UP Board Class 12 CHEMISTRY SET 1 Question Paper with Solutions

Time Allowed :3 Hour 15 Minutes	**Maximum Marks :**70	**Total Questions :**33

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. **A**ll 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. Four alternatives are given in each part of this question. Write the correct alternative in your answer-book.

(a) **5 g NaOH is dissolved in 450 mL solution. Molarity of the solution is:**

(A) $0.125\,\text{mol}\,\text{L}^{-1}$ (B) $0.139\,\text{mol}\,\text{L}^{-1}$

(C) $0.250\,\text{mol}\,\text{L}^{-1}$ (D) $0.278\,\text{mol}\,\text{L}^{-1}$

Correct Answer: (A) $0.125\,\text{mol}\,\text{L}^{-1}$

Solution:

Step 1: Calculate the molar mass of NaOH.

The molar mass of NaOH is:

$$\text{Na: } 23\,\text{g/mol}, \quad \text{O: } 16\,\text{g/mol}, \quad \text{H: } 1\,\text{g/mol}.$$

$$\text{Molar mass of NaOH} = 23 + 16 + 1 = 40\,\text{g/mol}.$$

Step 2: Calculate the number of moles of NaOH.

The number of moles is given by:

$$\text{Moles of NaOH} = \frac{\text{Mass of NaOH}}{\text{Molar mass of NaOH}} = \frac{5}{40} = 0.125\,\text{mol}.$$

Step 3: Calculate the molarity of the solution.

The volume of the solution is 450 mL, which is:

$$450\,\text{mL} = 0.450\,\text{L}.$$

Molarity is given by:

$$\text{Molarity} = \frac{\text{Moles of solute}}{\text{Volume of solution in liters}} = \frac{0.125}{0.450} = 0.125\,\text{mol}\,\text{L}^{-1}.$$

Quick Tip

When calculating molarity, ensure the volume is converted to liters. Always use the formula:

$$\text{Molarity} = \frac{\text{Moles of solute}}{\text{Volume of solution in liters}}.$$

1. (B) The oxidation number of Cobalt in $K_3[Co(C_2O_4)_3]$ complex is:
(A) 1 (B) 2
(C) 3 (D) 6
Correct Answer: (C) 3
Solution:
Step 1: The oxidation number of the oxalate ion $C_2O_4^{2-}$ is -2.
Step 2: Since the complex is neutral:

$$3(+1) + x + 3(-2) = 0 \quad \Rightarrow \quad 3 + x - 6 = 0 \quad \Rightarrow \quad x = 3.$$

Thus, the oxidation number of cobalt is +3.

Quick Tip

For coordination complexes, balance the charge using the known oxidation states of ligands.

1. (C) The transition element in which variable oxidation state is not found, is:
(A) Sc
(B) Ti
(C) V
(D) Cr
Correct Answer: (A) Sc
Solution:
Step 1: Scandium (Sc) shows only one stable oxidation state, which is +3.
Step 2: Other elements like Ti, V, and Cr show variable oxidation states due to their electron configurations.

Quick Tip

Transition elements exhibit variable oxidation states due to the involvement of d-orbitals in bonding.

1. (d) The compound having the most basic strength is:
(A) $(CH_3)_2NH$ (B) CH_3NH_2
(C) $(CH_3)_3N$ (D) NH_3
Correct Answer: (A) $(CH_3)_2NH$
Solution:
Step 1: The basicity depends on the availability of the lone pair of electrons on nitrogen.
Step 2: $(CH_3)_2NH$ is the most basic due to the inductive effect of methyl groups, which increases electron density on nitrogen.

Quick Tip

Electron-donating groups enhance the basicity of amines by increasing electron density on the nitrogen atom.

1. (e) The compound which is not a disaccharide is:
(A) Sucrose (B) Cellulose
(C) Lactose (D) Maltose
Correct Answer: (B) Cellulose
Solution:
Step 1: Disaccharides consist of two monosaccharide units. Examples include sucrose, lactose, and maltose.
Step 2: Cellulose is a polysaccharide and does not fall under the category of disaccharides.

> Quick Tip
>
> Disaccharides are formed by the glycosidic linkage between two monosaccharide units.

1. (f) Which of the following compounds is identified by Tollen's reagent?
(A) Alcohol (B) Aldehyde
(C) Ketone (D) Carboxylic acid
Correct Answer: (B) Aldehyde
Solution:
Step 1: Tollen's reagent is specific for aldehydes and gives a silver mirror test.
Step 2: Alcohols, ketones, and carboxylic acids do not respond to Tollen's reagent.

> Quick Tip
>
> Tollen's reagent is an oxidizing agent that reacts with aldehydes to form silver metal.

2. (a) 30 g Ethylene glycol ($C_2H_6O_2$) was mixed in 450 g water. Calculate the following:
(A) Depression in freezing point of solution.
(B) Freezing point of the solution.

Solution:
Step 1: Calculate the molality of the solution.
The molar mass of ethylene glycol ($C_2H_6O_2$) is:

$$\text{C: } 2 \times 12 = 24, \quad \text{H: } 6 \times 1 = 6, \quad \text{O: } 2 \times 16 = 32.$$

$$\text{Molar mass} = 24 + 6 + 32 = 62\,\text{g/mol}.$$

The number of moles of ethylene glycol is:

$$\text{Moles} = \frac{\text{Mass}}{\text{Molar mass}} = \frac{30}{62} \approx 0.484\,\text{mol}.$$

The mass of water is $450\,\text{g} = 0.450\,\text{kg}$, so:

$$\text{Molality} = \frac{\text{Moles of solute}}{\text{Mass of solvent in kg}} = \frac{0.484}{0.450} \approx 1.075\,\text{mol/kg}.$$

Step 2: Calculate the depression in freezing point.
The depression in freezing point is given by:

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

where K_f for water is $1.86\,\mathrm{K\,kg/mol}$.

$$\Delta T_f = 1.86 \times 1.075 \approx 2.00\,\mathrm{K}.$$

Step 3: Calculate the freezing point of the solution.
The freezing point of pure water is 0° C. Thus:

$$\text{Freezing point of solution} = 0 - 2.00 = -2.00^\circ\,\mathrm{C}.$$

Quick Tip

To calculate depression in freezing point, use the formula:

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

where K_f is the cryoscopic constant and m is the molality of the solution.

2. (b) Define the following:
(A) Mole fraction
(B) Molality

Solution:
(A) Mole fraction: It is the ratio of the number of moles of a component to the total number of moles of all components in the solution.

$$\text{Mole fraction} = \frac{\text{Number of moles of component}}{\text{Total moles of solution}}.$$

(B) Molality: It is defined as the number of moles of solute present in 1 kg of the solvent.

$$\text{Molality} = \frac{\text{Number of moles of solute}}{\text{Mass of solvent in kg}}.$$

Quick Tip

Mole fraction is unitless, while molality is expressed in mol/kg.

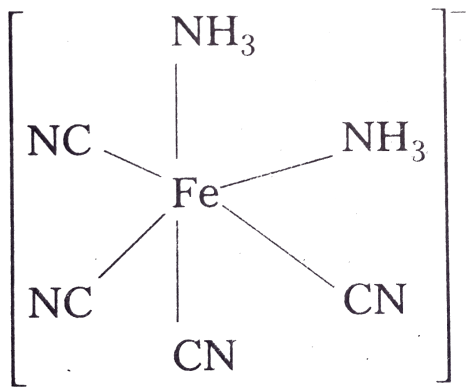
2. (c) What is Lanthanoid Contraction? Discuss the effect of Lanthanoid Contraction.
Solution:
Definition: Lanthanoid Contraction refers to the steady decrease in the ionic radii of the lanthanoid elements ($4f$-block) as the atomic number increases.
Effect:

- Leads to similar chemical properties of elements in the same group.
- Causes increased hardness and higher melting points of transition elements.
- Reduces the size difference between second and third-row transition metals.

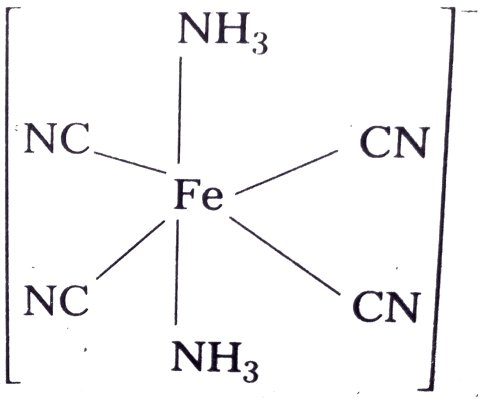
Quick Tip

Lanthanoid Contraction is caused by the imperfect shielding of $4f$-electrons.

2. (d) Show the structure of geometrical isomers of $[Fe(\mathbf{NH_3})_2(\mathbf{CN})_4]^-$.
Solution:
The complex $[Fe(NH_3)_2(CN)_4]^-$ exhibits **cis** and **trans** geometrical isomers.
Cis-isomer: NH_3 ligands are adjacent to each other.
Trans-isomer: NH_3 ligands are opposite to each other.



cis



trans

Quick Tip

Geometrical isomerism occurs in octahedral complexes when different ligands occupy adjacent or opposite positions.

3. (a) Recognize all the possible monochloro structural isomers formed by free radical chlorination of $\mathbf{CH_3 - CH_2 - CH_2 - CH_3}$.
Solution:
Step 1: Free radical chlorination replaces a single hydrogen atom with chlorine in the molecule.
Step 2: Possible structural isomers:

1-chlorobutane: $CH_2Cl - CH_2 - CH_2 - CH_3$

2-chlorobutane: $CH_3 - CHCl - CH_2 - CH_3$

3-chlorobutane: $CH_3 - CH_2 - CHCl - CH_3$

Quick Tip

In free radical chlorination, every unique hydrogen position in a molecule can yield a distinct monochloro product.

3. (b) Phenol shows acidic properties, but ethanol is almost neutral. Explain with reason.
Solution:
Step 1: Phenol (C_6H_5OH) is acidic because the phenoxide ion ($C_6H_5O^-$) formed after losing a proton is stabilized by resonance.
Step 2: Ethanol (C_2H_5OH) is neutral because the ethoxide ion ($C_2H_5O^-$) does not have any resonance stabilization.
Conclusion: Resonance stabilization in phenol makes it acidic, whereas ethanol lacks such stabilization.

Quick Tip

The acidity of a compound depends on the stability of its conjugate base. Resonance plays a key role in stabilization.

3. c Differentiate between the following:
(A)Acetaldehyde and Acetone
(B)Acetophenone and Benzophenone

Solution:
(A) Acetaldehyde (CH_3CHO) vs. Acetone (CH_3COCH_3):

- Acetaldehyde is an aldehyde with a terminal carbonyl group ($-CHO$).
- Acetone is a ketone with a carbonyl group bonded to two alkyl groups.

(B) Acetophenone ($C_6H_5COCH_3$) vs. Benzophenone ($C_6H_5COC_6H_5$):

- Acetophenone has one aromatic ring attached to the carbonyl group.
- Benzophenone has two aromatic rings attached to the carbonyl group.

Quick Tip

Aldehydes have a terminal carbonyl group, while ketones have a non-terminal carbonyl group. Aromatic ketones can have one or two rings attached to the carbonyl group.

3. (d) What is the difference between nucleoside and nucleotide? Explain.
Solution:
Definition:

- A nucleoside consists of a nitrogenous base and a sugar molecule.
- A nucleotide consists of a nitrogenous base, a sugar molecule, and a phosphate group.

Difference:

- Nucleosides are precursors to nucleotides.
- Nucleotides are building blocks of nucleic acids like DNA and RNA.

Quick Tip

Nucleosides lack phosphate groups, while nucleotides contain phosphate groups and are involved in forming nucleic acids.

4. (a) Define solution. In how many different ways may the concentration of a solution be expressed? Explain.

Solution:

Definition of Solution: A solution is a homogeneous mixture of two or more substances. The component present in a larger quantity is called the solvent, and the one in a smaller quantity is the solute.

Ways to Express Concentration:

(A) **Mass Percentage (% w/w):** The mass of solute per 100 g of the solution.
(B) **Volume Percentage (% v/v):** The volume of solute per 100 mL of the solution. (C) **Molarity (M):** The number of moles of solute per liter of solution.
(D) **Molality (m):** The number of moles of solute per kilogram of solvent. (E) **Mole Fraction (x):** The ratio of the number of moles of solute to the total number of moles in the solution.

Quick Tip

Always choose the method to express concentration based on the type of solution and the requirements of the experiment.

4. (b) Define the conductance and molar conductance of a solution of any electrolyte. Discuss their variation with concentration.

Solution:

Conductance (G): It is the reciprocal of resistance (R) and measures the ability of a solution to conduct electricity. Its SI unit is Siemens (S).

Molar Conductance (Λ_m): It is the conductance of all ions produced by one mole of an electrolyte in a solution. It is given by:

$$\Lambda_m = \frac{1000\,\mathrm{G}}{\mathrm{C}},$$

where C is the molarity of the solution.

Variation with Concentration:

- **Strong electrolytes:** Λ_m increases with dilution due to the complete dissociation of ions and a decrease in interionic attractions.
- **Weak electrolytes:** Λ_m increases sharply with dilution because ionization increases at lower concentrations.

Quick Tip

For weak electrolytes, use Kohlrausch's Law to calculate Λ_m° (limiting molar conductance) by extrapolation.

4. (c) What do you understand by first order reaction? The time taken in becoming 0.4 mol/L from initial concentration of 0.6 mol/L is 5 minutes in a first order reaction. How much time will be required for the initial concentration to reach 0.3 mol/L?
Solution:
Definition of First Order Reaction: A reaction is said to be of first order when the rate of reaction is directly proportional to the concentration of one reactant.
Step 1: Use the first-order rate equation:

$$k = \frac{1}{t} \ln \left(\frac{[A]_0}{[A]} \right).$$

From the given data:

$$k = \frac{1}{5} \ln \left(\frac{0.6}{0.4} \right) = \frac{1}{5} \ln \left(\frac{3}{2} \right).$$

Step 2: Calculate the time required to reach 0.3 mol/L:

$$t = \frac{1}{k} \ln \left(\frac{[A]_0}{[A]} \right).$$

Substitute the values:

$$t = \frac{5}{\ln(3/2)} \ln \left(\frac{0.6}{0.3} \right).$$

$$t = \frac{5}{\ln(3/2)} \ln(2).$$

Step 3: Simplify using logarithmic values:

$$\ln(3/2) \approx 0.405, \quad \ln(2) \approx 0.693.$$

$$t = \frac{5}{0.405} \times 0.693 \approx 8.55 \text{ minutes}.$$

Final Answer: The time required is approximately 8.55 minutes.

> Quick Tip
>
> For first-order reactions, the half-life ($t_{1/2}$) is constant and independent of concentration. Use $t_{1/2} = \frac{\ln(2)}{k}$ for quick calculations.

4. (d) Describe with reason:
(A) (Fe^{2+} is a reducing agent while Mn^{2+} is an oxidizing agent.
(B) (Sc (Z=21) is a transition element but Zn ($Z = 30$) is not.
(C) Transition elements and their compounds work as good catalysts.

Solution:
(A) Fe^{2+} is a reducing agent while Mn^{2+} is an oxidizing agent:

- Fe^{2+} can lose an electron to form Fe^{3+}, making it a reducing agent.
- Mn^{2+}, in contrast, can gain an electron to achieve a higher oxidation state like Mn^{3+}, making it an oxidizing agent.

Quick Tip

The reducing or oxidizing behavior of ions depends on their electronic configurations and stability of the resulting oxidation states.

4. (B) Sc $(Z = 21)$ is a transition element but Zn $(Z = 30)$ is not:

- **Transition elements are defined as those with partially filled d-orbitals. Sc has a $3d^1$ configuration.**
- **Zn has a $3d^{10}$ configuration, meaning its d-orbitals are completely filled, so it is not a transition element.**

Quick Tip

Transition elements must have an incomplete d-orbital either in their ground state or in one of their oxidation states.

4. (C) Transition elements and their compounds work as good catalysts:

- **Transition elements can use their variable oxidation states to provide alternate reaction pathways with lower activation energy.**
- **Their d-orbitals allow adsorption of reactants, facilitating the breaking and forming of bonds during the reaction.**
- **Example: Fe in the Haber process and V_2O_5 in the Contact process.**

Quick Tip

Catalysis by transition elements is effective due to their ability to form variable oxidation states and adsorb reactants on their surface.

1. (a) (i) Cu(s) does not dissolve in HCl. Why?

Solution: Copper (Cu) does not react with hydrochloric acid (HCl) because it is less reactive than hydrogen. As per the reactivity series, only metals above hydrogen can displace it from acids, and copper is below hydrogen.

Quick Tip

Check the reactivity series of metals to predict their ability to react with acids.

5. (a)(ii) Can you keep copper sulphate solution in a vessel of zinc? Explain with reason.

Solution: No, you cannot keep copper sulfate ($CuSO_4$) solution in a vessel made of zinc because zinc is more reactive than copper. Zinc will displace copper from the solution:

$$\text{Zn (s)} + \text{CuSO}_4\text{(aq)} \rightarrow \text{ZnSO}_4\text{(aq)} + \text{Cu (s)}.$$

Quick Tip

Use the reactivity series to predict displacement reactions between metals and metal salts.

1. (b) What is Activation Energy? Calculate velocity constant at 700 K.
Solution:
Definition: Activation energy is the minimum energy required for a chemical reaction to occur.
Step 1: Use the Arrhenius equation:

$$k = Ae^{-\frac{E_a}{RT}}.$$

Taking the logarithm:

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

Step 2: Given:

$$T_1 = 600\,\text{K}, \quad k_1 = 1.60 \times 10^{-5}\,\text{s}^{-1}, \quad E_a = 209\,\text{kJ/mol} = 209 \times 10^3\,\text{J/mol}.$$

$$T_2 = 700\,\text{K}, \quad R = 8.314\,\text{J/mol K}.$$

Using:

$$\ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right),$$

$$\ln\left(\frac{k_2}{1.60 \times 10^{-5}}\right) = \frac{209 \times 10^3}{8.314}\left(\frac{1}{600} - \frac{1}{700}\right).$$

Step 3: Solve for k_2:

$$\ln\left(\frac{k_2}{1.60 \times 10^{-5}}\right) = 30.79 \times 0.0002381 = 7.33.$$

$$k_2 = 1.60 \times 10^{-5} \times e^{7.33} \approx 1.60 \times 10^{-5} \times 1510 = 2.42 \times 10^{-2}\,\text{s}^{-1}.$$

Quick Tip

Use the Arrhenius equation to relate rate constants at different temperatures, knowing activation energy.

1. (c) (i) Solution of $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ is green, but $[\text{Ni}(\text{CN})_4]^{2-}$ is colourless. Explain.
Solution: $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ is green because water is a weak field ligand, causing incomplete splitting of d-orbitals and allowing d-d transitions. $[\text{Ni}(\text{CN})_4]^{2-}$ is colourless because cyanide is a strong field ligand that causes complete splitting of d-orbitals, suppressing d-d transitions.

Quick Tip

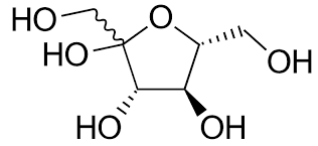
The colour of coordination compounds depends on the ligand field strength and d-d transitions.

1. (c) (ii)$[\text{Cr}(\text{NH}_3)_6]^{3+}$ is paramagnetic, while $[\text{Ni}(\text{CN})_4]^{2-}$ is diamagnetic. Explain.

Solution: $[Cr(NH_3)_6]^{3+}$ has unpaired electrons due to its d^3 configuration, making it paramagnetic. $[Ni(CN)_4]^{2-}$ has no unpaired electrons because cyanide is a strong field ligand, causing pairing of electrons in the d-orbitals.

> **Quick Tip**
>
> Paramagnetic behavior arises from unpaired electrons, while diamagnetic behavior occurs when all electrons are paired.

1. (d) Write the structural formula of fructose. Write chemical equations of three chemical properties of glucose.
Solution:
Structure of Fructose:



Chemical Properties of Glucose:
(A) Reduction:

$$C_6H_{12}O_6 + 2H_2 \xrightarrow{\text{Reduction}} C_6H_{14}O_6.$$

(B) Oxidation:

$$C_6H_{12}O_6 + Br_2 \xrightarrow{\text{Oxidation}} C_6H_{12}O_7.$$

(C) Fermentation:

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

> **Quick Tip**
>
> Glucose undergoes reduction, oxidation, and fermentation due to its aldehydic and hydroxyl groups.

6. (a) What happens when:
(i) Ethyl bromide reacts with sodium ethoxide?
(ii) Chlorobenzene reacts with nitric acid?
(iii) Chlorobenzene is heated at 623 K and 300 atmospheric pressure with aqueous sodium hydroxide?
(iv) Chlorobenzene reacts with sulphuric acid?
(v) Ethyl chloride is heated with aqueous KOH?

Solution:
(i)

$$C_2H_5Br + NaOEt \rightarrow C_2H_5OEt + NaBr$$

In substitution reactions, the halide (Br) in ethyl bromide is replaced by ethoxide (OEt), forming ethyl ethoxide and sodium bromide.
(ii)

$$C_6H_5Cl + HNO_3 \rightarrow C_6H_4ClNO_2 + H_2O$$

Nitration of chlorobenzene results in the substitution of a hydrogen atom with a nitro group (-NO_2)$underacidicconditions$.
(iii)

$$C_6H_5Cl + NaOH \xrightarrow{623\,K,\,300\,atm} C_6H_5OH + NaCl$$

This is a nucleophilic substitution reaction where chlorine is replaced by the hydroxyl group to form phenol under harsh conditions (high temperature and pressure).
(iv)

$$C_6H_5Cl + H_2SO_4 \rightarrow C_6H_4ClSO_3H + H_2O$$

Sulphonation is an electrophilic substitution where the -SO-3H group replaces a hydrogen atom on the benzene ring.
(v)

$$C_2H_5Cl + KOH \rightarrow C_2H_5OH + KCl$$

This reaction is an example of a nucleophilic substitution, where the chlorine atom in ethyl chloride is replaced by a hydroxyl group to form ethanol.

OR

6. (a) OR What is electrophilic substitution reaction? Explain with chemical equation the reactions of electrophilic substitution reactions of halogenation, nitration, and sulphonation of chlorobenzene.

Solution:
An electrophilic substitution reaction involves the substitution of a hydrogen atom in a benzene ring by an electrophile. The following are examples of electrophilic substitution reactions with chlorobenzene:
Halogenation of Chlorobenzene:

$$C_6H_5Cl + Cl_2 \xrightarrow{FeCl_3} C_6H_4Cl_2 + HCl$$

Halogenation occurs in the presence of a Lewis acid like $FeCl_3 toactivatechlorineastheelectrophile, whichthe$
Nitration of Chlorobenzene:
Reaction:

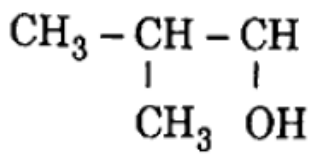
$$C_6H_5Cl + HNO_3 \xrightarrow{H_2SO_4} C_6H_4ClNO_2 + H_2O$$

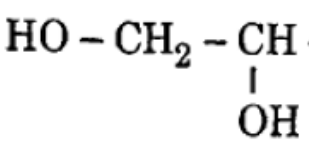
Nitration involves the generation of the nitronium ion (NO_2^+)$inthepresenceofconcentratedsulfuricacid, wh$
Sulphonation of Chlorobenzene:
Reaction:

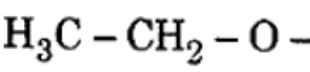
$$C_6H_5Cl + H_2SO_4 \rightarrow C_6H_4ClSO_3H + H_2O$$

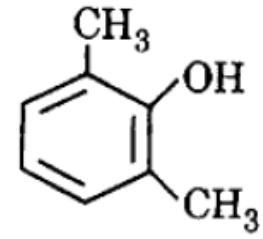
Sulphonation occurs when sulfuric acid reacts with chlorobenzene to replace a hydrogen atom with a sulfonic acid group (-SO_3H).

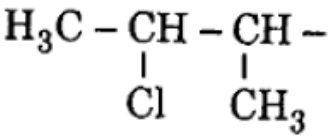
(b) Write IUPAC name of

(i) 

(ii) 

(iii) 

(iv) 

(v) 

6 (b) Write IUPAC name of the following compounds:

Solution: (A) The compound has a branching with two methyl groups on the second carbon and an alcohol (-OH) group on the third carbon. The IUPAC name is:

$$2,3-Dimethyl-3-pentanol.$$

Quick Tip

For compounds with branching, identify the longest chain containing the functional group and prioritize numbering based on the substituents and functional groups.

(B) The compound has two hydroxyl (-OH) groups attached to a propane chain. The IUPAC name is:

$$1,2,3-Propanetriol.$$

Quick Tip

For compounds with multiple functional groups of the same type, use the appropriate prefix (e.g., di-, tri-) and include the position of each group in the name.

(C) The compound is an ether with a propyl chain and a 2-methyl group on the attached butyl chain. The IUPAC name is:

$$2 - Methylbutoxypropane.$$

Quick Tip

For ethers, name the alkyl groups attached to the oxygen in alphabetical order and use the suffix "oxy" for the smaller group.

(D) The compound is a benzene ring with two methyl groups at positions 2 and 4 and an alcohol (-OH) group at position 1. The IUPAC name is:

$$2,4 - Dimethylphenol.$$

Quick Tip

For benzene derivatives, prioritize functional groups like -OH over substituents such as methyl and number the ring accordingly.

(v) The compound has a chlorine atom on the second carbon, two methyl groups on the third carbon, and an alcohol (-OH) group on the fifth carbon. The IUPAC name is:

$$5 - Chloro - 3,3 - dimethylpentan - 1 - ol.$$

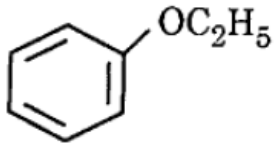
Quick Tip

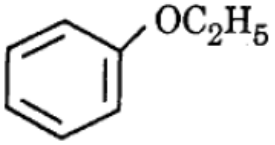
For compounds with multiple substituents, list them in alphabetical order, and ensure the functional group gets the lowest possible number.

6. Predict the products obtained in the following reactions:

OR

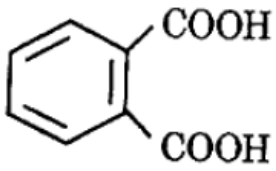
Predict the products obtained in the following reactions :

(i)  + HBr $\longrightarrow$

(ii)  $\xrightarrow[\text{conc. } HNO_3]{\text{conc. } H_2SO_4}$

(iii) $H_3C - CH = CH_2 \xrightarrow{H_2O/H^+}$

(iv) $H_3C - CH_2 - \underset{\displaystyle CH_3}{\underset{|}{CH}} - CHO \xrightarrow{NaBH_4}$

(v)  $\xrightarrow[\text{Temp.}]{SOCl_2}$

Solution:

(A) The reaction of ethyl phenyl ether ($C_6H_5OC_2H_5$) with HBr results in cleavage of the ether bond. The products are phenol (C_6H_5OH) and ethyl bromide (C_2H_5Br).

$$C_6H_5OC_2H_5 + HBr \rightarrow C_6H_5OH + C_2H_5Br$$

Ether cleavage with HBr forms an alcohol and an alkyl halide. The phenyl group always retains the hydroxyl (-OH) group.

(B) The reaction of ethyl phenyl ether ($C_6H_5OC_2H_5$) with concentrated H_2SO_4 and HNO_3 introduces a nitro group at the para position of the benzene ring. The product is 4-nitrophenyl ethyl ether.

$$C_6H_5OC_2H_5 + conc.\, HNO_3 \xrightarrow{conc.\, H_2SO_4} 4 - Nitrophenyl\, ethyl\, ether$$

Electrophilic substitution reactions of benzene derivatives often lead to substitution at the para position if the substituent is an ortho/para director.

(C) Propene ($H_3C - CH = CH_2$) undergoes acid-catalyzed hydration (H_2O/H^+) to form isopropanol ($CH_3CHOHCH_3$) as the major product.

$$H_3C - CH = CH_2 + H_2O \xrightarrow{H^+} CH_3CHOHCH_3$$

Acid-catalyzed hydration of alkenes follows Markovnikov's rule, where the hydroxyl group (-OH) attaches to the more substituted carbon.

(D) The reduction of 3-methylbutanal ($CH_3CH_2CH(CH_3)CHO$) with sodium borohydride ($NaBH_4$) results in the formation of 3-methylbutanol ($CH_3CH_2CH(CH_3)CH_2OH$).

$$CH_3CH_2CH(CH_3)CHO \xrightarrow{NaBH_4} CH_3CH_2CH(CH_3)CH_2OH$$

Sodium borohydride ($NaBH_4$) reduces aldehydes to primary alcohols without affecting other functional groups like alkenes.
(E) Benzenedicarboxylic acid ($C_6H_4(COOH)_2$) reacts with thionyl chloride ($SOCl_2$) to form the corresponding acid chloride ($C_6H_4(COCl)_2$).

$$C_6H_4(COOH)_2 + 2SOCl_2 \xrightarrow{\text{Temp.}} C_6H_4(COCl)_2 + 2SO_2 + 2HCl$$

Thionyl chloride ($SOCl_2$) converts carboxylic acids into acid chlorides, releasing SO_2 and HCl as by-products.

(a) Write only chemical equations for the following changes:

Solution:

(A) Butanoic acid from Butan-1-ol

$$CH_3CH_2CH_2CH_2OH + [O] \xrightarrow{K_2Cr_2O_7/H^+} CH_3CH_2CH_2COOH$$

Quick Tip

Oxidation of primary alcohols with $K_2Cr_2O_7$ and H^+ converts them to carboxylic acids.

(B) Butanoic acid from Butanal

$$CH_3CH_2CH_2CHO + [O] \xrightarrow{K_2Cr_2O_7/H^+} CH_3CH_2CH_2COOH$$

Quick Tip

Oxidation of aldehydes leads to carboxylic acids using oxidizing agents like $K_2Cr_2O_7$ or $KMnO_4$.

(C) 3-Nitrobenzoic acid from 3-Nitrobromobenzene

$$C_6H_4(NO_2)Br + Mg \xrightarrow{Dry\ Ether} C_6H_4(NO_2)MgBr \xrightarrow{CO_2,H^+} C_6H_4(NO_2)COOH$$

Quick Tip

Grignard reagents react with CO_2 to form carboxylic acids after hydrolysis.

(D) Phenyl ethanoic acid from Benzyl alcohol

$$C_6H_5CH_2OH + [O] \xrightarrow{KMnO_4/OH^-} C_6H_5CH_2COOH$$

Quick Tip

Benzyl alcohols oxidize to phenyl carboxylic acids using strong oxidizing agents like $KMnO_4$.

(v) Acetamide from Acetic acid

$$CH_3COOH + NH_3 \xrightarrow{\Delta} CH_3CONH_2 + H_2O$$

> Quick Tip
>
> Heating carboxylic acids with ammonia forms amides and releases water.

OR A carboxylic acid 'B' and an alcohol 'C' were obtained after hydrolysis of an organic compound 'A' (molecular formula $C_8H_{16}O_2$) with dilute sulphuric acid. 'B' is produced on oxidation of 'C' with chromic acid. But-1-ene is obtained on dehydration of 'C'. Identify 'A', 'B' and 'C'. Write chemical equations for all the reactions involved.
Solution:
Compound 'A' is $CH_3COOCH_2CH_2CH_3$ (propyl acetate).
Compound 'B' is CH_3COOH (acetic acid).
Compound 'C' is $CH_3CH_2CH_2OH$ (propan-1-ol).
Reactions:
Hydrolysis of A:

$$CH_3COOCH_2CH_2CH_3 + H_2O \xrightarrow{H^+} CH_3COOH + CH_3CH_2CH_2OH$$

Oxidation of C to B:

$$CH_3CH_2CH_2OH + [O] \xrightarrow{K_2Cr_2O_7/H^+} CH_3COOH$$

Dehydration of C:

$$CH_3CH_2CH_2OH \xrightarrow{H_2SO_4/\Delta} CH_2 = CHCH_3 + H_2O$$

> Quick Tip
>
> Ester hydrolysis produces an alcohol and a carboxylic acid. Oxidation of primary alcohols forms carboxylic acids, while dehydration forms alkenes.

(b) Differentiate between the following pairs of compounds by writing chemical equations of one chemical test:
Solution:
(A) Methylamine and Dimethylamine Methylamine gives a positive carbylamine test, forming isocyanide with an unpleasant smell:

$$CH_3NH_2 + CHCl_3 + 3KOH \xrightarrow{\Delta} CH_3NC + 3KCl + 3H_2O$$

Dimethylamine does not give the carbylamine test.

Quick Tip

The carbylamine test is specific for primary amines and helps distinguish them from secondary and tertiary amines.

(B) Ethylamine and Aniline Ethylamine forms a clear solution with water, while aniline forms a milky suspension due to its low solubility in water.

Quick Tip

The solubility test distinguishes aliphatic amines (soluble) from aromatic amines (less soluble).

(C) Aniline and Benzylamine Aniline reacts with bromine water to form a white precipitate of 2,4,6-tribromoaniline:

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

Benzylamine does not react with bromine water.

Quick Tip

Aromatic amines undergo bromination to form a tribromo derivative, unlike aliphatic amines.

(D) Aniline and N-Methylamine Aniline reacts with HNO_2 to form a diazonium salt:

$$C_6H_5NH_2 + HNO_2 \rightarrow C_6H_5N_2^+Cl^- + H_2O$$

N-Methylamine forms methanol:

$$CH_3NHCH_3 + HNO_2 \rightarrow CH_3OH + N_2 + H_2O$$

Quick Tip

The diazotization test is used to detect primary aromatic amines.

(v) Secondary and Tertiary Amine Secondary amines form nitrosamines with HNO_2, producing a yellow oily layer:

$$R_2NH + HNO_2 \rightarrow R_2NNO + H_2O$$

Tertiary amines do not react.

Quick Tip

Reaction with HNO_2 differentiates secondary and tertiary amines.

(b) OR Write short notes on the following:
Solution:
(A) Carbylamine Reaction:

The carbylamine reaction is used to detect primary amines. In this reaction, a primary amine reacts with chloroform ($CHCl_3$) and alcoholic potassium hydroxide (KOH) to produce an isocyanide, which has an unpleasant odor:

$$RNH_2 + CHCl_3 + 3KOH \xrightarrow{\Delta} RNC + 3KCl + 3H_2O$$

Quick Tip

The carbylamine test is specific for primary amines and does not occur with secondary or tertiary amines.

(B) Diazotization:
Diazotization is a process where a primary aromatic amine reacts with nitrous acid (HNO_2) to form a diazonium salt. The reaction is carried out at low temperatures ($0 - 5°C$) to stabilize the diazonium salt:

$$C_6H_5NH_2 + HNO_2 + HCl \xrightarrow{0-5°C} C_6H_5N_2^+Cl^- + 2H_2O$$

Quick Tip

Diazotization is commonly used in the synthesis of azo dyes and in coupling reactions for aromatic compounds.

(C) Gabriel Phthalimide Synthesis:
The Gabriel phthalimide synthesis is used to prepare primary amines. In this reaction, phthalimide is treated with potassium hydroxide (KOH) to form a potassium salt, which reacts with an alkyl halide to produce an N-alkylphthalimide. Hydrolysis of this intermediate yields the primary amine:

$$C_6H_4(CO)_2NH + KOH \rightarrow C_6H_4(CO)_2NK + H_2O$$

$$C_6H_4(CO)_2NK + RBr \rightarrow C_6H_4(CO)_2NR + KBr$$

$$C_6H_4(CO)_2NR + H_2O + NaOH \rightarrow RNH_2 + C_6H_4(COONa)_2$$

Quick Tip

Gabriel synthesis is ideal for preparing primary aliphatic amines but not for aromatic amines.