$:

- Each en ligand → 2 donor atoms
- Total ligands = 3

$$\text{Coordination number} = 3 \times 2 = 6$$

$$\boxed{6}$$

Answer: (C)

Q22.

Solution

Concept: Outer orbital complexes use *outer* d-orbitals (i.e., *nd* orbitals) and generally form with *weak field ligands*, leading to high-spin complexes. Inner orbital complexes use $(n-1)d$ orbitals and are formed with strong field ligands.

Solution:

- $[Co(NH_3)_6]^{3+}$: NH_3 is a strong field ligand ⇒ inner orbital
- $[Mn(CN)_6]^{4-}$: CN^- is strong field ⇒ inner orbital
- $[CoF_6]^{3-}$: F^- is weak field ⇒ outer orbital (high spin)
- $[Fe(CN)_6]^{4-}$: CN^- is strong field ⇒ inner orbital

Thus, the outer orbital complex is:

$$\boxed{[CoF_6]^{3-}}$$

Answer: (C)

Q23.

Solution

Concept: Facial (fac) and meridional (mer) isomerism occurs in octahedral complexes of the type $[MA_3B_3]$. In fac-isomer, three identical ligands occupy one face of the octahedron, while in mer-isomer, they lie in a meridian plane.

Solution:

- $[MA_4B_2]$ ⇒ shows geometrical (cis-trans) isomerism
- $[MA_3B_3]$ ⇒ shows fac-mer isomerism
- $[MA_2B_4]$ ⇒ shows geometrical isomerism
- $[M(AA)_3]$ ⇒ shows optical isomerism

Thus, the correct answer is:

$$\boxed{[MA_3B_3]}$$

Answer: (B)

Q24.

Solution

Concept: In an octahedral field:

- Each electron in t_{2g} contributes $-0.4\Delta_o$
- Each electron in e_g contributes $+0.6\Delta_o$

For a **high spin** d^4 complex:

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

Solution:

$$\text{CFSE} = (3 \times -0.4\Delta_o) + (1 \times +0.6\Delta_o)$$

$$= -1.2\Delta_o + 0.6\Delta_o = -0.6\Delta_o$$

$$\boxed{-0.6\Delta_o}$$

Answer: (A)

Q25.

Solution

Concept: Carbon monoxide (CO) is a neutral ligand. The overall charge on the complex is zero, so the oxidation state of the metal is equal to the overall charge.

Solution:

For $[Ni(CO)_4]$:

- CO is neutral ⇒ contributes 0 charge
- Overall charge on complex = 0

Let oxidation state of Ni = x

$$x + 4(0) = 0 \Rightarrow x = 0$$

$$\boxed{0}$$

Answer: (A)

Q26.

Solution

Concept: Coordination compounds play vital roles in biological systems and medicine. The geometry and isomerism of these complexes are crucial for their biological activity.

Solution: Cisplatin, or *cis*-diamminedichloroplatinum(II), is a well-known chemotherapy drug. Its formula is:

$$[Pt(NH_3)_2Cl_2]$$

In this complex, the two chloride ions and two ammonia molecules are adjacent to each other in a square planar arrangement around the central platinum(II) ion.

- **Action:** It binds to DNA, creating cross-links that interfere with cell division, eventually killing the cancer cells.
- **Stereochemistry:** Only the *cis* isomer is effective; the *trans* isomer is therapeutically inactive.

Other options:

- $[TiCl_4]$ is a component of Ziegler-Natta catalysts.
- $[Fe(EDTA)]$ is used for removing lead from the body or treating iron deficiency.
- $[Co(NH_3)_6]Cl_3$ is a standard coordination complex used for structural studies.

Answer: (A)

Q27.

Solution

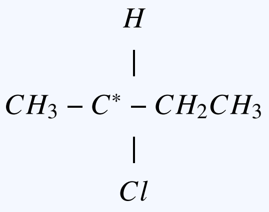
Concept: A molecule is chiral if it contains a chiral center, which is an atom (usually carbon) bonded to four different atoms or groups. Such molecules lack a plane of symmetry and are non-superimposable on their mirror images.

Solution: Let us examine the structures of the given compounds:

(a) **1-chlorobutane:** $CH_3CH_2CH_2CH_2Cl$. No carbon is bonded to four different groups.

(b) **2-chloropropane / Isopropyl chloride:** $CH_3 - CHCl - CH_3$. The central carbon is bonded to two identical methyl groups, making it achiral.

(c) **2-chlorobutane:** The structure is:



$$\begin{array}{c} H \\ | \\ CH_3 - C^* - CH_2CH_3 \\ | \\ Cl \end{array}$$

The C^* carbon is bonded to four distinct groups: $-H$, $-Cl$, $-CH_3$, and $-C_2H_5$.

Therefore, 2-chlorobutane possesses a chiral center and exhibits chirality.

Answer: (A)

Q28.

Solution

Concept: The reaction of alkyl halides with KOH depends on the solvent:

- **Aqueous KOH:** Favors *Nucleophilic Substitution* (S_N2) to form alcohols.
- **Alcoholic KOH:** Favors *Elimination* (β-elimination) to form alkenes.

Solution: When ethyl chloride (CH_3CH_2Cl) reacts with aqueous KOH, the OH^- ion acts as a nucleophile and replaces the chlorine atom:

$$CH_3CH_2Cl + KOH(aq) \rightarrow CH_3CH_2OH + KCl$$

The product formed is ethanol (ethyl alcohol).
In contrast, if alcoholic KOH were used, the reaction would be:

$$CH_3CH_2Cl + KOH(alc) \rightarrow CH_2 = CH_2 + KCl + H_2O$$

Since the question specifies *aqueous* KOH, the reaction is a substitution.

Answer: (B)

Q29.

Solution

Concept: The commercial production of chlorobenzene often utilizes the Raschig process, which is an oxychlorination method. This process is economically viable because it uses HCl and air instead of more expensive Cl_2 gas.

Solution: In the Raschig process, benzene is treated with a mixture of hydrogen chloride gas and air (oxygen) in the presence of a catalyst like $CuCl_2$ or $FeCl_3$ at a temperature of approximately $250°C$.

The chemical equation is:

$$2C_6H_6 + 2HCl + O_2 \xrightarrow{\Delta,\text{catalyst}} 2C_6H_5Cl + 2H_2O$$

Distinction from other options:

- **Wurtz-Fittig reaction:** Used for preparing alkyl benzenes.
- **Friedel-Crafts reaction:** Used for alkylation or acylation of benzene.
- **Deacon's process:** Used for the manufacture of chlorine gas (Cl_2).

Answer: (A)

Q30.

Solution

Concept: The coupling of halides using sodium metal in dry ether is classified based on the nature of the organic groups involved:

- **Wurtz Reaction:** $2R - X + 2Na \rightarrow R - R + 2NaX$ (Alkyl halides)
- **Fittig Reaction:** $2Ar - X + 2Na \rightarrow Ar - Ar + 2NaX$ (Aryl halides)
- **Wurtz-Fittig Reaction:** $R - X + Ar - X + 2Na \rightarrow Ar - R + 2NaX$ (Mixed)

Solution: In the given reaction:

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

Chlorobenzene (C_6H_5Cl) is an aryl halide. Two aryl groups are being coupled to form biphenyl. According to the definitions above, this specific coupling of two aryl halides is known as the Fittig reaction.

Answer: (B)

Q31.

Solution

Concept: Aspirin is the common name for acetylsalicylic acid. It is prepared by the acetylation of salicylic acid (2-hydroxybenzoic acid) using an acetylating agent such as acetic anhydride or acetyl chloride in the presence of an acid catalyst.

Solution: The chemical reaction for the synthesis of aspirin is as follows:

$$C_6H_4(OH)COOH + (CH_3CO)_2O \xrightarrow{H^+} C_6H_4(OCOCH_3)COOH + CH_3COOH$$

In this reaction:

- Salicylic acid provides the aromatic framework.
- **Acetic anhydride** acts as the source of the acetyl group ($-COCH_3$).
- The phenolic $-OH$ group of salicylic acid is converted into an ester group.

Reaction with methanol (Option A) would yield methyl salicylate, while reaction with ethanol (Option C) would yield ethyl salicylate.

Answer: (B)

Q32.

Solution

Concept: Phenol undergoes reduction when heated with zinc dust. Zinc acts as a reducing agent, removing the oxygen from the phenolic hydroxyl group.

Solution: The chemical reaction between phenol and zinc dust is as follows:

$$C_6H_5OH + Zn \xrightarrow{\text{heat}} C_6H_6 + ZnO$$

In this process:

- The hydroxyl group ($-OH$) of phenol is reduced to a hydrogen atom.
- Zinc (Zn) is oxidized to zinc oxide (ZnO).
- The resulting organic product is benzene (C_6H_6).

Other options like toluene ($C_6H_5CH_3$) or benzaldehyde (C_6H_5CHO) require different reagents or carbon-addition steps. Zinc phenoxide is an intermediate in some reactions but is not the final product when heating with zinc dust.

Answer: (A)

Q33.

Solution

Concept: Solubility in water for phenols is largely determined by the ability of the molecule to form hydrogen bonds with water molecules.

- **Intramolecular H-bonding:** Occurs within a single molecule.
- **Intermolecular H-bonding:** Occurs between different molecules (or between a molecule and solvent).

Solution: In *ortho*-nitrophenol, the $-OH$ and $-NO_2$ groups are positioned close to each other, resulting in **intramolecular hydrogen bonding**. This forms a stable five or six-membered ring structure (chelation), which prevents the $-OH$ group from forming hydrogen bonds with water molecules.
In *para*-nitrophenol, the groups are far apart, leading to **intermolecular hydrogen bonding** with water molecules.

$$\text{Solubility: } para > ortho$$

Therefore, *ortho*-nitrophenol is less soluble because its hydrogen bonding is internal.

Answer: (B)

Q34.

Solution

Concept: The reaction of alcohols with concentrated HCl and $ZnCl_2$ (Lucas reagent) proceeds via an S_N1 mechanism. The rate of reaction depends on the stability of the intermediate carbocation formed:

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

Tertiary alcohols react immediately, while primary alcohols require heating.
Solution: Classifying the given alcohols based on the carbon atom attached to the $-OH$ group:

- **Butan-1-ol:** $CH_3CH_2CH_2CH_2OH$ (Primary, 1°)
- **Butan-2-ol:** $CH_3CH(OH)CH_2CH_3$ (Secondary, 2°)
- **2-methylpropan-2-ol:** $(CH_3)_3COH$ (Tertiary, 3°)
- **Propan-1-ol:** $CH_3CH_2CH_2OH$ (Primary, 1°)

Since 2-methylpropan-2-ol is a tertiary alcohol, it forms a stable tertiary carbocation and reacts fastest with conc. HCl and $ZnCl_2$.

Answer: (C)

Q35.

Solution

Concept: The cleavage of unsymmetrical ethers by HI involves the protonation of the ether oxygen followed by a nucleophilic attack by the I^- ion.

- If the alkyl groups are primary or secondary, the reaction follows an S_N2 mechanism.
- The I^- ion attacks the smaller (less sterically hindered) alkyl group.

Solution: In the reaction of ethyl methyl ether ($CH_3CH_2OCH_3$) with HI: 1. The ether is protonated: $[CH_3CH_2-\text{O}^+(H)-CH_3]$. 2. The I^- ion attacks the smaller methyl group rather than the bulkier ethyl group. 3. This results in the formation of methyl iodide and ethanol.

$$CH_3CH_2OCH_3 + HI \rightarrow CH_3CH_2OH + CH_3I$$

If one of the alkyl groups were tertiary (e.g., *tert*-butyl), the reaction would follow an S_N1 mechanism, and the iodide would attach to the tertiary group. However, since both groups here are primary, steric hindrance dictates the outcome.

Answer: (B)

Q36.

Solution

Concept: Carbonyl compounds (aldehydes and ketones) undergo nucleophilic addition reactions due to the polar nature of the carbonyl group ($> C^{\delta+} = O^{\delta-}$). The carbon atom is electrophilic and susceptible to attack by nucleophiles.

Solution: In the formation of cyanohydrin, the nucleophile (CN^-) attacks the carbonyl carbon:

$$R_2C = O + CN^- \rightarrow R_2C(CN)O^-$$

The intermediate then picks up a proton (H^+) from the medium (usually HCN or water) to yield the cyanohydrin:

$$R_2C(CN)O^- + H^+ \rightarrow R_2C(OH)CN$$

Since the rate-determining step involves the attack of a nucleophile and the overall result is the addition of HCN across the $C = O$ double bond, the reaction is classified as **nucleophilic addition**.

Answer: (B)

Q37.

Solution

Concept: The acidity of carboxylic acids is enhanced by the presence of electron-withdrawing groups (EWGs) via the inductive effect ($-I$ effect). These groups stabilize the conjugate base (carboxylate ion) by dispersing the negative charge.

$$\text{Acidity} \propto -I \text{ effect of the substituent}$$

Solution: Comparing the given compounds:

(a) CH_3COOH: No $-I$ groups; methyl group has a $+I$ effect.

(b) $ClCH_2COOH$: One chlorine atom exerting a $-I$ effect.

(c) $Cl_2CHCOOH$: Two chlorine atoms exerting a stronger cumulative $-I$ effect.

(d) Cl_3CCOOH: Three chlorine atoms exerting the maximum cumulative $-I$ effect.

As the number of electronegative chlorine atoms on the α-carbon increases, the carboxylate ion becomes increasingly stabilized, and the $O-H$ bond becomes more polarized, making it easier to release a proton. Thus, the order of acidity is:

$$Cl_3CCOOH > Cl_2CHCOOH > ClCH_2COOH > CH_3COOH$$

Answer: (C)

Q38.

Solution

Concept: The Hell-Volhard-Zelinsky (HVZ) reaction is used to replace an α-hydrogen of a carboxylic acid with a halogen atom (chlorine or bromine).

$$R-CH_2-COOH \xrightarrow[\text{(ii) } H_2O]{\text{(i) } X_2/\text{Red } P} R-CH(X)-COOH$$

Where $X = Cl, Br$.

Solution: For the reaction to occur, the carboxylic acid must possess at least one α-hydrogen atom. The red phosphorus reacts with the halogen to form PX_3, which facilitates the formation of an enolizable acid halide intermediate.

- **Option A:** Oxidation of aldehydes usually produces carboxylic acids but is not the HVZ reaction.
- **Option B:** Describes the specific utility of the HVZ reaction: halogenation at the α-carbon.
- **Option C:** Decarboxylation removes the carboxyl group entirely.
- **Option D:** Esterification involves the formation of an ester from an acid and an alcohol.

Thus, HVZ is strictly for α-halogenation of carboxylic acids.

Answer: (B)

Q39.

Solution

Concept: Aldehydes and ketones show different reactivity towards mild oxidizing agents and specific structural reagents.

- **Tollen's and Fehling's:** React with aldehydes but not ketones.
- **Iodoform Test:** Reacts with compounds containing the CH_3CO- group or $CH_3CH(OH)-$ group.

Solution: Let us evaluate the reagents for Propanal (CH_3CH_2CHO) and Propanone (CH_3COCH_3):

(a) **Tollen's Reagent:** Propanal (aldehyde) gives a silver mirror; Propanone (ketone) does not. This distinguishes them.

(b) **Fehling's Solution:** Propanal (aliphatic aldehyde) gives a red precipitate; Propanone does not. This distinguishes them.

(c) **Iodoform Test:** Propanone contains a methyl keto group ($CH_3 - CO-$) and gives a yellow precipitate of CHI_3. Propanal does not have this group and fails the test. This also distinguishes them.

Since all three methods can be used to tell the two compounds apart, the correct choice is D.

Answer: (D)

Q40.

Solution

Concept: The Wolff-Kishner reduction is a method used to reduce aldehydes and ketones to their corresponding alkanes. The carbonyl group ($> C = O$) is converted into a methylene group ($> CH_2$).

$$> C = O \xrightarrow[\Delta,\text{ethylene glycol}]{NH_2NH_2,KOH} > CH_2 + N_2 \uparrow + H_2O$$

Solution: The reaction proceeds through the formation of a hydrazone intermediate. Under the influence of a strong base (KOH) at high temperatures, the hydrazone decomposes with the evolution of nitrogen gas:

(a) $R_2C = O + NH_2NH_2 \rightarrow R_2C = N - NH_2 + H_2O$ (Hydrazone)

(b) $R_2C = N - NH_2 \xrightarrow{KOH,\Delta} R_2CH_2 + N_2$

As the final organic product is an alkane where the oxygen has been replaced by two hydrogens, the carbonyl group has been reduced to a methylene group ($-CH_2-$).

Answer: (B)

Q41.

Solution

Concept: The Etard reaction is a method for the selective oxidation of a terminal methyl group on an aromatic ring to an aldehyde group.

$$C_6H_5CH_3 \xrightarrow{\text{(i) } CrO_2Cl_2/CS_2 \text{ (ii) } H_3O^+} C_6H_5CHO$$

Solution: The reagent used in this reaction is chromyl chloride (CrO_2Cl_2). It reacts with toluene to form a brown-colored chromium complex:

$$C_6H_5CH_3 + 2CrO_2Cl_2 \rightarrow C_6H_5CH(OCr(OH)Cl_2)_2$$

Subsequent hydrolysis of this intermediate complex yields benzaldehyde.

- $KMnO_4$ is too strong and yields benzoic acid (C_6H_5COOH).
- H_2/Pd and $LiAlH_4$ are reducing agents, not oxidizing agents.

Thus, chromyl chloride is the characteristic reagent for the Etard reaction.

Answer: (A)

Q42.

Solution

Concept: Primary aromatic amines react with nitrous acid (produced from $NaNO_2$ and HCl) at low temperatures ($0-5°C$) to form stable arenediazonium salts. This reaction is called the **diazotization reaction**.

Solution: When aniline ($C_6H_5NH_2$) is treated with $NaNO_2$ and HCl at $0-5°C$, the following reaction occurs:

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

The product $C_6H_5N_2^+Cl^-$ is benzene diazonium chloride.

- At temperatures higher than $5°C$, the diazonium salt decomposes to form phenol (C_6H_5OH).
- Benzene diazonium chloride is a versatile intermediate used to prepare chlorobenzene, bromobenzene, iodobenzene, and various azo dyes.

Answer: (B)

Q43.

Solution

Concept: The Hoffmann bromamide degradation reaction is used for the preparation of primary amines from amides. The term "degradation" refers to the shortening of the carbon chain.

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

Solution: During the reaction mechanism, the alkyl or aryl group (R) migrates from the carbonyl carbon to the nitrogen atom, and the carbonyl carbon is eliminated as a carbonate (CO_3^{2-}).

- The starting material is an amide ($R - CONH_2$).
- The final organic product is a primary amine ($R - NH_2$).
- Since the carbonyl carbon ($C = O$) is lost, the resulting amine has exactly **one carbon atom less** than the original amide.

This makes it a very useful "step-down" reaction in organic synthesis to descend a homologous series.

Answer: (B)

Q44.

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Answer: (B)

Q45.

Solution

Concept: The reduction of nitro compounds depends significantly on the pH of the reaction medium. In an acidic medium, nitrobenzene undergoes a 6-electron reduction to form aniline.

$$C_6H_5NO_2 \xrightarrow{Sn/HCl} C_6H_5NH_2$$

Solution: When nitrobenzene ($C_6H_5NO_2$) is treated with tin (Sn) and concentrated HCl:

(a) The nitro group is reduced to the amino group ($-NH_2$).

(b) Due to the acidic conditions, the aniline formed reacts with HCl to form anilinium chloride ($C_6H_5NH_3^+Cl^-$).

(c) Upon subsequent treatment with a base, free aniline ($C_6H_5NH_2$) is obtained.

Reduction in neutral or alkaline media would yield different products such as phenylhydroxylamine, azobenzene, or hydrazobenzene. Therefore, in the presence of Sn/HCl, the product is aniline.

Answer: (A)

Q46.

Solution

Concept: A sugar is classified as non-reducing if it lacks a free hemiacetal or hemiketal group. In disaccharides, if the glycosidic linkage involves the anomeric carbons of both monosaccharide units, the sugar cannot reduce Fehling's or Tollen's reagent.
Solution: Let us examine the structures:

- **Glucose:** A monosaccharide with a free aldehyde group; it is a reducing sugar.
- **Maltose:** Formed by two glucose units ($C_1 - C_4$ linkage). The C_1 of the second glucose is free; it is a reducing sugar.
- **Lactose:** Formed by galactose and glucose ($C_1 - C_4$ linkage). The C_1 of the glucose unit is free; it is a reducing sugar.
- **Sucrose:** Formed by α-D-glucose and β-D-fructose. The linkage is between C_1 of glucose and C_2 of fructose. Since both anomeric carbons are used in the bond, it cannot form an open-chain aldehyde or ketone. Thus, it is a **non-reducing sugar**.

Answer: (C)

Q47.

Solution

Concept: Vitamins are organic compounds required in small amounts for various metabolic processes. Each vitamin deficiency is associated with specific clinical symptoms or diseases.

- **Vitamin A (Retinol):** Essential for vision, especially in dim light.
- **Vitamin C (Ascorbic acid):** Essential for collagen synthesis and immunity.
- **Vitamin K (Phylloquinone):** Necessary for the synthesis of blood clotting factors.

Solution: Vitamin A is a precursor to retinal, a component of the visual pigment rhodopsin. Rhodopsin is vital for the function of the rod cells in the retina, which detect light in low-intensity environments. A lack of Vitamin A leads to a decrease in rhodopsin levels, resulting in "Night Blindness" (Nyctalopia).

- **Option A:** Vitamin B-complex deficiency leads to Beriberi, Pellagra, etc.
- **Option B:** Vitamin C deficiency leads to Scurvy.
- **Option C:** Vitamin K deficiency leads to impaired blood clotting.
- **Option D:** Vitamin A deficiency leads to Night Blindness.

Answer: (D)

Q48.

Solution

Concept: A zwitterion is a neutral molecule with non-adjacent positive and negative charges. It is formed when a molecule contains both an acidic group and a basic group, allowing for an internal acid-base reaction.

Solution: Amino acids have the general formula $R - CH(NH_2)COOH$.

- The carboxyl group $(-COOH)$ can donate a proton (H^+).
- The amino group $(-NH_2)$ can accept a proton (H^+).

In aqueous solution, the proton from the carboxyl group is transferred to the amino group:

$$R - CH(NH_2)COOH \rightleftharpoons R - CH(NH_3^+)COO^-$$

This dipolar structure is the zwitterionic form. Glucose, fatty acids, and nucleotides do not exhibit this specific internal proton transfer to form a stable dipolar neutral species in the same manner.

Answer: (B)

Q49.

Solution

Concept: Denaturation involves the disruption of the non-covalent interactions (hydrogen bonding, hydrophobic effects, and ionic interactions) that stabilize the higher-order structures of a protein.

- **Primary Structure:** Sequence of amino acids (Covalent peptide bonds).
- **Secondary Structure:** α-helices and β-pleated sheets.
- **Tertiary Structure:** Overall 3D folding.

Solution: During denaturation (caused by heat, pH changes, etc.), the secondary and tertiary structures are lost as the protein unfolds into a disordered string of amino acids.

$$\text{Native Protein} \xrightarrow{\text{Denaturation}} \text{Denatured (Unfolded) Protein}$$

Crucially, the primary structure (the sequence of amino acids and the peptide bonds) is **not** destroyed. Since the biological function of a protein is dependent on its specific 3D shape, denaturation usually results in the loss of biological activity.

Answer: (B)

Q50.

Solution

Concept: In the double-helix structure of DNA, the two strands are held together by hydrogen bonds between complementary base pairs.

- Adenine (A) always pairs with Thymine (T).
- Guanine (G) always pairs with Cytosine (C).

Solution: The chemical structures of Guanine and Cytosine allow for the formation of exactly three hydrogen bonds between them:

(a) A bond between the carbonyl oxygen of Guanine and the amino group of Cytosine.

(b) A bond between the $N - H$ of Guanine and the nitrogen of Cytosine.

(c) A bond between the amino group of Guanine and the carbonyl oxygen of Cytosine.

In contrast, Adenine and Thymine form only two hydrogen bonds. Therefore, the Cytosine-Guanine pair is linked by three H-bonds.

Answer: (C)

Answer Key

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