UP Board 12 Chemistry 347 (GE) Question Paper with Solutions

Time Allowed :3 hours 15 minutes	**Maximum Marks :**70	**Total questions :**26

General Instructions

Read the following instructions very carefully and strictly follow them:

1. First 15 minutes are allotted for the candidates to read the question paper.
2. **All** questions are compulsory. Marks allotted to each question are given against it.
3. Give relevant answers to the questions.
4. Give chemical equations, wherever necessary.

1. (a) The colligative property of a solution depends upon (i) the number of particles of solute
(ii) the nature of particles of solute
(iii) the nature of particles of solvent
(iv) the nature of particles of both solute and solvent

Correct Answer: (i) the number of particles of solute

Solution:

Step 1: Colligative properties (such as boiling point elevation, freezing point depression, osmotic pressure, and vapor pressure lowering) depend only on the number of solute particles, not their identity.

Step 2: These properties are a function of solute concentration, not the chemical nature of solute or solvent.

Quick Tip

Colligative properties are independent of the type of solute and depend only on the concentration of solute particles.

(b) Oxidation number of Mn in $KMnO_4$ is

(i) zero

(ii) +2

(iii) +4

(iv) +7

Correct Answer: (iv) +7

Solution:

Step 1: Let the oxidation number of Mn be x in $KMnO_4$.

Step 2: Since $K = +1$ and $O_4 = -8$, the equation is:

$$1 + x + (-8) = 0$$

$$x = +7$$

Thus, the oxidation state of Mn in $KMnO_4$ is +7.

Quick Tip

The oxidation state of Mn in $KMnO_4$ can be calculated using the sum rule: Sum of oxidation states $= 0$.

(c) The coordination number of Co in $[Co(NH_3)_4Cl_2]Cl$ is

(i) 2

(ii) 3

(iii) 4

(iv) 6

Correct Answer: (iv) 6

Solution:

Step 1: The coordination number is determined by counting the number of ligands directly attached to the central metal atom.

Step 2: In $[Co(NH_3)_4Cl_2]Cl$, cobalt is surrounded by four NH_3 ligands and two Cl^- ligands, making a total coordination number of 6.

Quick Tip

Coordination number is the number of donor atoms directly attached to the metal center.

(d) In Etard's reaction, toluene is oxidized to benzaldehyde by

(i) H_2O_2

(ii) CrO_2Cl_2

(iii) Cl_2

(iv) $KMnO_4$

Correct Answer: (ii) CrO_2Cl_2

Solution:

Step 1: In Etard's reaction, toluene is selectively oxidized to benzaldehyde using chromyl chloride (CrO_2Cl_2).

Step 2: The reaction proceeds as:

$$C_6H_5CH_3 + CrO_2Cl_2 \rightarrow C_6H_5CHO$$

Quick Tip

Etard's reaction is a mild oxidation method used to convert toluene to benzaldehyde.

(e) Reaction of Benzene diazonium chloride with phenol in basic medium gives

(i) Diphenyl ether

(ii) p-hydroxy azobenzene

(iii) Chlorobenzene

(iv) Benzene

Correct Answer: (ii) p-hydroxy azobenzene

Solution:

Step 1: Benzene diazonium chloride reacts with phenol in basic medium to form p-hydroxy azobenzene, an example of azo coupling.

Step 2: The reaction is:

$$C_6H_5N_2Cl + C_6H_5OH \xrightarrow{NaOH} C_6H_5N = N - C_6H_4OH$$

Quick Tip

Azo coupling is an electrophilic substitution reaction between diazonium salts and phenols.

(f) Deficiency of which vitamin causes night blindness?

(i) Vitamin A

(ii) Vitamin B_1

(iii) Vitamin C

(iv) Vitamin D

Correct Answer: (i) Vitamin A

Solution:

Step 1: Night blindness (nyctalopia) is caused due to the deficiency of Vitamin A.

Step 2: Vitamin A is essential for the production of rhodopsin, a pigment necessary for low-light vision.

Step 3: Deficiency can be treated by increasing intake of vitamin A-rich foods like carrots, fish oil, and leafy greens.

Quick Tip

Vitamin A is crucial for vision and immune function. Its deficiency causes night blindness.

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2. (a) Explain the difference between molarity and molality of a solution. How does a

change in temperature influence their values?

Solution:

Step 1: Definition

- Molarity (M): Number of moles of solute per liter of solution.

$$M = \frac{\text{moles of solute}}{\text{volume of solution in liters}}$$

- Molality (m): Number of moles of solute per kg of solvent.

$$m = \frac{\text{moles of solute}}{\text{mass of solvent in kg}}$$

Step 2: Effect of Temperature

- Molarity depends on volume, which changes with temperature due to thermal expansion. Thus, molarity decreases with an increase in temperature. - Molality depends on the mass of the solvent, which remains unaffected by temperature, making it temperature-independent.

Quick Tip

Molarity changes with temperature due to volume expansion, whereas molality remains constant as it depends only on mass.

(b) Discuss the method of preparation of potassium permanganate from pyrolusite and write the structural formula of permanganate ion.

Solution:

Step 1: Potassium permanganate ($KMnO_4$) is prepared from pyrolusite (MnO_2) via the following steps:

Step 2: Oxidation of Pyrolusite:

$$2MnO_2 + 4KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$$

Step 3: Disproportionation of Manganate:

$$3K_2MnO_4 + 2H_2O \rightarrow 2KMnO_4 + MnO_2 + 4KOH$$

Step 4: The structural formula of the permanganate ion (MnO_4^-):

A tetrahedral structure with Mn in +7 oxidation state.

Quick Tip

Potassium permanganate is synthesized via oxidation of manganese dioxide followed by disproportionation in acidic medium.

(c) Explain ionisation isomerism and linkage isomerism in coordination compounds with example.

Solution:

Step 1: Ionisation Isomerism:

- Occurs when two coordination compounds produce different ions in solution but have the same molecular formula. - Example:

$$[Co(NH_3)_5Br]SO_4 \quad \text{and} \quad [Co(NH_3)_5SO_4]Br$$

Step 2: Linkage Isomerism:

- Occurs when a ligand can bind through two different donor atoms. - Example:

$$[Co(NO_2)(NH_3)_5]^{2+} \quad \text{(Nitro complex, N-bound)}$$

$$[Co(ONO)(NH_3)_5]^{2+} \quad \text{(Nitrito complex, O-bound)}$$

Quick Tip

Ionisation isomerism occurs due to exchangeable ions, while linkage isomerism occurs when a ligand bonds through different atoms.

(d) Discuss the mechanism of unimolecular nucleophilic substitution reaction (S_N1) in haloalkanes.

Solution:

Step 1: Definition:

- The S_N1 (unimolecular nucleophilic substitution) reaction follows a two-step mechanism.
- It occurs in tertiary haloalkanes due to carbocation stability.

Step 2: Mechanism:

Step 2.1: Formation of Carbocation (Rate Determining Step):

$$R - X \rightarrow R^+ + X^-$$

Step 2.2: Nucleophilic Attack:

$$R^+ + Nu^- \rightarrow R - Nu$$

Step 3: Example:

$$(CH_3)_3CBr \xrightarrow{H_2O} (CH_3)_3C^+ + Br^-$$

$$(CH_3)_3C^+ + H_2O \rightarrow (CH_3)_3COH + H^+$$

Quick Tip

S_N1 reactions involve carbocation formation and follow first-order kinetics: rate $\propto [R - X]$.

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3. (a) Explain Raoult's law for solutions containing non-volatile solute in volatile solvent. Derive mathematical expression for this law.

Solution:

Step 1: Statement of Raoult's Law:

Raoult's law states that the partial vapor pressure of a solvent in a solution is directly proportional to its mole fraction.

$$P_A = X_A P_A^0$$

where P_A is the partial vapor pressure of the solvent, X_A is its mole fraction, and P_A^0 is the vapor pressure of the pure solvent.

Step 2: Mathematical Derivation:

For a solution containing a non-volatile solute:

$$X_A + X_B = 1$$

$$X_A = 1 - X_B$$

Substituting in Raoult's law:

$$P_A = (1 - X_B)P_A^0$$

Step 3: Relative Lowering of Vapor Pressure:

$$\frac{P_A^0 - P_A}{P_A^0} = X_B$$

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

Quick Tip

Raoult's law helps explain colligative properties like boiling point elevation and freezing point depression.

(b) Explain the mechanism of dehydration of ethanol.

Solution:

Step 1: Definition:

Dehydration of ethanol is an acid-catalyzed elimination reaction, producing ethene.

Step 2: Mechanism:

Step 2.1: Protonation of Ethanol:

$$C_2H_5OH + H^+ \rightarrow C_2H_5OH_2^+$$

Step 2.2: Formation of Carbocation:

$$C_2H_5OH_2^+ \rightarrow C_2H_5^+ + H_2O$$

Step 2.3: Elimination of Proton:

$$C_2H_5^+ \rightarrow C_2H_4 + H^+$$

Step 3: Overall Reaction:

$$C_2H_5OH \xrightarrow{H_2SO_4} C_2H_4 + H_2O$$

Quick Tip

Dehydration of alcohols follows an E1 mechanism in acid medium, favoring alkene formation.

(c) Explain the difference between aldehydes and ketones by Fehling solution and Schiff reagent.

Solution:

Step 1: Fehling's Test:

- Aldehydes reduce Fehling's solution (blue) to a red precipitate of Cu_2O. - Ketones do not react.

$$R - CHO + 2Cu^{2+} + 5OH^- \rightarrow R - COO^- + Cu_2O + 3H_2O$$

Step 2: Schiff's Test:

- Aldehydes turn Schiff's reagent pink/magenta. - Ketones do not react.

Step 3: Conclusion:

- Aldehydes give positive tests in both reactions. - Ketones give negative results.

Quick Tip

Fehling's test detects reducing aldehydes, while Schiff's reagent gives a color change for aldehydes but not ketones.

(d) Define carbohydrates and write the differences between glucose and fructose.

Solution:

Step 1: Definition of Carbohydrates:

Carbohydrates are biomolecules consisting of carbon, hydrogen, and oxygen, generally following the formula $C_n(H_2O)_n$. They serve as an energy source and structural material.

Step 2: Differences Between Glucose and Fructose:

Property	**Glucose**	**Fructose**
Type	Aldose (Aldehyde group)	Ketose (Ketone group)
Structure	Hexagonal (Pyranose)	Pentagonal (Furanose)
Optical Activity	D-Glucose (dextrorotatory)	D-Fructose (levorotatory)
Occurrence	Blood sugar	Found in fruits, honey

Quick Tip

Glucose is an aldose with a six-membered ring, while fructose is a ketose with a five-membered ring.

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4. (a) Define molal elevation constant. Calculate the boiling point of an aqueous solution containing 0.6 g of urea (molar mass = 60) in 100 g of water. The value of molal elevation constant for water is 0.52 K kg mol^{-1} and boiling point of water is 373.15 K.

Solution:

Step 1: Definition: The molal elevation constant (K_b) is the increase in boiling point when 1 mole of a non-volatile solute is dissolved in 1 kg of solvent.

Step 2: Formula for Boiling Point Elevation:

$$\Delta T_b = K_b \times m$$

where,

$$m = \frac{\text{moles of solute}}{\text{mass of solvent (kg)}}$$

Step 3: Calculate Molality:

$$\text{Moles of urea} = \frac{0.6}{60} = 0.01 \text{ mol}$$

$$m = \frac{0.01}{0.1} = 0.1 \text{ mol/kg}$$

Step 4: Calculate Boiling Point Elevation:

$$\Delta T_b = 0.52 \times 0.1 = 0.052 \text{ K}$$

Step 5: Final Boiling Point:

$$T_b = 373.15 + 0.052 = 373.202 \text{ K}$$

Thus, the boiling point of the solution is 373.20 K.

Quick Tip

The increase in boiling point is proportional to the molality of the solute, and molal elevation constant (K_b) is solvent-specific.

(b) Explain the difference between an electrochemical cell and electrolytic cell. State Kohlrausch's law and write its applications.

Solution:

Step 1: Difference Between Electrochemical and Electrolytic Cells:

Feature	**Electrochemical Cell**	**Electrolytic Cell**
Energy Conversion	Chemical to electrical	Electrical to chemical
Spontaneity	Spontaneous reaction	Non-spontaneous reaction
Example	Galvanic/Daniel cell	Electrolysis of NaCl

Step 2: Kohlrausch's Law:

Kohlrausch's law states:

$$\Lambda_m^0 = \lambda_+^0 + \lambda_-^0$$

where λ_+^0 and λ_-^0 are the limiting molar conductivities of cations and anions, respectively.

Step 3: Applications:

- Used to calculate the molar conductivity of weak electrolytes. - Helps in determining dissociation constants of weak acids and bases.

Quick Tip

Electrochemical cells generate electricity via redox reactions, whereas electrolytic cells drive non-spontaneous reactions using electrical energy.

(c) Define molecularity and order of a reaction. Derive the integrated rate equation for the rate constant of first-order reaction.

Solution:

Step 1: Definitions:

- Molecularity: The number of reactant molecules participating in an elementary reaction.
- Order of Reaction: The sum of powers of reactant concentrations in the rate law.

Step 2: Derivation of First-Order Rate Equation:

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

Step 3: Separating Variables:

$$\frac{d[A]}{[A]} = -kdt$$

Step 4: Integrating Both Sides:

$$\int \frac{d[A]}{[A]} = -\int kdt$$

$$\ln[A] = -kt + C$$

Step 5: Applying Initial Conditions: $[A] = [A]_0$ at $t = 0$:

$$\ln[A]_0 = C$$

$$\ln[A] = -kt + \ln[A]_0$$

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

Thus, the first-order rate equation is:

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

Quick Tip

Molecularity is a theoretical concept for elementary steps, while reaction order is experimentally determined.

(d) (i) Why is $La(OH)_3$ a stronger base than $Lu(OH)_3$?

Solution:

Step 1: Basicity and Lanthanoid Contraction:

- As we move across the lanthanide series, atomic size decreases due to lanthanoid contraction.

- $La(OH)_3$ has a larger ionic radius, making it more basic than $Lu(OH)_3$.

Step 2: Explanation:

- Larger ionic size in La^{3+} leads to weaker bond strength in $La(OH)_3$, making hydroxide ions (OH^-) more available.

- Lu^{3+} has a smaller radius, leading to a stronger attraction between Lu^{3+} and OH^-, reducing basicity.

Quick Tip

Lanthanoid contraction reduces atomic size across the series, affecting basicity trends.

(d) (ii) Write a short note on the paramagnetic behaviour and formation of coloured ions of transition elements.

Solution:

Step 1: Paramagnetic Behaviour:

- Transition metals exhibit paramagnetism due to the presence of unpaired electrons in d-orbitals. - Magnetic moment:

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

where n is the number of unpaired electrons.

Step 2: Formation of Coloured Ions:

- Colour in transition metal ions arises due to d-d transitions when electrons absorb visible light and jump between d-orbitals. - Example:

$$[Cu(H_2O)_6]^{2+}\ \text{(Blue)}$$

Quick Tip

The paramagnetic nature of transition elements depends on unpaired electrons, while colour formation is due to d-d transitions.

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5. (a) (i) What are fuel cells? State *two* advantages of hydrogen-oxygen fuel cell over ordinary cell.

Solution:

Step 1: Definition of Fuel Cells:

Fuel cells are electrochemical devices that convert chemical energy into electrical energy through a redox reaction between fuel (e.g., hydrogen) and an oxidizing agent (e.g., oxygen).

Step 2: Advantages of Hydrogen-Oxygen Fuel Cell:

1. Higher Efficiency: Fuel cells have higher efficiency compared to conventional electrochemical cells. 2. Eco-friendly: Produces only water as a byproduct, making it environmentally friendly.

Quick Tip

Fuel cells are highly efficient and environmentally friendly as they produce water instead of harmful emissions.

(a) (ii) Calculate the e.m.f. of the following cell:

$$\text{Mg(s)}|\text{Mg}^{2+}(0.1M)||\text{Cu}^{2+}(0.001M)|\text{Cu(s)}$$

Given:

$$E^0_{\text{Cu}^{2+}/\text{Cu}} = +0.34V, \quad E^0_{\text{Mg}^{2+}/\text{Mg}} = -2.37V$$

Solution:

Step 1: Cell Reaction:

$$\text{Mg} + \text{Cu}^{2+} \rightarrow \text{Mg}^{2+} + \text{Cu}$$

Step 2: Standard E.M.F. Calculation:

$$E^0_{\text{cell}} = E^0_{\text{cathode}} - E^0_{\text{anode}}$$

$$= 0.34 - (-2.37) = 2.71V$$

Step 3: Nernst Equation:

$$E_{\text{cell}} = E^0_{\text{cell}} - \frac{0.0591}{n} \log \frac{[\text{Mg}^{2+}]}{[\text{Cu}^{2+}]}$$

$$E_{\text{cell}} = 2.71 - \frac{0.0591}{2} \log \frac{0.1}{0.001}$$

$$E_{\text{cell}} = 2.71 - \frac{0.0591}{2} \times 2$$

$$E_{\text{cell}} = 2.71 - 0.0591 = 2.6509V$$

Thus, the e.m.f. of the cell is 2.65V.

Quick Tip

The Nernst equation helps calculate the actual cell potential under non-standard conditions.

(b) Effect of temperature on rate of reaction and calculation of time for 80% completion.

Solution:

Step 1: Effect of Temperature:

- Higher temperature increases reaction rate by providing activation energy.

- Follows Arrhenius equation:

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

Step 2: First-Order Reaction Calculation:

Given: 20% completion in 10 minutes.

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

$$k = \frac{2.303}{10} \log \frac{100}{80}$$

$$k = \frac{2.303}{10} \times 0.0969 = 0.0223 \text{ min}^{-1}$$

For 80% completion:

$$t = \frac{2.303}{k} \log \frac{100}{20}$$

$$t = \frac{2.303}{0.0223} \times 0.6989$$

$$t = 72.2 \text{ minutes}$$

Thus, the time required for 80% completion is 72.2 minutes.

Quick Tip

Reaction rate increases with temperature due to increased kinetic energy and collision frequency.

(c) (i) $[Cr(NH_3)_6]^{3+}$ is paramagnetic while $[Ni(CN)_4]^{2+}$ is diamagnetic. Explain on the basis of valence bond theory.

Solution:

Step 1: Electronic Configuration:

- Cr^{3+}: $3d^3$, unpaired electrons → Paramagnetic
- Ni^{2+}: $3d^8$, paired electrons due to strong ligand effect → Diamagnetic

Step 2: Explanation:

- NH_3 is a weak field ligand, so Cr^{3+} retains unpaired electrons.
- CN^- is a strong field ligand, causing pairing in Ni^{2+}.

Quick Tip

Ligand strength affects electron pairing, influencing magnetic properties of complexes.

(c) (ii) I.U.P.A.C. names of coordination compounds.

(a) $K[Cr(H_2O)_2(C_2O_4)_2]$

Potassium diaquadioxalatochromate(III)

(b) $[PtCl(NO_2)(NH_3)_4]SO_4$

Tetraamminechloronitroplatinum(IV) sulfate

Quick Tip

IUPAC naming follows sequence: ligands (alphabetical) → metal with oxidation state → counter ion.

(d) (i) What are nucleic acids? Discuss the structure of DNA with a diagram.

Solution:

Step 1: Definition: Nucleic acids (DNA RNA) are biomolecules composed of nucleotides, responsible for genetic information storage.

Step 2: Structure of DNA:

- Double-helix model by Watson and Crick.
- Consists of phosphate backbone and nitrogenous bases (A, T, C, G).

- Complementary base pairing: A-T, C-G.

Step 3: Diagram:

(Include diagram of DNA double-helix)

Quick Tip

DNA follows Chargaff's rule: A pairs with T, and C pairs with G via hydrogen bonds.

(d) (ii) Describe the primary and secondary structures of proteins.

Solution:

- Primary Structure: Linear sequence of amino acids in a polypeptide chain.
- Secondary Structure: Regular coiling or folding due to hydrogen bonds (e.g., -helix, -pleated sheet).

Quick Tip

Protein structure determines its function: primary structure defines sequence, while secondary gives stability.

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6. (a) Explain the resonance effect in nucleophilic substitution reactions of haloarenes. By giving the example of chlorobenzene, write short notes on the following:

(i) Wurtz-Fittig reaction

(ii) Friedel-Crafts reaction

Solution:

Step 1: Resonance Effect in Haloarenes:

Haloarenes (e.g., chlorobenzene) show resonance due to delocalization of lone pair electrons on the halogen. This results in partial double bond character, reducing reactivity towards nucleophilic substitution.

$$C_6H_5Cl \leftrightarrow \text{Various Resonating Structures}$$

Step 2: Wurtz-Fittig Reaction:

- This reaction involves the coupling of aryl halides with alkyl halides using sodium in dry ether. - Reaction:

$$C_6H_5Cl + 2Na + C_2H_5Cl \xrightarrow{\text{Dry Ether}} C_6H_5C_2H_5 + 2NaCl$$

Step 3: Friedel-Crafts Reaction:

- Aromatic compounds undergo electrophilic substitution with alkyl halides in the presence of a Lewis acid catalyst ($AlCl_3$). - Example:

$$C_6H_6 + CH_3Cl \xrightarrow{AlCl_3} C_6H_5CH_3 + HCl$$

Quick Tip

Haloarenes resist nucleophilic substitution due to resonance stabilization. Wurtz-Fittig and Friedel-Crafts reactions introduce alkyl groups.

OR

(a) What happens when – (write chemical equations only)?

(i) Ethyl bromide reacts with sodium ethoxide?

$$C_2H_5Br + C_2H_5ONa \rightarrow C_2H_5 - O - C_2H_5 + NaBr$$

(ii) Ethyl chloride reacts with alcoholic KCN?

$$C_2H_5Cl + KCN \xrightarrow{\text{alc.}} C_2H_5CN + KCl$$

(iii) Chlorobenzene reacts with nitric acid?

$$C_6H_5Cl + HNO_3 \xrightarrow{H_2SO_4} o - C_6H_4ClNO_2 + p - C_6H_4ClNO_2$$

(iv) n-butyl chloride reacts with alcoholic KOH?

$$C_4H_9Cl + KOH \xrightarrow{\text{alc.}} C_4H_8 + H_2O + KCl$$

(v) Ethyl bromide reacts with magnesium metal in the presence of dry ether?

$$C_2H_5Br + Mg \xrightarrow{\text{Dry Ether}} C_2H_5MgBr$$

Quick Tip

Reactions with alkyl halides depend on nucleophile strength and solvent polarity, affecting substitution vs. elimination outcomes.

(b) Write short notes on the following:

(i) Preparation of ethanol from fermentation of sugar

$$C_6H_{12}O_6 \xrightarrow{\text{Yeast}} 2C_2H_5OH + 2CO_2$$

(ii) Reimer-Tiemann Reaction

$$C_6H_5OH + CHCl_3 + NaOH \rightarrow o-\text{hydroxybenzaldehyde} + p-\text{hydroxybenzaldehyde}$$

(iii) Williamson's Synthesis

$$R-O^- + R'-X \rightarrow R-O-R' + X^-$$

Quick Tip

Fermentation produces ethanol biologically, Reimer-Tiemann introduces -CHO into phenol, and Williamson's synthesis forms ethers.

OR

(b) (i) Write chemical equations for the preparation of primary, secondary, and tertiary alcohols from Grignard's reagent.

Primary Alcohol:

$$R-MgX + HCHO \xrightarrow{H_2O} R-CH_2OH + Mg(OH)X$$

Secondary Alcohol:

$$R - MgX + CH_3CHO \xrightarrow{H_2O} R - CHOH - CH_3 + Mg(OH)X$$

Tertiary Alcohol:

$$R - MgX + R'CO - R'' \xrightarrow{H_2O} R - C(OH) - R'R'' + Mg(OH)X$$

Quick Tip

Grignard reagents react with aldehydes/ketones to produce alcohols of different types.

(b) (ii) How will you obtain the following? (Write chemical equations only.)

(a) Picric acid from phenol

$$C_6H_5OH + 3HNO_3 \xrightarrow{H_2SO_4} C_6H_2(NO_2)_3OH + 3H_2O$$

(b) Methanol from ethanol

$$C_2H_5OH \xrightarrow{Cu, 300^\circ C} CH_3OH + CO$$

Quick Tip

Nitration of phenol produces picric acid, while methanol can be synthesized by oxidation of ethanol.

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7. (a) Write short notes on the following:

(i) Cannizzaro's reaction

Solution:

Step 1: Definition: Cannizzaro's reaction is a redox reaction where non-enolizable aldehydes undergo disproportionation in a strong base.

Step 2: Reaction:

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

One aldehyde molecule is reduced to an alcohol, and the other is oxidized to a carboxylate.

Quick Tip

Cannizzaro's reaction occurs with aldehydes lacking α-hydrogen atoms.

(ii) Gattermann-Koch reaction

Step 1: Definition: Gattermann-Koch reaction is a method for formylation of benzene.

Step 2: Reaction:

$$C_6H_6 + CO + HCl \xrightarrow{AlCl_3, CuCl} C_6H_5CHO$$

The reaction introduces a formyl (-CHO) group into benzene.

Quick Tip

The Gattermann-Koch reaction is useful for direct formylation of aromatic rings.

(iii) Aldol condensation

Step 1: Definition: Aldol condensation is an organic reaction in which an enolate ion reacts with a carbonyl compound, forming a beta-hydroxy ketone.

Step 2: Reaction:

$$CH_3CHO + CH_3CHO \xrightarrow{NaOH} CH_3CH(OH)CH_2CHO \xrightarrow{\Delta} CH_3CH = CHCHO + H_2O$$

Quick Tip

Aldol condensation is crucial in carbon-carbon bond formation and occurs under basic or acidic conditions.

OR

(a) How will you obtain the following? (Write chemical equations only.)

(i) Ethyl acetate from acetic acid

$$CH_3COOH + C_2H_5OH \xrightarrow{H_2SO_4} CH_3COOC_2H_5 + H_2O$$

(ii) Acetone hydrazone from acetone

$$CH_3COCH_3 + NH_2NH_2 \rightarrow CH_3C = NNH_2CH_3 + H_2O$$

(iii) Acetyl chloride from acetic acid

$$CH_3COOH + PCl_5 \rightarrow CH_3COCl + POCl_3 + HCl$$

(iv) Benzaldehyde from benzyl chloride

$$C_6H_5CH_2Cl + H_2O \xrightarrow{MnO_2} C_6H_5CHO + HCl$$

(v) Benzoic acid from benzamide

$$C_6H_5CONH_2 + H_2O \xrightarrow{H^+} C_6H_5COOH + NH_3$$

Quick Tip

Functional group conversions rely on specific reagents, such as oxidation for aldehydes and acid hydrolysis for amides.

(b) Write short notes on the following:

Solution:

(i) Gabriel phthalimide synthesis

$$C_6H_4(CO)_2N^-K^+ + RX \rightarrow C_6H_4(CO)_2NR + KX$$

It produces primary amines selectively.

(ii) Hoffmann bromamide reaction

$$RCONH_2 + Br_2 + 4NaOH \rightarrow RNH_2 + Na_2CO_3 + 2NaBr + 2H_2O$$

Converts amides to primary amines.

(iii) Carbylamine reaction

$$R - NH_2 + CHCl_3 + 3KOH \rightarrow R - NC + 3KCl + 3H_2O$$

Produces isocyanides (carbylamines).

Quick Tip

Gabriel synthesis selectively forms primary amines, Hoffmann's reaction removes carbonyls, and Carbylamine reaction identifies primary amines.

OR (b) How is benzene diazonium chloride prepared from aniline? How will you convert benzene diazonium chloride into the following?

Solution:

Preparation of Benzene Diazonium Chloride:

$$C_6H_5NH_2 + HNO_2 + HCl \xrightarrow{0^\circ C} C_6H_5N_2Cl + 2H_2O$$

Conversions:

(i) Benzene

$$C_6H_5N_2Cl + H_3PO_2 + H_2O \rightarrow C_6H_6 + N_2 + H_3PO_3 + HCl$$

(ii) Chlorobenzene

$$C_6H_5N_2Cl + CuCl \rightarrow C_6H_5Cl + N_2$$

(iii) Nitrobenzene

$$C_6H_5N_2Cl + CuNO_2 \rightarrow C_6H_5NO_2 + N_2$$

Quick Tip

Diazonium salts are versatile intermediates, enabling substitution with hydrogen, halogens, and functional groups.
