UP Board Class 12 Chemistry - 347 (KF) - 2025 Question Paper with Solutions

Time Allowed :3 Hours	**Maximum Marks :**70	**Total questions :**35

General Instructions

Instruction:

i) *All* questions are compulsory. Marks allotted to each question are given in the margin.

ii) In numerical questions, give all the steps of calculation.

iii) Give relevant answers to the questions.

iv) Give chemical equations, wherever necessary.

Q1(a). The aqueous solution having maximum boiling point is

i) 1% Glucose

ii) 1% NaCl

iii) 1% $CaCl_2$

iv) 1% Sucrose

Correct Answer: (iii) 1% $CaCl_2$

Solution:

Step 1: Relate boiling point to colligative properties.

The elevation of the boiling point is a colligative property, meaning it depends on the concentration of solute particles (ions or molecules) in the solution, not on the identity of the solute itself. A higher concentration of particles leads to a greater elevation in the boiling point.

Step 2: Analyze the nature of each solute in water.

We need to determine how many particles each solute produces when dissolved.

- **Glucose and Sucrose:** These are covalent compounds that do not dissociate in water. Each formula unit produces only one dissolved particle.
- **NaCl (Sodium Chloride):** This is an ionic compound that dissociates into two ions: Na^+ and Cl^-. Each formula unit produces two particles.
- **$CaCl_2$ (Calcium Chloride):** This is an ionic compound that dissociates into three ions: one Ca^{2+} and two Cl^-. Each formula unit produces three particles.

Step 3: Compare the effective particle concentration.

Assuming similar molal concentrations for the 1% solutions, $CaCl_2$ will generate the highest number of dissolved particles for a given number of formula units.

Step 4: Conclusion.

Since the $CaCl_2$ solution will have the greatest concentration of particles, it will exhibit the largest boiling point elevation and therefore have the highest boiling point.

Final Answer:

$$\boxed{1\%\ CaCl_2}$$

Quick Tip

Electrolytes with greater ion dissociation give stronger colligative effects.

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Q1(b). A colourless ion in the following is

i) Cu^{+}

ii) Cu^{2+}

iii) Ni^{2+}

iv) Fe^{3+}

Correct Answer: (i) Cu^{+}

Solution:

Step 1: Explain the origin of color in transition metal ions.

Color in these ions is due to the absorption of visible light, which promotes an electron from a lower-energy d-orbital to a higher-energy d-orbital (a "d-d transition"). This is only possible if the d-subshell is partially filled. Ions with empty (d^0) or completely filled (d^{10}) d-subshells cannot undergo d-d transitions and are typically colorless.

Step 2: Determine the electron configuration for each ion.

- **Cu^{+}:** Neutral Cu is [Ar] $3d^{10}4s^1$. Removing the 4s electron gives **[Ar] $3d^{10}$**.
- **Cu^{2+}:** Neutral Cu is [Ar] $3d^{10}4s^1$. Removing the 4s and one 3d electron gives **[Ar] $3d^{9}$**.
- **Ni^{2+}:** Neutral Ni is [Ar] $3d^{8}4s^2$. Removing the two 4s electrons gives **[Ar] $3d^{8}$**.
- **Fe^{3+}:** Neutral Fe is [Ar] $3d^{6}4s^2$. Removing the two 4s and one 3d electron gives **[Ar] $3d^{5}$**.

Step 3: Identify the colorless ion.

The Cu^{+} ion has a $3d^{10}$ configuration, meaning its d-subshell is completely filled. Therefore, no d-d transition can occur, and the ion is colorless. The other three ions (Cu^{2+}, Ni^{2+}, Fe^{3+}) all have partially filled d-subshells and are colored.

Final Answer:

$$\boxed{Cu^+}$$

> **Quick Tip**
>
> Transition metal ions with completely filled d^{10} or empty d^0 configurations are colourless.

—

Q1(c). The oxidation number of Cu in the ion $[Cu(CN)_4]^{3-}$ is

i) +2

ii) +3

iii) +1

iv) –7

Correct Answer: (iii) +1

Solution:

Step 1: Identify the components and overall charge.

The complex ion is $[Cu(CN)_4]^{3-}$.

- The central metal atom is Copper (Cu).
- The ligands are four cyanide ions (CN^-).
- The overall charge of the entire ion is -3.

Step 2: Determine the total charge of the ligands.

The cyanide ligand (CN) is an ion with a charge of -1. Since there are four of them, their total charge contribution is:

$$4 \times (-1) = -4$$

Step 3: Calculate the oxidation state of the metal.

The sum of the oxidation state of the central metal and the total charge of the ligands must equal the overall charge of the complex ion. Let the oxidation state of Cu be x.

$$(\text{Oxidation state of Cu}) + (\text{Total ligand charge}) = \text{Overall charge}$$

$$x + (-4) = -3$$

Solving for x:

$$x = -3 + 4 = +1$$

Final Answer:

$$\boxed{+1}$$

> **Quick Tip**
>
> Always balance total oxidation states with overall charge of the complex ion.

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Q1(d). Rosenmund reduction gives

i) Aldehyde

ii) Ether

iii) Carboxylic acid

iv) Hydrocarbon

Correct Answer: (i) Aldehyde

Solution:

Step 1: Define Rosenmund Reduction.

The Rosenmund reduction is a chemical reaction that reduces an acyl chloride to an aldehyde. It is a form of catalytic hydrogenation.

Step 2: Identify the specific reagents.

The reaction is characterized by the use of hydrogen gas (H_2) with a special "poisoned" catalyst, which is typically palladium supported on barium sulfate ($Pd/BaSO_4$).

Step 3: Explain the purpose of the poisoned catalyst.

Palladium is a highly active catalyst that, on its own, would reduce the acyl chloride first to an aldehyde and then further to a primary alcohol. The barium sulfate acts as a catalyst poison, reducing the activity of the palladium. This deactivation is crucial as it stops the reduction at the aldehyde stage, preventing over-reduction to the alcohol.

Step 4: Conclude the product.

Due to this controlled and selective reduction, the characteristic product of the Rosenmund reaction is an aldehyde.

Final Answer:

$$\boxed{Aldehyde}$$

> Quick Tip
>
> Rosenmund reduction selectively reduces acyl chlorides to aldehydes, not further to alcohols.

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Q1(e). How many primary amines are possible for the formula $C_4H_{11}N$?

i) 4

ii) 3

iii) 2

iv) 5

Correct Answer: (i) 4

Solution:

Step 1: General approach.

Primary amines have $–NH_2$ group attached to an alkyl chain. We need to find all possible structural isomers for $C_4H_{11}N$.

Step 2: Possible structures.

1. n-Butylamine: $CH_3–CH_2–CH_2–CH_2–NH_2$

2. sec-Butylamine: $CH_3–CH(NH_2)–CH_2–CH_3$

3. Isobutylamine: $(CH_3)_2CH–CH_2–NH_2$

4. tert-Butylamine: $(CH_3)_3C–NH_2$

Step 3: Conclude.

Total = 4 primary amines.

Final Answer:

$$\boxed{4}$$

> Quick Tip
>
> Count structural isomers carefully — position of $–NH_2$ and branching matters.

—

Q1(f). How many primary alcoholic groups are there in glucose?

i) One

ii) Two

iii) Three

iv) Four

Correct Answer: (i) One

Solution:

Step 1: Recall glucose structure.

Glucose (an aldohexose) has 6 carbons: one aldehyde group (–CHO) at C1, four secondary –OH groups (on C2, C3, C4, C5), and one terminal $–CH_2OH$ (primary alcohol) at C6.

Step 2: Identify primary alcohol.

Only carbon 6 has $–CH_2OH$ group, which is primary alcohol.

Step 3: Conclude.

There is exactly one primary alcoholic group in glucose.

Final Answer:

$$\boxed{One}$$

Quick Tip

In glucose: 1 aldehyde, 4 secondary –OH, and 1 primary –OH group.

Q2. (a) 5.85 g of NaCl is dissolved in 200 ml water. Calculate the molarity of the solution. [Na = 23, Cl = 35.5]

Solution:

Step 1: Calculate molar mass of NaCl.

Molar mass of NaCl = Atomic mass of Na + Atomic mass of Cl

= 23 + 35.5 = 58.5 g/mol

Step 2: Calculate moles of NaCl.

Moles of NaCl = $\dfrac{\text{Given mass}}{\text{Molar mass}}$

= $\dfrac{5.85}{58.5} = 0.1\,\text{mol}$

Step 3: Convert volume of solution to liters.

200 ml = $\dfrac{200}{1000} = 0.2\,\text{L}$

Step 4: Calculate molarity.

Molarity $M = \dfrac{\text{Moles of solute}}{\text{Volume of solution in L}}$

= $\dfrac{0.1}{0.2} = 0.5\,M$

Final Answer:

$$\boxed{0.5\,M}$$

Quick Tip

Always remember: Molarity = $\dfrac{\text{Moles of solute}}{\text{Liters of solution}}$. Convert ml to liters carefully to avoid errors.

(b) In comparison to Mn^{3+} ions Mn^{2+} ions are more stable. Why?

Solution:

Step 1: Consider electronic configurations.

- Mn (Z = 25): [Ar] $3d^5\ 4s^2$

- Mn^{2+}: [Ar] $3d^5$ (stable half-filled configuration)

- Mn^{3+}: [Ar] $3d^4$ (unstable, not half-filled)

Step 2: Stability explanation.

Mn^{2+} has exactly half-filled 3d orbitals ($3d^5$), which is particularly stable due to exchange energy and symmetrical distribution. On the other hand, Mn^{3+} with $3d^4$ lacks this extra stability.

Final Answer:

Mn^{2+} ions are more stable than Mn^{3+} due to half-filled 3d orbitals.

Quick Tip

Half-filled and fully filled electronic configurations provide extra stability to ions due to exchange energy and symmetrical distribution.

(c) Differentiate between double salt and complex salt by giving two examples of each.

Solution:

Step 1: Double salt.

- Double salts are crystalline salts formed by the combination of two simple salts in a fixed ratio.

- They dissociate completely into their constituent ions when dissolved in water.

- Examples: Mohr's salt ($FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$), Carnallite ($KCl \cdot MgCl_2 \cdot 6H_2O$).

Step 2: Complex salt.

- Complex salts consist of a central metal ion bonded to ligands through coordinate bonds.

- They do not dissociate completely into simple ions; instead, they give a complex ion in solution.

- Examples: $[Cu(NH_3)_4]SO_4$, $[Ag(CN)_2]K$.

Final Answer:

Double salt $\rightarrow$ Complete dissociation, Complex salt $\rightarrow$ Gives complex ions in solution.

Quick Tip

Double salts lose their identity in solution, whereas complex salts retain their complex ion structure.

(d) Write the equation of any one of nucleophilic substitution reactions of ethyl bromide.

Solution:

Step 1: General reaction.

Nucleophilic substitution occurs when a nucleophile replaces a leaving group (like Br^-) in ethyl bromide (C_2H_5Br).

Step 2: Example reaction with aqueous KOH.

$$C_2H_5Br + OH^- \longrightarrow C_2H_5OH + Br^-$$

Here, the hydroxide ion acts as the nucleophile, replacing bromine, and producing ethanol.

Final Answer:

$$\boxed{C_2H_5Br + KOH(aq) \rightarrow C_2H_5OH + KBr}$$

Quick Tip

In nucleophilic substitution reactions, the nucleophile attacks the carbon attached to the leaving group, displacing it and forming a new product.

Q3. (a) At what temperature does a 5% (w/v) solution of glucose produce 7 atmospheric osmotic pressure? $[R = 0.0821\,\mathbf{L \cdot atm/K\,mol}]$

Solution:

Step 1: Use the osmotic pressure formula.

The formula for osmotic pressure is:

$$\Pi = \frac{nRT}{V}$$

Where: Π = Osmotic pressure = 7 atm n = Moles of solute R = Ideal gas constant = 0.0821 L atm / K mol T = Temperature in Kelvin V = Volume of the solution = 1 L (assumed for simplicity)

Step 2: Moles of glucose (n).

Given that the solution is 5

$$\text{Mass of glucose} = 5\,\text{g} \times 10 = 50\,\text{g}$$

Molar mass of glucose $C_6H_{12}O_6$ is:

$$6(12) + 12(1) + 6(16) = 180\,\text{g/mol}$$

Moles of glucose = $\frac{50}{180} = 0.2778\,\text{mol}$

Step 3: Calculate temperature (T).

Substitute the known values into the osmotic pressure equation:

$$7 = \frac{0.2778 \times 0.0821 \times T}{1}$$

Solving for T:

$$T = \frac{7}{0.2778 \times 0.0821} = 307.7\,\text{K}$$

Final Answer:

$$\boxed{307.7\,\text{K}}$$

> Quick Tip
>
> In osmotic pressure calculations, ensure that you convert the volume to liters and use the appropriate molar mass for the solute.

(b) Write the chemical equation for the preparation of phenol.

Solution:

The preparation of phenol can be done via several methods. One common method is the **Caustic soda method**, where chlorobenzene reacts with sodium hydroxide.

$$C_6H_5Cl + NaOH \xrightarrow{\Delta} C_6H_5OH + NaCl$$

Here, chlorobenzene (C_6H_5Cl) reacts with sodium hydroxide (NaOH) in the presence of heat () to form phenol (C_6H_5OH) and sodium chloride (NaCl).

Final Answer:

$$\boxed{C_6H_5Cl + NaOH \xrightarrow{\Delta} C_6H_5OH + NaCl}$$

Quick Tip

The preparation of phenol involves the hydroxylation of benzene, often using sodium hydroxide in the presence of heat.

(c) pK_b value of aniline is more in comparison to that of methyl amine. State the reason.

Solution:

Step 1: Understand the structure of aniline and methylamine.

- Aniline ($C_6H_5NH_2$) has a phenyl group (C_6H_5) attached to the amino group (NH_2). - Methylamine (CH_3NH_2) has a methyl group (CH_3) attached to the amino group.

Step 2: Effect of substituents.

- The phenyl group in aniline is electron-withdrawing through induction and resonance, which decreases the electron density on the nitrogen atom. This makes aniline less basic, increasing its pK_b. - The methyl group in methylamine is electron-donating through induction, which increases the electron density on nitrogen, making it more basic and lowering its pK_b.

Step 3: Conclusion.

Since aniline is less basic than methylamine, its pK_b is higher, meaning aniline has a weaker tendency to accept a proton compared to methylamine.

Final Answer:

Aniline's pK_b is higher than methylamine because the phenyl group is electron-withdrawing, reducing t

Quick Tip

Substituent effects play a significant role in determining the basicity of compounds. Electron-donating groups increase basicity, while electron-withdrawing groups decrease it.

(d) Write a note on Tollen's test.

Solution:

Tollen's test is used to detect the presence of **aldehydes** in a given sample. The reagent used is **Tollen's reagent**, which is a solution of silver nitrate ($AgNO_3$) in aqueous ammonia (NH_3).

Step 1: Reaction with aldehydes.

When an aldehyde is present, it reduces the Tollen's reagent, resulting in the deposition of **silver mirror** on the inner surface of the test tube. The aldehyde is oxidized to a carboxylic acid in the process:

$$\text{RCHO} + 2[Ag(NH_3)_2]^+ + 3OH^- \rightarrow \text{RCOOH} + 2Ag + 2NH_3 + H_2O$$

Here, **RCHO** is the aldehyde group, and **RCOOH** is the corresponding carboxylic acid. The silver ions (Ag^+) are reduced to metallic silver, which deposits as a mirror.

Step 2: Application.

This test is widely used for the qualitative detection of aldehydes, as ketones do not react with Tollen's reagent.

Final Answer:

Tollen's test detects aldehydes, resulting in the formation of a silver mirror due to reduction of silver ion

Quick Tip

Aldehydes are easily distinguished from ketones using Tollen's test, which forms a silver mirror with aldehydes due to reduction.

Q4. (a) Which one between 0.1 M Urea and 0.1 M NaCl solution will have greater osmotic pressure? Explain the reason.

Solution:

Step 1: Osmotic Pressure Formula

The osmotic pressure (π) is given by the formula:

$$\pi = iMRT$$

where, - i = van't Hoff factor (number of particles into which a solute dissociates), - M = molarity of the solution, - R = universal gas constant, - T = temperature in Kelvin.

Step 2: Analyze Urea and NaCl

- Urea does not dissociate in water, so $i = 1$. - NaCl dissociates into two ions: Na^+ and Cl^-, so $i = 2$.

Step 3: Compare Osmotic Pressure

Given that NaCl dissociates into more particles, the osmotic pressure for NaCl will be higher than that for Urea, even though both have the same molarity.

Final Answer: The 0.1 M NaCl solution will have greater osmotic pressure.

Correct Answer: (NaCl has higher osmotic pressure)

Quick Tip

The van't Hoff factor plays a significant role in determining the osmotic pressure of a solution. More dissociation leads to higher osmotic pressure.

Q4(b). Explain the redox potential.

Solution:

Step 1: Define Redox Potential

Redox potential, also known as electrode potential, refers to the tendency of a chemical species to acquire electrons and thereby be reduced. It is measured in volts (V). The standard redox potential is denoted as E°, which is the potential of a half-cell in standard conditions (1 M concentration, 1 atm pressure, 25°C).

Step 2: Relation to Electrode Reactions

The redox potential indicates how easily a species gains or loses electrons. A positive E° value indicates that the species is more likely to be reduced (gain electrons), while a negative E° value suggests that it is more likely to be oxidized (lose electrons).

Final Answer: Redox potential quantifies the ability of a species to either gain or lose electrons during redox reactions.

Correct Answer: Redox potential refers to the tendency of a species to gain or lose electrons.

> Quick Tip
>
> A higher redox potential means a species is more readily reduced. Conversely, a lower redox potential indicates it is more likely to be oxidized.

Q4(c). Explain the zero order of reaction by giving examples.

Solution:

Step 1: Define Zero Order Reaction

A zero-order reaction is one in which the rate of reaction is independent of the concentration of the reactants. Mathematically, it is expressed as:

$$\text{Rate} = k$$

where k is the rate constant. The concentration of reactants does not affect the rate, and the reaction rate remains constant over time.

Step 2: Example of Zero Order Reaction

An example of a zero-order reaction is the decomposition of hydrogen peroxide on the surface of platinum:

$$2H_2O_2 \xrightarrow{Pt} 2H_2O + O_2$$

In this reaction, the rate of decomposition is independent of the concentration of hydrogen peroxide.

Final Answer: In zero-order reactions, the rate is constant and does not depend on the concentration of reactants.

Correct Answer: Zero-order reactions have a constant rate, unaffected by reactant concentration.

Quick Tip

Zero-order reactions are rare, typically occurring on a surface or where a catalyst is involved.

Q4(d). Write the color of following metal ions in aqueous solution:

Solution:

i) Zn^{2+}: Zinc ions in aqueous solution are colorless because they do not have any d-electrons to cause absorption in the visible spectrum.

ii) Cu^{2+}: Copper(II) ions in aqueous solution are blue due to the d-d transitions of the d^9 configuration in Cu^{2+}.

iii) Cu^{+}: Copper(I) ions are colorless in aqueous solution because they have a fully filled d^{10} configuration, which does not allow any electronic transitions in the visible range.

Correct Answer: i) Colorless

ii) Blue

iii) Colorless

Quick Tip

The color of metal ions in solution is often due to electronic transitions in the d-orbitals. The presence of unpaired electrons in the d-orbitals is key to these colorations.

Q5. (a) Calculate the electromotive force of the following cell:

$$\text{Cu}|\text{Cu}^{2+}(1M)||\text{Ag}^{+}(1M)|\text{Ag}$$

Given $E^{\circ}_{\text{Cu}^{2+}/\text{Cu}} = +0.34V$, $E^{\circ}_{\text{Ag}^{+}/\text{Ag}} = +0.80V$

Solution:

Step 1: Write the Nernst equation

The Nernst equation for a cell is given by:

$$E_{\text{cell}} = E^{\circ}_{\text{cell}} - \frac{0.0592}{n} \log Q$$

where: - E_{cell} is the electromotive force (EMF) of the cell, - E°_{cell} is the standard cell potential, - n is the number of electrons involved, - Q is the reaction quotient.

Step 2: Standard Cell Potential

The standard cell potential is:

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

Since the reduction half-reaction occurs at the cathode and the oxidation half-reaction occurs at the anode: - $E^{\circ}_{\text{cell}} = E^{\circ}_{\text{Ag}^{+}/\text{Ag}} - E^{\circ}_{\text{Cu}^{2+}/\text{Cu}}$

$$E^{\circ}_{\text{cell}} = 0.80V - 0.34V = 0.46V$$

Step 3: Calculate the Electromotive Force

Since both solutions are 1M, the reaction quotient $Q = 1$, and hence the log term becomes zero. Therefore, the electromotive force is equal to the standard cell potential:

$$E_{\text{cell}} = 0.46V$$

Final Answer: The electromotive force of the cell is $0.46V$.

Correct Answer: 0.46V

> Quick Tip
>
> When the concentrations of the solutions are 1 M, the electromotive force equals the standard cell potential.

Q5(b). Explain the molecularity of reaction with example.

Solution:

Step 1: Define Molecularity

Molecularity refers to the number of reactant molecules involved in an elementary reaction step. It is the number of particles (atoms, molecules, or ions) that collide to produce a reaction.

Step 2: Types of Molecularity

- **Unimolecular**: A reaction involving the collision of a single molecule, e.g., the decomposition of NO:

$$N_2O_5 \rightarrow 2NO_2 + O_2$$

- **Bimolecular**: A reaction involving the collision of two molecules, e.g., the reaction between hydrogen and iodine:

$$H_2 + I_2 \rightarrow 2HI$$

- **Trimolecular**: A reaction involving the collision of three molecules, e.g., a reaction between two nitrogen dioxide molecules and one oxygen molecule:

$$2NO_2 + O_2 \rightarrow 2NO_2$$

Final Answer: Molecularity refers to the number of molecules or ions involved in an elementary reaction.

Correct Answer: The number of molecules or ions involved in an elementary reaction.

Quick Tip

Molecularity is different from the order of reaction; molecularity is applicable to elementary reactions, while the order of reaction is a broader concept.

Q5(c). Explain that $[Co(NH_3)_5Cl]SO_4$ and $[Co(NH_3)_5SO_4]Cl$ are of which type of isomers.

Solution:

Step 1: Identify the Isomers

The given compounds are coordination compounds of cobalt. They have the same molecular formula but differ in the position of the ligands, so they are a type of **linkage isomers**.

Step 2: Explanation of Linkage Isomerism

In linkage isomerism, a ligand can coordinate to the metal center through different atoms. For example, in $[Co(NH_3)_5Cl]SO_4$, the chloride ion (Cl^-) is coordinating to the cobalt center, while in $[Co(NH_3)_5SO_4]Cl$, the sulfate ion (SO_4^{2-}) is coordinating.

Final Answer: The compounds $[Co(NH_3)_5Cl]SO_4$ and $[Co(NH_3)_5SO_4]Cl$ are linkage isomers.

Correct Answer: Linkage isomers.

Quick Tip

Linkage isomerism occurs when a ligand can bind to the metal through different atoms.

Q5(d). Fehling's solution is used to identify which type of compounds? Write chemical equations.

Solution:

Step 1: Identify the Type of Compounds

Fehling's solution is used to identify **reducing sugars** and **aldehydes**. It contains copper(II) ions that are reduced to copper(I) oxide when reacted with reducing agents.

Step 2: Chemical Equation

When Fehling's solution reacts with an aldehyde group, the copper(II) ions are reduced, and a red precipitate of copper(I) oxide forms:

$$\text{R-CHO} + \text{Cu}^{2+} + 2\text{OH}^- \rightarrow \text{R-COOH} + \text{Cu}_2\text{O} \downarrow + \text{H}_2\text{O}$$

where R-CHO is the aldehyde, and Cu_2O is the red precipitate.

Final Answer: Fehling's solution identifies reducing sugars and aldehydes.

Correct Answer: Reducing sugars and aldehydes.

Quick Tip

Fehling's solution is used in the detection of aldehydes by observing the formation of a red precipitate.

Q6. (a) Write IUPAC names of the following:

Solution:

i) CH3 - CH = CH(CH3)Br:

This is 3-Bromo-2-methylpropene.

ii) (CH3)$_2C - C - CH2$(Br) :

This is 1-Bromo-3-methylbutane.

iii) (CH3)$_2CBrCH2$CH3 :

This is 1-Bromo-2,3-dimethylpropane.

iv) (CH3)$_3CCl$:

This is tert-Butyl chloride.

v) NO2OHCl on the benzene ring:

This is 3-Nitro-4-hydroxyphenyl chloride.

Final Answer: i) 3-Bromo-2-methylpropene

ii) 1-Bromo-3-methylbutane

iii) 1-Bromo-2,3-dimethylpropane

iv) tert-Butyl chloride

v) 3-Nitro-4-hydroxyphenyl chloride

> Quick Tip
>
> When naming organic compounds, ensure the longest chain is chosen as the parent structure and numbering starts from the end nearest to the substituents.

OR

Q6(a). How may the following be obtained?

Solution:

i) Ethane from methyl iodide:

Ethane can be obtained from methyl iodide via a reduction reaction:

$$CH_3I + H_2 \xrightarrow{Ni} C_2H_6 + HI$$

Here, methyl iodide reacts with hydrogen in the presence of nickel catalyst to form ethane.

ii) Allyl chloride from propene:

Allyl chloride can be obtained by chlorination of propene:

$$CH_2 = CHCH_3 + Cl_2 \rightarrow CH_2CHCH_2Cl$$

Here, propene reacts with chlorine to form allyl chloride.

iii) Isopropyl bromide from propene:

Isopropyl bromide can be obtained from propene by reacting with hydrogen bromide:

$$CH_2 = CHCH_3 + HBr \rightarrow CH_3CH(Br)CH_3$$

Here, propene reacts with HBr to form isopropyl bromide.

iv) 1-Bromobutane from butene-1:

1-Bromobutane can be obtained by the addition of hydrogen bromide to butene-1:

$$CH_2 = CHCH_2CH_3 + HBr \rightarrow CH_3CH_2CH(Br)CH_3$$

Here, butene-1 reacts with HBr to form 1-bromobutane.

v) Propene from propene:

Propene is already present and no further reaction is needed.

Final Answer: i) Ethane from methyl iodide: Reduction with hydrogen

ii) Allyl chloride from propene: Chlorination with chlorine

iii) Isopropyl bromide from propene: Addition of HBr

iv) 1-Bromobutane from butene-1: Addition of HBr

v) Propene from propene: No reaction needed

> Quick Tip
>
> Alkene reactions with HX (like HBr) follow Markovnikov's rule where the halide adds to the carbon with the greater number of hydrogen atoms.

Q6(b). Write chemical equations for obtaining carboxylic acid from the following:

Solution:

i) Toluene:

Toluene can be oxidized to benzoic acid using potassium permanganate:

$$C_6H_5CH_3 + 2KMnO_4 + 2H_2O \rightarrow C_6H_5COOH + 2MnO_2 + 2KOH$$

ii) Ethane nitrile:

Ethane nitrile (ethyl cyanide) can be hydrolyzed to acetic acid:

$$CH_3CN + 2H_2O \xrightarrow{H^+} CH_3COOH$$

iii) Ethanamide:

Ethanamide can be hydrolyzed to acetic acid under acidic conditions:

$$CH_3CONH_2 + 2H_2O \xrightarrow{H^+} CH_3COOH + NH_3$$

iv) RMgX:

Grignard reagents (RMgX) can react with carbon dioxide to form carboxylic acids:

$$RMgX + CO_2 \xrightarrow{H^+} RCOOH$$

v) Benzoic anhydride:

Benzoic anhydride can be hydrolyzed to benzoic acid:

$$C_6H_5CO_2COC_6H_5 + H_2O \rightarrow 2C_6H_5COOH$$

Final Answer: i) Toluene $\rightarrow$ Benzoic acid with potassium permanganate

ii) Ethane nitrile $\rightarrow$ Acetic acid with water and acid

iii) Ethanamide $\rightarrow$ Acetic acid with water and acid

iv) RMgX $\rightarrow$ Carboxylic acid with CO

v) Benzoic anhydride $\rightarrow$ Benzoic acid with water

Correct Answer: Equations for each reaction are shown above.

> Quick Tip
>
> When working with Grignard reagents, always ensure that they are handled under anhydrous conditions to prevent hydrolysis.

Or

Q6(i). Explain the mechanism of the reaction of diethyl ether with HI.

Solution:

Step 1: Reaction Mechanism Overview

The reaction of diethyl ether with HI involves the cleavage of the ether bond, resulting in the formation of ethyl iodide and ethanol. The reaction proceeds via a nucleophilic substitution mechanism (S_N2).

Step 2: Mechanism

1. The protonation of the ether oxygen occurs due to the acidic nature of HI:

$$CH_3CH_2OCH_2CH_3 + HI \rightarrow CH_3CH_2OCH_2CH_3^+ + I^-$$

2. The protonated ether is now more electrophilic and undergoes cleavage, with the iodide ion (I^-) attacking one of the ethyl groups, leading to the formation of ethyl iodide:

$$CH_3CH_2OCH_2CH_3^+ \rightarrow CH_3CH_2I + CH_3CH_2OH$$

Final Answer: The reaction of diethyl ether with HI produces ethyl iodide and ethanol via an S_N2 mechanism.

Correct Answer: Ethyl iodide and ethanol are formed.

> Quick Tip
>
> In ether cleavage reactions, the bond between the oxygen and carbon atoms is broken, with the nucleophile attacking the less sterically hindered carbon.

Q6(ii). Explain the mechanism of dehydration of alcohol.

Solution:

Step 1: Reaction Overview

Dehydration of alcohols typically occurs in the presence of a strong acid, such as sulfuric acid (H_2SO_4), resulting in the elimination of a water molecule to form an alkene.

Step 2: Mechanism

1. Protonation of the alcohol's hydroxyl group to form a better leaving group:

$$\text{R-OH} + \text{H}^+ \rightarrow \text{R-OH}_2^+$$

2. The protonated alcohol undergoes loss of water to form a carbocation:

$$\text{R-OH}_2^+ \rightarrow \text{R}^+ + \text{H}_2\text{O}$$

3. The carbocation undergoes a rearrangement (if necessary) to form the most stable carbocation. 4. The carbocation then undergoes elimination of a proton (H^+) to form the alkene:

$$\text{R}^+ \rightarrow \text{C} = \text{C} + \text{H}^+$$

Final Answer: The dehydration of alcohols proceeds via the formation of a carbocation and elimination of a proton to form an alkene.

Correct Answer: The mechanism involves protonation, carbocation formation, and proton elimination.

Quick Tip

Dehydration of alcohols usually follows an E1 mechanism and works best with tertiary alcohols, as they form more stable carbocations.

Q7. (a) Write the chemical equation for the preparation of acetaldehyde and write a note on Aldol condensation and cross-Aldol condensation.

Solution:

Preparation of Acetaldehyde:

Acetaldehyde can be prepared by the reduction of acetic acid using a reducing agent like lithium aluminium hydride (LiAlH):

$$CH_3COOH + LiAlH_4 \rightarrow CH_3CHO + LiAlO_2$$

Acetaldehyde can also be prepared by the catalytic dehydrogenation of ethanol:

$$CH_3CH_2OH \xrightarrow{\text{Cu, 300°C}} CH_3CHO + H_2$$

Aldol Condensation:

Aldol condensation involves the reaction between two molecules of an aldehyde or ketone under basic conditions to form a -hydroxy aldehyde or ketone, which can then undergo dehydration to form an ,-unsaturated carbonyl compound.

For example, the condensation of acetaldehyde (ethanal):

$$2CH_3CHO \xrightarrow{\text{NaOH}} CH_3CH(OH)CH{=}CH_2$$

On heating, the -hydroxy aldehyde undergoes dehydration to form crotonaldehyde:

$$CH_3CH(OH)CH{=}CH_2 \xrightarrow{\Delta} CH_3CH{=}CHCHO$$

Cross-Aldol Condensation:

In cross-Aldol condensation, two different aldehydes or ketones react in the presence of a base to form a mixture of products, resulting in the formation of ,-unsaturated carbonyl compounds. For example, the reaction between acetaldehyde and benzaldehyde:

$$CH_3CHO + C_6H_5CHO \xrightarrow{\text{NaOH}} CH_3CH(OH)CH{=}CHC_6H_5$$

Upon heating, this -hydroxy product undergoes dehydration to form the ,-unsaturated compound:

$$CH_3CH(OH)CH{=}CHC_6H_5 \xrightarrow{\Delta} CH_3CH{=}CHC_6H_5$$

Final Answer: Acetaldehyde can be prepared by the reduction of acetic acid or by dehydrogenation of ethanol. Aldol condensation leads to the formation of -hydroxy aldehydes or ketones, which can undergo dehydration to form ,-unsaturated carbonyl compounds. Cross-Aldol condensation involves two different aldehydes or ketones and results in a mixture of products.

Correct Answer: The chemical equations for the preparation of acetaldehyde and the steps for Aldol and Cross-Aldol condensation are shown above.

Quick Tip

Aldol condensation is widely used in organic synthesis for the formation of carbon-carbon bonds, especially in the preparation of conjugated ,-unsaturated carbonyl compounds.

OR

Q7(a). Write notes on the following:

i) Mechanism of esterification of carboxylic acid:

Solution:

Esterification of carboxylic acids is typically carried out by reaction with an alcohol in the presence of an acid catalyst (usually concentrated sulfuric acid). This reaction forms an ester and water. The mechanism involves the following steps:

1. Protonation of the carboxyl group of the carboxylic acid to make it more electrophilic. 2. Nucleophilic attack of the alcohol's hydroxyl group on the electrophilic carbonyl carbon of the carboxylic acid. 3. Formation of a tetrahedral intermediate, followed by proton transfer. 4. Loss of a proton from the tetrahedral intermediate to form the ester and water.

$$\text{R-COOH} + \text{R'-OH} \xrightarrow{\text{H}^+} \text{R-COOR'} + \text{H}_2\text{O}$$

ii) Hell-Volhard-Zelinsky Reaction:

The Hell-Volhard-Zelinsky (HVZ) reaction is a halogenation of -position of carboxylic acids. In this reaction, a carboxylic acid reacts with a halogen (such as bromine) in the presence of phosphorus tribromide (PBr) to form an -halogenated carboxylic acid.

$$\text{R-COOH} + \text{Br}_2 \xrightarrow{\text{PBr}_3} \text{R-CH(Br)-COOH}$$

The mechanism involves the formation of an acyl halide intermediate, which reacts with halogen to introduce a halogen at the -position.

Final Answer: The esterification of carboxylic acids involves a reaction with alcohols to form esters and water, with sulfuric acid acting as a catalyst. The Hell-Volhard-Zelinsky reaction involves the halogenation of the -position of carboxylic acids using bromine and PBr.

Correct Answer: The mechanisms for esterification and Hell-Volhard-Zelinsky reaction are provided above.

Quick Tip

Esterification is a reversible reaction, and to drive it to completion, it's common to remove the water produced in the reaction or use excess alcohol.

Q7(b). Write the chemical equation for the preparation of Aniline and write the chemical equation of its reaction with the following:

Solution:

Preparation of Aniline:

Aniline can be prepared by reducing nitrobenzene with hydrogen in the presence of a palladium catalyst or using iron and hydrochloric acid:

$$\text{C}_6\text{H}_5\text{NO}_2 + 3\text{H}_2 \xrightarrow{\text{Pd/C}} \text{C}_6\text{H}_5\text{NH}_2 + 2\text{H}_2\text{O}$$

Alternatively, it can be prepared from chlorobenzene using a reaction with ammonia under high temperature and pressure:

$$C_6H_5Cl + NH_3 \xrightarrow{\text{High Temp.}} C_6H_5NH_2 + HCl$$

i) Reaction with CHCl in presence of KOH:

When aniline reacts with chloroform (CHCl) in the presence of potassium hydroxide (KOH), it undergoes a reaction known as the carbylamine reaction, forming an isocyanide (or isocyanide group):

$$C_6H_5NH_2 + CHCl_3 + KOH \rightarrow C_6H_5NC + KCl + H_2O$$

ii) Reaction with CHMgBr (Grignard reagent):

Aniline reacts with Grignard reagents like ethylmagnesium bromide (CHMgBr) to form a secondary amine:

$$C_6H_5NH_2 + C_2H_5MgBr \rightarrow C_6H_5NH(C_2H_5) + Mg(OH)Br$$

iii) Reaction with Bromine water:

Aniline reacts with bromine water to form 2,4,6-tribromoaniline:

$$C_6H_5NH_2 + 3Br_2 + 3H_2O \rightarrow C_6H_2Br_3NH_2 + 3HBr$$

iv) Reaction with NaNO and HCl (273-278 K):

Aniline reacts with sodium nitrite (NaNO) and hydrochloric acid (HCl) at low temperatures (273-278 K) to form diazonium salt, which is an important intermediate in many reactions:

$$C_6H_5NH_2 + NaNO_2 + HCl \xrightarrow{273-278K} C_6H_5N_2Cl + NaCl + H_2O$$

Final Answer: The preparation of aniline and its reactions with various reagents are shown above.

Correct Answer: Chemical equations for each reaction are shown above.

Quick Tip

In organic chemistry, the reaction of an amine with chloroform and KOH is a classic test for amines, known as the carbylamine reaction.

Or

Q7(b). Write short notes on the following:

i) Coupling reaction:

Solution:

A coupling reaction is a reaction in which two molecules, usually aromatic compounds, are joined together by the formation of a new carbon-carbon bond. This occurs typically in the presence of a catalyst like iron or copper. A well-known example is the coupling of diazonium salts with phenols or aniline derivatives to form azo compounds:

$$\text{ArN}_2^+ + \text{Ar'-OH} \rightarrow \text{Ar-N=Ar'} + \text{H}_2\text{O}$$

This reaction is used in the synthesis of azo dyes.

ii) Ammonolysis:

Ammonolysis is a chemical reaction in which an amine reacts with a substrate to replace a leaving group (often a halide or ester group) with an amino group (-NH). A common example is the reaction of alkyl halides with ammonia:

$$\text{R-Cl} + \text{NH}_3 \rightarrow \text{R-NH}_2 + \text{HCl}$$

Ammonolysis reactions are often used in the formation of primary amines.

iii) Gabriel phthalimide synthesis:

The Gabriel phthalimide synthesis is a method used to prepare primary amines from potassium phthalimide and an alkyl halide. The reaction involves the nucleophilic attack of phthalimide on an alkyl halide, followed by hydrolysis to release the primary amine:

$$\text{C}_6\text{H}_4\text{C(O)N}(\text{C}_2\text{H}_5)\text{K} + \text{R-Cl} \rightarrow \text{R-NH}_2 + \text{C}_6\text{H}_4\text{C(O)N}(\text{C}_2\text{H}_5) + \text{KCl}$$

Final Answer: Coupling reactions involve the joining of two molecules to form a new carbon-carbon bond, ammonolysis involves the replacement of a leaving group with an amino group, and the Gabriel phthalimide synthesis is a method for preparing primary amines.

Correct Answer: The notes on Coupling reaction, Ammonolysis, and Gabriel phthalimide synthesis are provided above.

Quick Tip

The Gabriel phthalimide synthesis is a useful method for preparing primary amines and avoids the use of toxic reagents like sodium azide.
