UP Board Class 12 Chemistry Code 347 CA 2023 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.

1(a). The solid which is electrical conductor, ductile and tensile, is called:

(A) Molecular solid

(B) Ionic solid

(C) Metallic solid

(D) Coordinate solid

Correct Answer: (C) Metallic solid

Solution:

Step 1: Understanding the properties of solids.

- Molecular solids are soft and poor conductors.

- Ionic solids conduct only in molten/aqueous form.

- Metallic solids are good conductors, ductile and malleable.

- Coordinate solids are not ductile or conductive like metals.

Step 2: Conclusion.

Hence, the correct answer is **Metallic solid**.

Quick Tip

Metallic solids show metallic bonding (”sea of electrons”) responsible for conductivity and ductility.

1(b). In a 200 g solution of glucose with 10% mass per cent, amount of glucose will be:

(A) 5.0 g

(B) 10.0 g

(C) 20.0 g

(D) 40.0 g

Correct Answer: (C) 20.0 g

Solution:

Step 1: Mass percent formula.

Mass percent = $\frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100$.

Step 2: Calculation.

$$\frac{\text{Mass of solute}}{200} \times 100 = 10 \quad \Rightarrow \quad \text{Mass of solute} = 20\,g$$

Step 3: Conclusion.

Therefore, glucose present = **20 g**.

Quick Tip

For mass percent: Mass of solute = (Mass percent × Mass of solution)/100.

1(c). Velocity constant (k) for a reaction is $2.3 \times 10^{-5}\,L\,mol^{-1}s^{-1}$. Order of the reaction will be:

(A) Zero order

(B) First order

(C) Second order

(D) None of these

Correct Answer: (C) Second order

Solution:

Step 1: Dimensions of k.

- For zero order: unit = mol L^{-1} s^{-1}.

- For first order: unit = s^{-1}.

- For second order: unit = L mol^{-1} s^{-1}.

Step 2: Given unit.

Here, $k = 2.3 \times 10^{-5}\,Lmol^{-1}s^{-1}$, which matches second order.

Step 3: Conclusion.

Thus, the reaction is **second order**.

Quick Tip

Always determine reaction order by comparing units of rate constant.

1(d). The base not present in RNA is:

(A) Adenine

(B) Guanine

(C) Thymine

(D) Uracil

Correct Answer: (C) Thymine

Solution:

Step 1: Bases in RNA.

RNA contains Adenine (A), Guanine (G), Cytosine (C), and Uracil (U).

Step 2: Absence of Thymine.

Thymine is present only in DNA, where it pairs with Adenine. In RNA, Uracil replaces Thymine.

Step 3: Conclusion.

Therefore, the base not present in RNA is **Thymine**.

Quick Tip

DNA has Thymine, while RNA has Uracil instead.

1(e). Cannizzaro's reaction is exhibited by:

(A) Benzoic acid

(B) Toluene

(C) Benzaldehyde

(D) Formic acid

Correct Answer: (C) Benzaldehyde

Solution:

Step 1: Understanding Cannizzaro's reaction.

Cannizzaro's reaction occurs in aldehydes that lack α-hydrogen atoms.

Step 2: Application.

- Benzaldehyde has no α-hydrogen $\rightarrow$ undergoes Cannizzaro reaction.

- Benzoic acid is not an aldehyde $\rightarrow$ does not undergo.

- Toluene is hydrocarbon $\rightarrow$ no reaction.

- Formic acid is carboxylic acid $\rightarrow$ no reaction.

Step 3: Conclusion.

Therefore, the compound is **Benzaldehyde**.

Quick Tip

Remember: Aldehydes without α-hydrogen undergo Cannizzaro's reaction.

1(f). Carbylamine reaction gives:

(A) CH_3NH_2

(B) $(CH_3)_2NH$

(C) $(CH_3)_3N$

(D) $(C_2H_5)_2NH$

Correct Answer: (A) CH_3NH_2

Solution:

Step 1: Reaction principle.

Carbylamine reaction (isocyanide test) occurs with primary amines.

Step 2: Application.

- Primary amine (CH_3NH_2) gives foul-smelling isocyanide.

- Secondary and tertiary amines (B, C, D) do not give the reaction.

Step 3: Conclusion.

Hence, the correct answer is $\mathbf{CH_3NH_2}$.

Quick Tip

Carbylamine test is a qualitative test to detect primary amines.

2(a). Calculate the packing capacity (efficiency) of a simple cubic lattice.

Correct Answer: 52.4%

Solution:

Step 1: Atoms per unit cell.

In a simple cubic lattice, each corner atom is shared by 8 unit cells. Thus, number of atoms per unit cell = $\frac{1}{8} \times 8 = 1$.

Step 2: Relation between atomic radius and edge length.

For simple cubic: $a = 2r$.

Step 3: Volume of atom and unit cell.

- Volume of one atom = $\frac{4}{3}\pi r^3$.

- Volume of unit cell = $a^3 = (2r)^3 = 8r^3$.

Step 4: Packing efficiency.

$$\text{Packing efficiency} = \frac{\text{Volume of atoms in cell}}{\text{Volume of unit cell}} \times 100 = \frac{\frac{4}{3}\pi r^3}{8r^3} \times 100 \approx 52.4\%$$

Step 5: Conclusion.

Thus, the packing efficiency of a simple cubic lattice is **52.4%**.

Quick Tip

Remember: Packing efficiency is lowest for simple cubic (52.4%), higher for bcc (68%), and highest for fcc (74%).

2(b). The structure of a cell of an element is body-centred cubic (bcc). The length of the core of the cell is 200 pm. Density of the element is 7 g/cm^3. Determine the number of atoms in 20 g element.

Correct Answer: $\approx 1.2 \times 10^{23}$ atoms

Solution:

Step 1: Relation in bcc structure.

In bcc, body diagonal = $4r = \sqrt{3}a$.

Here, edge length $a = 200\,\text{pm} = 2 \times 10^{-8}\,\text{cm}$.

Step 2: Volume of unit cell.

$$a^3 = (2 \times 10^{-8})^3 = 8 \times 10^{-24}\,\text{cm}^3$$

Step 3: Mass of unit cell.

$$\text{Mass} = \text{Density} \times \text{Volume} = 7 \times 8 \times 10^{-24} = 5.6 \times 10^{-23}\,g$$

Step 4: Atoms per unit cell.

In bcc: 2 atoms/unit cell.

So, molar mass = $\frac{\text{Mass of unit cell} \times N_A}{2}$.

$$M = \frac{5.6 \times 10^{-23} \times 6.022 \times 10^{23}}{2} \approx 17\,g/mol$$

Step 5: Number of atoms in 20 g.

$$\text{Moles} = \frac{20}{17} \approx 1.18\,mol$$

$$\text{Atoms} = 1.18 \times 6.022 \times 10^{23} \approx 1.2 \times 10^{23}$$

Step 6: Conclusion.

Number of atoms in 20 g element = $\approx 1.2 \times 10^{23}$.

Quick Tip

In bcc, 2 atoms per unit cell; always use density formula: $\rho = \frac{Z \times M}{a^3 \times N_A}$.

2(c). Give answers:

(i) Why does the conductivity of any solution decrease with dilution?

(ii) Conductivity of 0.20 M KCl solution at 298 K is 0.248 S cm^{-1}. What will be its molar conductivity?

Correct Answer:

(i) Due to decrease in number of ions per unit volume.

(ii) 124 S cm^2 mol^{-1}.

Solution:

(i) Reason.

Conductivity decreases with dilution because the number of ions per unit volume decreases, reducing total current carrying capacity.

(ii) Calculation.

Molar conductivity:

$$\Lambda_m = \frac{\kappa \times 1000}{C} = \frac{0.248 \times 1000}{0.20} = 124\, S\, cm^2\, mol^{-1}$$

Step 3: Conclusion.

(i) Fewer ions per volume $\rightarrow$ lower conductivity.

(ii) Molar conductivity = **124 S cm^2 mol^{-1}**.

Quick Tip

Conductivity decreases with dilution, but molar conductivity increases due to increased ion mobility.

2(d). Initial concentration of N_2O_5 in a first-order reaction was 1.24×10^{-2} mol L^{-1} at 310 K, which remained 0.20×10^{-2} mol L^{-1} after 30 minutes. Calculate velocity constant at 310 K. $(\log_{10} 6.2 = 0.7924)$

Correct Answer: $k \approx 0.044\, min^{-1}$

Solution:

Step 1: First-order rate equation.

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

Step 2: Substitution.

$$k = \frac{2.303}{30} \log \frac{1.24 \times 10^{-2}}{0.20 \times 10^{-2}} = \frac{2.303}{30} \log(6.2)$$

Step 3: Simplification.

$$k = \frac{2.303}{30} \times 0.7924 \approx 0.044\, min^{-1}$$

Step 4: Conclusion.

The velocity constant is $\approx 0.044\, min^{-1}$.

Quick Tip

Always use $\log_{10}$ in first-order kinetics formula: $k = \frac{2.303}{t} \log \frac{[A]_0}{[A]}$.

3(a). Justify with reasons:

(i) Why does physical adsorption decrease on increasing temperature?

(ii) Why are powdered materials better effective adsorbents in comparison to their crystalline forms?

Correct Answer:

(i) Because physical adsorption is an exothermic process.

(ii) Because powdered materials have larger surface area.

Solution:

(i) Explanation.

Physical adsorption is exothermic in nature. According to Le Chatelier's principle, increasing temperature decreases the extent of exothermic processes, hence adsorption decreases.

(ii) Explanation.

Powdered materials have more surface area exposed compared to crystalline solids.

Adsorption being a surface phenomenon, greater surface area enhances adsorption.

Conclusion.

(i) Adsorption decreases with temperature.

(ii) Powdered form acts as a better adsorbent due to large surface area.

Quick Tip

Remember: Adsorption is surface phenomenon, and higher surface area leads to higher adsorption.

3(b). Explain the following:

(i) NCl_3 occurs but NCl_5 does not. Why?

(ii) Why are halogens strong oxidising agents?

Correct Answer:

(i) Due to absence of d-orbitals in nitrogen.

(ii) Due to high electronegativity and high electron affinity.

Solution:

(i) Explanation.

Nitrogen has only $2s$ and $2p$ orbitals, no vacant d-orbitals. Therefore, nitrogen cannot expand its octet to form NCl_5. But phosphorus (in PCl_5) can, due to vacant 3d orbitals. Hence only NCl_3 exists.

(ii) Explanation.

Halogens have high electronegativity and very high electron affinity. They readily accept electrons to form halide ions, making them strong oxidising agents.

Quick Tip

NCl_5 cannot form as nitrogen lacks d-orbitals; halogens are strong oxidisers due to high electron affinity.

3(c). What do you mean by bidentate and ambidentate ligands? Give one example of each.

Correct Answer:

- Bidentate: Ligand with two donor atoms (Example: Ethylenediamine, en).

- Ambidentate: Ligand with two possible donor atoms, but only one donates at a time (Example: NO_2^-).

Solution:

Bidentate ligands.

These have two donor atoms that coordinate simultaneously to the metal ion. Example: Ethylenediamine (en), $H_2N\text{-}CH_2CH_2NH_2$.

Ambidentate ligands.

These have two donor atoms but can bind through only one at a time, leading to linkage isomerism. Example: NO_2^- (binds via N or O).

Conclusion.

Bidentate ligands $\rightarrow$ two donor atoms at once; Ambidentate ligands $\rightarrow$ two possible donor atoms, but only one attaches.

Quick Tip

Bidentate ligands increase stability of complexes (chelation effect); ambidentate ligands cause linkage isomerism.

3(d). Differentiate between the structures of D-glucose and D-fructose.

Correct Answer:

- D-glucose: Aldohexose (contains an aldehyde group).
- D-fructose: Ketohexose (contains a ketone group).

Solution:

Step 1: D-Glucose.

It is an aldohexose (6-carbon sugar with an aldehyde group at C-1). Open-chain form: $CH_2OH - (CHOH)_4 - CHO$. In cyclic form, it forms a pyranose ring.

Step 2: D-Fructose.

It is a ketohexose (6-carbon sugar with a ketone group at C-2). Open-chain form: $CH_2OH - C = O - (CHOH)_3 - CH_2OH$. In cyclic form, it forms a furanose ring.

Step 3: Key Difference.

Glucose has an aldehyde (aldohexose), Fructose has a ketone (ketohexose).

Quick Tip

Glucose = aldohexose; Fructose = ketohexose. Both are hexoses but differ in functional groups.

4(a). The resistance of a conductivity cell, filled with 0.1 mol L^{-1} KCl solution is 100 Ω. If the resistance of this cell is 500 Ω on filling 0.02 mol L^{-1} KCl solution, then calculate the conductivity and molar conductivity of 0.02 mol L^{-1} KCl solution. The conductivity of 0.1 mol L^{-1} KCl solution is 1.29 S m^{-1}.

Correct Answer:

Conductivity (κ) = 0.258 S m^{-1}

Molar Conductivity (Λ_m) = 12.9 S cm^2 mol^{-1}

Solution:

Step 1: Calculate cell constant.

Conductivity (κ) = Cell constant / Resistance.

For 0.1 M KCl:

$$1.29 = \frac{\text{Cell constant}}{100} \quad \Rightarrow \quad \text{Cell constant} = 129\, m^{-1}$$

Step 2: Find conductivity for 0.02 M KCl.

$$\kappa = \frac{\text{Cell constant}}{R} = \frac{129}{500} = 0.258\, S\, m^{-1}$$

Step 3: Find molar conductivity.

$$\Lambda_m = \frac{\kappa \times 1000}{C} = \frac{0.258 \times 1000}{0.02 \times 1000} = 12.9\, S\, cm^2\, mol^{-1}$$

Step 4: Conclusion.

Conductivity = $\mathbf{0.258\,S\,m^{-1}}$, Molar conductivity = $\mathbf{12.9\,S\,cm^2\,mol^{-1}}$.

Quick Tip

Always calculate cell constant from a standard solution first, then apply it to other resistances.

4(b). Differentiate between the following:

(i) True solution and suspension

(ii) Lyophilic and Lyophobic colloid

(iii) Multimolecular and Macromolecular colloid

Correct Answer:

(i) True solution: homogeneous; Suspension: heterogeneous.

(ii) Lyophilic: solvent-loving; Lyophobic: solvent-hating.

(iii) Multimolecular: aggregates of small molecules; Macromolecular: large molecules act as colloid.

Solution:

(i) True solution vs Suspension.

- True solution: Homogeneous, particle size ¡ 1 nm, particles invisible, stable (e.g., sugar solution).

- Suspension: Heterogeneous, particle size ¿ 1000 nm, visible particles, unstable (e.g., chalk in water).

(ii) Lyophilic vs Lyophobic colloids.

- Lyophilic: Solvent-loving, stable, easily formed, reversible (e.g., starch sol, gelatin).

- Lyophobic: Solvent-hating, unstable, requires special methods, irreversible (e.g., gold sol).

(iii) Multimolecular vs Macromolecular colloids.

- Multimolecular: Colloidal particles are aggregates of small molecules (e.g., gold sol).

- Macromolecular: Large molecules act as colloids (e.g., starch, proteins).

Quick Tip

Remember: Stability order $\rightarrow$ True solution ¿ Lyophilic colloid ¿ Lyophobic colloid ¿ Suspension.

4(c). Write short notes on the following:

(i) Secondary structure of proteins

(ii) Peptide bond

(iii) Monosaccharides

Correct Answer:

(i) Secondary structure = α-helix / β-sheet.

(ii) Peptide bond = $-CO-NH-$ linkage.

(iii) Monosaccharides = simplest sugars, cannot be hydrolysed further.

Solution:

(i) Secondary structure of proteins.

Formed by hydrogen bonding between peptide chains. Two main types: α-helix (spiral) and β-pleated sheet (zig-zag). Gives stability and shape to proteins.

(ii) Peptide bond.

A covalent linkage $-CO-NH-$ formed between carboxyl group of one amino acid and amino group of another. Responsible for formation of polypeptides and proteins.

(iii) Monosaccharides.

Simplest carbohydrates ($C_nH_{2n}O_n$). Cannot be hydrolysed further. Examples: glucose, fructose, galactose. They are reducing sugars.

Quick Tip

Proteins $\rightarrow$ peptides $\rightarrow$ amino acids; Carbohydrates $\rightarrow$ monosaccharides are the basic units.

4(d). Give reasons of the following:

(i) Aniline does not exhibit Friedel–Crafts reaction.

(ii) Ethyl amine is soluble in water while aniline is not.

Correct Answer:

(i) Aniline forms complex with Lewis acid catalyst, deactivating the ring.

(ii) Ethyl amine forms H-bonds with water, aniline is bulky and less soluble.

Solution:

(i) Friedel–Crafts reaction.

Aniline reacts with Lewis acid catalysts (like $AlCl_3$) forming insoluble complexes. This deactivates the benzene ring, preventing Friedel–Crafts alkylation/acylation.

(ii) Solubility difference.

Ethyl amine: Small size, strong H-bonding with water $\rightarrow$ soluble.

Aniline: Bulkier phenyl group decreases polarity and reduces hydrogen bonding with water $\rightarrow$ very low solubility.

Step 3: Conclusion.

(i) Aniline does not undergo Friedel–Crafts due to catalyst complexation.

(ii) Ethyl amine soluble; Aniline not soluble.

Quick Tip

Remember: Solubility in water depends on hydrogen bonding capacity and molecular size.

5(a). What do you understand by osmosis and osmotic pressure? 1.26 g protein is present in 200 cm^3 aqueous solution of protein. Molar mass of protein is 61,022 g mol^{-1}. What will be osmotic pressure of this solution at 300 K?

Correct Answer: Osmotic pressure = 0.103 atm

Solution:

Step 1: Definitions.

- Osmosis: Flow of solvent molecules through a semipermeable membrane from lower solute concentration to higher solute concentration.

- Osmotic pressure: The pressure required to stop osmosis.

Step 2: Moles of protein.

$$n = \frac{\text{Mass}}{\text{Molar mass}} = \frac{1.26}{61022} \approx 2.07 \times 10^{-5}\, mol$$

Step 3: Concentration of solution.

Volume = 200 cm^3 = 0.200 L.

$$C = \frac{n}{V} = \frac{2.07 \times 10^{-5}}{0.200} = 1.035 \times 10^{-4}\, mol/L$$

Step 4: Osmotic pressure formula.

$$\pi = CRT = (1.035 \times 10^{-4})(0.0821)(300) \approx 0.103\, atm$$

Step 5: Conclusion.

Osmotic pressure = $\mathbf{0.103\,atm}$.

Quick Tip

For dilute solutions, osmotic pressure follows $\pi = CRT$, analogous to ideal gas law.

5(b). (i) What do you understand by velocity of a chemical reaction? (ii) Explain Raoult's law.

Correct Answer:

(i) Rate of change of concentration of reactants/products per unit time.

(ii) Raoult's law: Relative lowering of vapour pressure is proportional to mole fraction of solute.

Solution:

(i) Velocity of reaction.

The velocity (rate) of a chemical reaction is the change in concentration of reactants or products per unit time.

$$\text{Rate} = -\frac{d[\text{Reactant}]}{dt} = \frac{d[\text{Product}]}{dt}$$

(ii) Raoult's law.

According to Raoult's law, for a solution of non-volatile solute:

$$\frac{\Delta p}{p^0} = x_{\text{solute}}$$

where $\Delta p = p^0 - p$, p^0 = vapour pressure of pure solvent, x_{solute} = mole fraction of solute.

Step 3: Conclusion.

- Reaction velocity = rate of change of concentration.

- Raoult's law = vapour pressure lowering proportional to solute mole fraction.

Quick Tip

Reaction rate measures speed of reaction; Raoult's law explains colligative properties.

5(c). Explain the following with reasons:

(i) Transition metals generally form coloured compounds.

(ii) Transition metals and their maximum compounds are paramagnetic.

Correct Answer:

(i) Due to d–d electronic transitions.

(ii) Due to presence of unpaired d-electrons.

Solution:

(i) Coloured compounds.

Transition metals have partially filled d-orbitals. When light falls, electrons undergo d–d transitions, absorbing certain wavelengths, and the complementary colour is observed. Example: Ti^{3+} (violet), Cu^{2+} (blue).

(ii) Paramagnetism.

Transition metals and their ions often contain unpaired d-electrons. These unpaired electrons produce magnetic moments, leading to paramagnetic behaviour. Example: Fe^{2+}, Mn^{2+}.

Quick Tip

Colour in transition metal compounds arises from d–d transitions; paramagnetism from unpaired d-electrons.

5(d). Write IUPAC names of the following coordination compounds:

(i) $[CrCl_2(en)_2]Cl$

(ii) $Cs[FeCl_4]$

(iii) $K_3[Co(C_2O_4)_3]$

(iv) $[CoCl_3(NH_3)_3]$

Correct Answer:

(i) Dichloridobis(ethane-1,2-diamine)chromium(III) chloride

(ii) Caesium tetrachloridoferrate(III)

(iii) Potassium tris(oxalato)cobaltate(III)

(iv) Triamminetrichloridocobalt(III)

Solution:

(i) $[CrCl_2(en)_2]Cl$: Coordination sphere contains 2 Cl^- ligands and 2 en ligands. Oxidation state of Cr = +3. Name = Dichloridobis(ethane-1,2-diamine)chromium(III) chloride.

(ii) $Cs[FeCl_4]$: Complex anion = $[FeCl_4]^-$. Oxidation state of Fe = +3. Name = Caesium tetrachloridoferrate(III).

(iii) $K_3[Co(C_2O_4)_3]$: Oxidation state of Co = +3. Oxalate = bidentate ligand. Name = Potassium tris(oxalato)cobaltate(III).

(iv) $[CoCl_3(NH_3)_3]$: Coordination sphere has 3 Cl^-, 3 NH_3. Oxidation state of Co = +3. Name = Triamminetrichloridocobalt(III).

Quick Tip

Always name ligands alphabetically, specify coordination number, and oxidation state in Roman numerals.

6(a). Describe the industrial manufacture of sulphur dioxide gas. Give also chemical equations of the reactions. Give chemical equations of the reactions of sulphuric acid with calcium fluoride, copper and sulphur.

Correct Answer:

- SO_2 is manufactured in industries mainly by roasting sulphide ores.

- Reactions: 1. $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2 \uparrow$

2. $4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2 \uparrow$

- Reactions of H_2SO_4: 1. $CaF_2 + H_2SO_4 \rightarrow CaSO_4 + 2HF \uparrow$

2. $Cu + 2H_2SO_4$ (conc.) $\rightarrow CuSO_4 + SO_2 \uparrow + 2H_2O$

3. $S + 2H_2SO_4$ (conc.) $\rightarrow 3SO_2 \uparrow + 2H_2O$

Solution:

Step 1: Manufacture of SO_2.

SO_2 is produced by burning sulphur or roasting metal sulphides in air/oxygen.

Step 2: Important reactions.

$$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2 \uparrow$$

$$4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2 \uparrow$$

Step 3: Reactions of H_2SO_4.

$$CaF_2 + H_2SO_4 \rightarrow CaSO_4 + 2HF \uparrow$$

$$Cu + 2H_2SO_4\,(conc.) \rightarrow CuSO_4 + SO_2 \uparrow + 2H_2O$$

$$S + 2H_2SO_4\,(conc.) \rightarrow 3SO_2 \uparrow + 2H_2O$$

Step 4: Conclusion.

SO_2 is industrially produced by roasting sulphides, and conc. H_2SO_4 liberates gases from CaF_2, Cu, and S.

Quick Tip

SO_2 is mainly obtained by roasting metal sulphides in industry, and conc. H_2SO_4 acts as a dehydrating oxidising agent.

OR

6(a). What happens when (Give chemical equations only):

(i) Iodine reacts with nitric acid solution?

(ii) Chlorine reacts with sulphur dioxide?

(iii) Chlorine reacts with hot and conc. NaOH solution?

(iv) Chlorine reacts with fluorine?

(v) Zinc reacts with dil. nitric acid?

Correct Answer (Equations):

(i) I_2 + 10HNO_3 → 2HIO_3 + 10NO_2 + 4H_2O

(ii) Cl_2 + SO_2 + 2H_2O → H_2SO_4 + 2HCl

(iii) 3Cl_2 + 6NaOH (hot, conc.) → 5NaCl + $NaClO_3$ + 3H_2O

(iv) Cl_2 + 3F_2 → 2ClF_3

(v) Zn + 4HNO_3 (dil.) → $Zn(NO_3)_2$ + 2NO_2 + 2H_2O

Solution:

(i) Iodine with HNO_3.

Nitric acid oxidises iodine to iodic acid:

$$I_2 + 10HNO_3 \rightarrow 2HIO_3 + 10NO_2 + 4H_2O$$

(ii) Chlorine with SO_2.

Chlorine oxidises SO_2 to H_2SO_4:

$$Cl_2 + SO_2 + 2H_2O \rightarrow H_2SO_4 + 2HCl$$

(iii) Chlorine with hot conc. NaOH.

Disproportionation reaction:

$$3Cl_2 + 6NaOH\ (hot, conc.) \rightarrow 5NaCl + NaClO_3 + 3H_2O$$

(iv) Chlorine with fluorine.

Formation of chlorine trifluoride:

$$Cl_2 + 3F_2 \rightarrow 2ClF_3$$

(v) Zinc with dilute nitric acid.

Zinc gives zinc nitrate and nitrogen dioxide gas:

$$Zn + 4HNO_3\ (dil.) \rightarrow Zn(NO_3)_2 + 2NO_2 + 2H_2O$$

Quick Tip

Chlorine often shows disproportionation reactions with alkalis, while nitric acid oxidises both iodine and zinc.

6(b). Write structures of the following compounds:

(i) 2-chloro-3-methylpentane

(ii) 1,4-dibromobut-2-ene

(iii) 1-chloro-2-methylbenzene

(iv) 1-chloro-4-ethylcyclohexane

(v) 3-bromo-2-methylbut-2-ene

Correct Answer (Structures):

(i) CH_3-CH(Cl)-CH(CH_3)-CH_2-CH_3

(ii) Br-CH_2-CH=CH-CH_2-Br

(iii) Chlorine at position 1, CH_3 at position 2 on benzene ring (ortho-chlorotoluene).

(iv) Cyclohexane ring with Cl at C-1 and –CH_2-CH_3 at C-4.

(v) CH_2=C(CH_3)-CH(Br)-CH_3

Solution:

(i) 2-chloro-3-methylpentane.

Pentane chain, Cl at C-2, CH_3 at C-3:

$$CH_3 - CH(Cl) - CH(CH_3) - CH_2 - CH_3$$

(ii) 1,4-dibromobut-2-ene.

4-carbon chain, double bond at C-2, Br at C-1 and C-4:

$$Br - CH_2 - CH = CH - CH_2 - Br$$

(iii) 1-chloro-2-methylbenzene.

Benzene ring with Cl at position 1, CH_3 at position 2 (ortho-chlorotoluene).

(iv) 1-chloro-4-ethylcyclohexane.

Cyclohexane ring with Cl at C-1 and –CH_2CH_3 at C-4.

(v) 3-bromo-2-methylbut-2-ene.

4-carbon chain with double bond at C-2, CH_3 substituent at C-2, Br at C-3:

$$CH_2 = C(CH_3) - CH(Br) - CH_3$$

Quick Tip

Always select the longest chain, number to give lowest locants, and place substituents alphabetically in naming.

OR

6(b). What happens when (Give chemical equations only):

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

(ii) Methyl iodide reacts with magnesium in presence of dry ether?

(iii) Methyl bromide reacts with sodium in presence of dry ether?

(iv) Methyl iodide reacts with KCN solution?

(v) Chlorobenzene reacts with aqueous NaOH?

Correct Answer (Equations):

(i) C_4H_9Cl + alc. KOH $\rightarrow$ C_4H_8 + HCl

(ii) CH_3I + Mg $\rightarrow$ CH_3MgI (Grignard reagent)

(iii) $2CH_3Br$ + 2Na $\rightarrow$ C_2H_6 + 2NaBr (Wurtz reaction)

(iv) CH_3I + KCN $\rightarrow$ CH_3CN + KI

(v) C_6H_5Cl + NaOH (aq., 300°C, 200 atm) $\rightarrow$ C_6H_5OH + NaCl

Solution:

(i) n-Butyl chloride + alc. KOH.

Dehydrohalogenation occurs, giving 1-butene:

$$C_4H_9Cl + alc.KOH \rightarrow C_4H_8 + HCl$$

(ii) Methyl iodide + Mg (dry ether).

Grignard reagent formation:

$$CH_3I + Mg \rightarrow CH_3MgI$$

(iii) Methyl bromide + Na (dry ether).

Wurtz reaction gives ethane:

$$2CH_3Br + 2Na \rightarrow C_2H_6 + 2NaBr$$

(iv) Methyl iodide + KCN.

Forms methyl cyanide:

$$CH_3I + KCN \rightarrow CH_3CN + KI$$

(v) Chlorobenzene + aq. NaOH.

At high temp. and pressure forms phenol:

$$C_6H_5Cl + NaOH\,(300^\circ C, 200\,atm) \rightarrow C_6H_5OH + NaCl$$

Quick Tip

Alc. KOH causes elimination, Mg in ether gives Grignard reagents, Na gives Wurtz products, KCN gives nitriles, and chlorobenzene needs drastic conditions for nucleophilic substitution.

7(a). Describe the industrial manufacture of ethanol. Give also the chemical equation of reactions. What is formed after dehydrogenation of ethanol? Write the mechanism of acidic dehydration of ethanol to get ethene.

Correct Answer:

- Ethanol is manufactured industrially by fermentation of sugars or by hydration of ethene.
- Dehydrogenation gives acetaldehyde.
- Acidic dehydration gives ethene.

Solution:

Step 1: Industrial manufacture of ethanol.

(i) Fermentation: Glucose is converted into ethanol using enzymes.

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

(ii) From ethene: Ethene reacts with steam at 300°C in presence of phosphoric acid catalyst.

$$C_2H_4 + H_2O \xrightarrow{H_3PO_4, 300^\circ C} C_2H_5OH$$

Step 2: Dehydrogenation of ethanol.

On heating with Cu at 573 K:

$$C_2H_5OH \xrightarrow{Cu, 573K} CH_3CHO + H_2$$

Thus, ethanol gives acetaldehyde.

Step 3: Dehydration mechanism (acidic).

$$C_2H_5OH \xrightarrow{H_2SO_4, 443K} C_2H_4 + H_2O$$

Mechanism: 1. Protonation of OH group → formation of oxonium ion.

2. Loss of water → carbocation formation.

3. Rearrangement → elimination of H^+ to give ethene.

Step 4: Conclusion.

- Ethanol industrially: fermentation/hydration of ethene.

- Dehydrogenation product = acetaldehyde.

- Dehydration (acidic) = ethene.

Quick Tip

Fermentation is biological; industrially, ethene hydration is faster. Cu gives dehydrogenation, H_2SO_4 gives dehydration.

OR

7(a). Complete the following reactions and write the names and formulae of A, B, C, D, E, F:

(i)

$$\text{Phenol (OH group)} \xrightarrow{\text{conc. } HNO_3} A$$

(ii)

$$\text{Phenol} \xrightarrow{CHCl_3 + aq.NaOH} B$$

(iii)

$$CH_3 - CH_2 - CH_2 - O - C(CH_3)_2 - CH_2 - CH_3 \xrightarrow{HI,\Delta} C + D$$

(iv)

$$CH_3CH(OH)CH_3 \xrightarrow{CrO_3} E$$

(v)

$$CH_3COOH \xrightarrow{(i)LiAlH_4\,(ii)H_2O} F$$

Correct Answer:

(i) A = 2,4,6-trinitrophenol (picric acid), $C_6H_2(NO_2)_3OH$

(ii) B = Salicylaldehyde, $C_6H_4(OH)(CHO)$

(iii) C = Propanol (C_3H_7OH), D = 2-iodo-2-methylbutane ($C_5H_{11}I$)

(iv) E = Acetone (CH_3COCH_3)

(v) F = Ethanol (C_2H_5OH)

Solution:

(i) Phenol + conc. HNO_3.

Forms picric acid (2,4,6-trinitrophenol).

$$C_6H_5OH + 3HNO_3 \rightarrow C_6H_2(NO_2)_3OH + 3H_2O$$

(ii) Phenol + $CHCl_3$ + NaOH (Reimer–Tiemann).

Forms salicylaldehyde.

$$C_6H_5OH + CHCl_3 + 3NaOH \rightarrow C_6H_4(OH)(CHO) + 3NaCl + 2H_2O$$

(iii) Ether cleavage with HI.

$$CH_3CH_2CH_2 - O - C(CH_3)_2CH_2CH_3 + HI \rightarrow CH_3CH_2CH_2OH + (CH_3)_2CHCH_2CH_2I$$

C = Propanol, D = 2-iodo-2-methylbutane.

(iv) Oxidation of isopropanol.

$$CH_3CH(OH)CH_3 \xrightarrow{CrO_3} CH_3COCH_3$$

E = Acetone.

(v) Reduction of acetic acid.

$$CH_3COOH \xrightarrow{LiAlH_4} CH_3CH_2OH$$

F = Ethanol.

Step 3: Conclusion.

- A = Picric acid.
- B = Salicylaldehyde.
- C = Propanol.
- D = 2-iodo-2-methylbutane.
- E = Acetone.
- F = Ethanol.

Quick Tip

Picric acid forms by nitration, salicylaldehyde by Reimer–Tiemann, ethers split with HI, secondary alcohols oxidise to ketones, and acids reduce to alcohols.

7(b). An organic compound 'A' having molecular formula C_8H_8O, gives orange-red precipitate with 2,4-DNP (2,4-Dinitrophenylhydrazine) reagent. 'A' gives yellow precipitate on heating with iodine in presence of NaOH. 'A' neither reduces Tollen's reagent, Fehling's solution nor decolourises bromine water. It forms a carboxylic acid 'B' having molecular formula $C_7H_6O_2$, on strong oxidation with chromic acid. Identify compounds 'A' and 'B' and explain the main reactions.

Correct Answer:

- Compound A = Acetophenone ($C_6H_5COCH_3$)
- Compound B = Benzoic acid (C_6H_5COOH)

Solution:

Step 1: 2,4-DNP test.

Compound A gives orange-red precipitate $\rightarrow$ confirms presence of a carbonyl group (aldehyde or ketone).

Step 2: Iodoform test.

Yellow precipitate with iodine + NaOH $\rightarrow$ confirms presence of CH_3–CO group. Hence A must be a methyl ketone.

Step 3: Negative tests.

- No Tollen's/Fehling's reduction $\rightarrow$ not an aldehyde.

- No bromine water decolourisation $\rightarrow$ not an alkene.

Step 4: Oxidation product.

On oxidation with chromic acid, A gives a monocarboxylic acid B ($C_7H_6O_2$) = benzoic acid.

$$C_6H_5COCH_3 \xrightarrow{[O]} C_6H_5COOH$$

Step 5: Conclusion.

- A = Acetophenone ($C_6H_5COCH_3$)

- B = Benzoic acid (C_6H_5COOH)

Quick Tip

Iodoform test always confirms CH_3–CO group; oxidation of side chain in aromatic ketones gives benzoic acid.

OR

7(b). How will you obtain (Give chemical equations only):

(i) 4-hydroxy-4-methylpentan-2-one from propanone?

(ii) 3-hydroxybutanol from ethanol?

(iii) Butanoic acid from butanal?

(iv) Ethanoic anhydride from ethanoic acid?

(v) Phenyl ethanoic acid from benzyl alcohol?

Correct Answer (Equations):

(i) Aldol condensation:

$$2CH_3COCH_3 \xrightarrow{NaOH} CH_3C(OH)CH_2COCH_3$$

Product = 4-hydroxy-4-methylpentan-2-one.

(ii) Oxidation of ethanol $\rightarrow$ acetaldehyde $\rightarrow$ aldol condensation:

$$2CH_3CH_2OH \xrightarrow{[O]} CH_3CHO \quad \xrightarrow{NaOH} CH_3CH(OH)CH_2CHO$$

Product = 3-hydroxybutanal.

(iii) Oxidation of butanal:

$$CH_3CH_2CH_2CHO \xrightarrow{[O]} CH_3CH_2CH_2COOH$$

Product = butanoic acid.

(iv) Dehydration of ethanoic acid:

$$2CH_3COOH \xrightarrow{\Delta} (CH_3CO)_2O + H_2O$$

Product = ethanoic anhydride.

(v) Oxidation of benzyl alcohol:

$$C_6H_5CH_2OH \xrightarrow{[O]} C_6H_5CH_2COOH$$

Product = phenyl ethanoic acid.

Quick Tip

Aldol condensation gives -hydroxy carbonyls; oxidation of aldehydes/alcohols always yields acids.
