UP Board Class 12 Chemistry Code 347 BZ 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 number of atoms in a body centred cubic (bcc) unit cell is

(A) 1

(B) 2

(C) 4

(D) 6

Correct Answer: (B) 2

Solution:

Step 1: Understanding body-centered cubic (bcc).

In a bcc unit cell, there are 2 atoms: 1 at the center and 1/8 of each of the 8 corner atoms.

Thus, the total number of atoms is $1 + 8 \times \frac{1}{8} = 2$.

Step 2: Conclusion.

Hence, the correct answer is (B) 2.

> Quick Tip
>
> In a body-centered cubic unit cell, the number of atoms is 2.

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b. 3.0 g of acetic acid is dissolved in 80 g of benzene. The molality of the solution is

(A) 0.0625 mol kg^{-1}

(B) 0.00625 mol kg^{-1}

(C) 0.625 mol kg^{-1}

(D) 6.25 mol kg^{-1}

Correct Answer: (B) 0.00625 mol kg^{-1}

Solution:

Step 1: Formula for molality.

The molality m is given by:

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

Step 2: Calculate moles of acetic acid.

Moles of acetic acid = $\frac{\text{mass of solute}}{\text{molar mass of acetic acid}} = \frac{3.0\,\text{g}}{60\,\text{g/mol}} = 0.05\,\text{mol}$

Step 3: Calculate molality.

Mass of benzene = 80 g = 0.080 kg Molality = $\frac{0.05\,\text{mol}}{0.080\,\text{kg}} = 0.00625\,\text{mol/kg}$

Step 4: Conclusion.

Hence, the correct answer is (B) 0.00625 mol kg^{-1}.

Quick Tip

Molality is the ratio of the moles of solute to the mass of the solvent in kilograms.

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c. Velocity constant for a first order reaction is $2 \times 10^{-3}\,\text{s}^{-1}$. The half-life period for this reaction is

(A) $3.465 \times 10^{3}\,\text{s}$

(B) $3.465 \times 10^{2}\,\text{s}$

(C) $3.465 \times 10^{1}\,\text{s}$

(D) $3.465 \times 10^{-2}\,\text{s}$

Correct Answer: (A) $3.465 \times 10^{3}\,\text{s}$

Solution:

Step 1: Formula for half-life period.

For a first-order reaction, the half-life period $t_{1/2}$ is given by:

$$t_{1/2} = \frac{0.693}{k}$$

where k is the rate constant.

Step 2: Calculate half-life.

Given that $k = 2 \times 10^{-3}\,\text{s}^{-1}$,

$$t_{1/2} = \frac{0.693}{2 \times 10^{-3}} = 3.465 \times 10^{3}\,\text{s}$$

Step 3: Conclusion.

Hence, the correct answer is (A) 3.465×10^3 s.

Quick Tip

For a first-order reaction, the half-life is independent of the concentration of the reactant.

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d. The base not present in DNA is

(A) Adenine

(B) Guanine

(C) Cytosine

(D) Uracil

Correct Answer: (D) Uracil

Solution:

Step 1: DNA Base Pairs.

DNA contains four nitrogenous bases: adenine (A), thymine (T), guanine (G), and cytosine (C). Uracil (U) is found in RNA, not DNA.

Step 2: Conclusion.

Hence, the correct answer is (D) Uracil.

Quick Tip

Uracil is a base found in RNA, not DNA.

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e. IUPAC name of CH_3-CH-CH_3 is

(A) 2-hydroxy 3-methyl butanal

(B) 2-methyl butan-3-ol

(C) 3-methyl butan-2-ol

(D) methyl hydroxybutanal

Correct Answer: (C) 3-methyl butan-2-ol

Solution:

Step 1: Identify the structure.

The given structure is CH_3-CH-CH_3 with a hydroxyl group at the 2-position. This indicates it is 3-methyl butan-2-ol.

Step 2: Conclusion.

Hence, the correct answer is (C) 3-methyl butan-2-ol.

> **Quick Tip**
>
> When naming compounds, identify the longest carbon chain and number it to give the functional groups the lowest possible numbers.

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f. Hinsberg reagent is

(A) Ethyl oxalate

(B) Trimethyl amine

(C) Benzene sulphonyl chloride

(D) Benzyl chloride

Correct Answer: (C) Benzene sulphonyl chloride

Solution:

Step 1: Hinsberg Reagent.

Hinsberg reagent is benzene sulphonyl chloride, which is used in the Hinsberg test for differentiating primary, secondary, and tertiary amines.

Step 2: Conclusion.

Hence, the correct answer is (C) Benzene sulphonyl chloride.

> **Quick Tip**
>
> Benzene sulphonyl chloride is used in the Hinsberg test for amines.

2.a An element forms CCP lattice. If the length of its core of unit cell is 408.6 pm, then calculate the density of the element. (Atomic weight = 107.9 u)

Solution:

Step 1: Understanding CCP Lattice.

A cubic close-packed (CCP) unit cell contains 4 atoms. The edge length of the unit cell is given as 408.6 pm (1 pm = 10^{-12} m).

Step 2: Volume of Unit Cell.

The volume of the unit cell can be calculated using the formula:

$$\text{Volume of unit cell} = a^3$$

where a is the edge length of the unit cell. Given that $a = 408.6\,\text{pm} = 408.6 \times 10^{-12}$ m, we can calculate the volume of the unit cell:

$$V = (408.6 \times 10^{-12})^3 = 6.8 \times 10^{-29}\,\text{m}^3$$

Step 3: Mass of Unit Cell.

The mass of the unit cell is given by the formula:

$$\text{Mass of unit cell} = \frac{\text{Atomic weight}}{\text{Avogadro's number}} \times \text{number of atoms in the unit cell}$$

Given that the atomic weight is 107.9 u, Avogadro's number is 6.022×10^{23} atoms/mol, and there are 4 atoms in the unit cell, we get:

$$\text{Mass of unit cell} = \frac{107.9}{6.022 \times 10^{23}} \times 4 = 7.17 \times 10^{-23}\,\text{g}$$

Step 4: Calculate the Density.

The density is given by the formula:

$$\text{Density} = \frac{\text{Mass of unit cell}}{\text{Volume of unit cell}}$$

Substituting the values:

$$\text{Density} = \frac{7.17 \times 10^{-23}}{6.8 \times 10^{-29}} = 8.2\,\text{g/cm}^3$$

Step 5: Conclusion.

Hence, the correct answer is (B) 8.2 g cm^{-3}.

Quick Tip

For CCP lattice, there are 4 atoms per unit cell, and the density can be calculated using atomic weight and unit cell volume.

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b. Explain the following defects:

(i) Interstitial

(ii) F-centred

Solution :

(i) Interstitial Defect:

An interstitial defect occurs when an extra atom or ion is inserted into a lattice at a position that is normally unoccupied. This defect disturbs the regular pattern of atoms in the lattice.

(ii) F-centred Defect:

An F-centre occurs when an ion is missing from a lattice site, and the vacancy is occupied by an electron. This type of defect results in a color change in ionic solids, and is typical of ionic crystals.

Quick Tip

Defects in solids can affect properties like color, conductivity, and density.

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c. What is Kohlrausch law? Write its applications.

Solution:

Step 1: Kohlrausch Law.

Kohlrausch's law states that the molar conductivity of an electrolyte at infinite dilution is the sum of the molar conductivities of its individual ions. Mathematically:

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

where Λ_m^∞ is the molar conductivity at infinite dilution, and λ_+^∞ and λ_-^∞ are the molar conductivities of the cation and anion respectively.

Step 2: Applications.

- It is used to determine the limiting molar conductivity of ions. - It helps in calculating the conductivity of strong and weak electrolytes. - It is also used to calculate the dissociation constant of weak electrolytes.

> Quick Tip
>
> Kohlrausch's law is particularly useful for calculating the conductivity of electrolytes at infinite dilution.

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d. On dissolution of 2.0 g of a non-electrolyte in 50.0 g benzene, its freezing point decreases by 0.40 K. The freezing point depression constant of benzene is 5.12 K kg mol^{-1}. Calculate the molar mass of the solute.

Solution:

Step 1: Formula for freezing point depression.

The freezing point depression ΔT_f is related to the molality m by the formula:

$$\Delta T_f = K_f \times m$$

where K_f is the freezing point depression constant and m is the molality.

Step 2: Calculate molality.

We are given that $\Delta T_f = 0.40\,\text{K}$ and $K_f = 5.12\,\text{K kg mol}^{-1}$, so:

$$m = \frac{\Delta T_f}{K_f} = \frac{0.40}{5.12} = 0.0781\,\text{mol/kg}$$

Step 3: Calculate molar mass.

Molality is given by:

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

The mass of the solvent (benzene) is 50.0 g = 0.0500 kg. Thus:

$$\text{Moles of solute} = m \times \text{mass of solvent} = 0.0781 \times 0.0500 = 0.003905\,\text{mol}$$

Step 4: Calculate molar mass.

The molar mass is given by:

$$\text{Molar mass} = \frac{\text{mass of solute}}{\text{moles of solute}} = \frac{2.0\,\text{g}}{0.003905\,\text{mol}} = 160.25\,\text{g/mol}$$

Step 5: Conclusion.

Hence, the correct answer is (B) 160 g mol^{-1}.

> Quick Tip
>
> Freezing point depression can be used to calculate the molar mass of a solute when the solvent's freezing point depression constant is known.

3.a Explain the following:

(i) Electrophoresis

(ii) Dialysis

Solution:

(i) Electrophoresis:

Electrophoresis is a laboratory technique used to separate charged molecules (such as proteins, DNA, or RNA) by applying an electric field. The molecules are loaded into a gel matrix, and an electric current is passed through the gel. Charged particles migrate towards the electrode of opposite charge. The rate of migration depends on the size, shape, and charge of the molecule. Smaller molecules or those with a higher charge density move faster than larger or less charged ones. Electrophoresis is commonly used for DNA fingerprinting, protein analysis, and RNA separation.

(ii) Dialysis:

Dialysis is a process that separates small molecules or ions from larger molecules by passing them through a semi-permeable membrane. The membrane allows small molecules to diffuse across it while larger molecules, such as proteins, are retained. Dialysis is used in medical treatments, such as kidney dialysis, to remove waste products from blood. In laboratory applications, it is used to remove salts or other small impurities from protein solutions.

Quick Tip

Electrophoresis is based on the movement of charged particles, whereas dialysis relies on size and diffusion.

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b. Explain the following:

(i) Why is the atomic size of noble gases comparatively larger?

(ii) Being almost equal in electronegativity, Nitrogen forms hydrogen bond while chlorine does not.

Solution:

(i) Atomic Size of Noble Gases:

The atomic size of noble gases is comparatively larger because these gases have completely filled electron shells, which reduces the effective nuclear charge acting on the outermost electrons. The electrons in the outer shell experience less attraction from the nucleus, allowing them to be farther from the nucleus, which increases the atomic radius. Additionally, noble gases have high ionization energies, making it harder for their electrons to be removed, contributing to their larger atomic size.

(ii) Hydrogen Bonding in Nitrogen vs. Chlorine:

Although nitrogen and chlorine have similar electronegativities, nitrogen is able to form hydrogen bonds, whereas chlorine cannot. This is because nitrogen has a smaller atomic size, and its lone pair of electrons is more concentrated, making it highly electronegative and able to form strong hydrogen bonds with hydrogen. Chlorine, on the other hand, is larger, and its lone pair of electrons is more diffuse, making it less effective at forming hydrogen bonds despite having a similar electronegativity.

Quick Tip

Hydrogen bonding is influenced not just by electronegativity but also by the size and electron density of the atom.

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c. Justify with reasons:

(i) [NiCl$_4$]$^{2-}$ is paramagnetic while [Ni(CO)$_4$] is diamagnetic, although both are tetrahedral.

Solution:

The magnetic properties of $[NiCl_4]^{2-}$ and $[Ni(CO)_4]$ differ due to the nature of the ligands. In $[NiCl_4]^{2-}$, chloride ions are weak field ligands, which cause minimal splitting of the d-orbitals. This results in unpaired electrons, making the complex paramagnetic. On the other hand, carbon monoxide is a strong field ligand, which causes a significant splitting of the d-orbitals, leading to the pairing of electrons in $[Ni(CO)_4]$. This electron pairing makes the complex diamagnetic, despite both complexes having a tetrahedral geometry.

Quick Tip

The type of ligand determines the extent of d-orbital splitting and influences the magnetic properties of the complex.

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c. (ii) [Fe(H$_2$O)$_6$]$^{3+}$ is stronger paramagnetic while [Fe(CN)$_6$]$^{3-}$ is weaker paramagnetic.

Solution:

The difference in the magnetic properties of $[Fe(H_2O)_6]^{3+}$ and $[Fe(CN)_6]^{3-}$ can be attributed to the ligands involved. Water is a weak field ligand that causes minimal splitting of the d-orbitals in $[Fe(H_2O)_6]^{3+}$. As a result, unpaired electrons remain in the d-orbitals, making the complex strongly paramagnetic. Cyanide, however, is a strong field ligand, which causes a large splitting of the d-orbitals in $[Fe(CN)_6]^{3-}$, leading to the pairing of electrons and reducing the paramagnetism of the complex.

Quick Tip

The strength of the ligand affects the d-orbital splitting and determines the magnetic properties of the complex.

d. What are polypeptides? Explain with example.

Solution:

Polypeptides are long chains of amino acids linked together by peptide bonds. Each peptide bond forms between the carboxyl group of one amino acid and the amino group of the next. The sequence of amino acids in a polypeptide determines its three-dimensional structure and its biological function. Polypeptides can vary in length from just a few amino acids to hundreds or thousands.

An example of a polypeptide is insulin, a hormone involved in glucose regulation. Insulin consists of two polypeptide chains: one with 21 amino acids and the other with 30 amino acids. These chains are linked by disulfide bonds, and they fold into a specific structure that allows insulin to bind to its receptor and regulate glucose metabolism in cells.

Quick Tip

Polypeptides fold into specific shapes that determine their function in the body, such as enzymes, hormones, or structural proteins.

4.a The column of a solution of 0.05 mol L^{-1} NaOH has diameter 2.0 cm and length 100 cm. The resistance of the column of solution is 5.55 $\times$ 10^3 ohm. Calculate its resistivity, conductivity and molar conductivity.

Solution:

Step 1: Formula for Resistivity.

The resistivity ρ of a solution is given by:

$$\rho = R \times \frac{A}{L}$$

where: - R is the resistance of the solution (5.55 × 10^3 ohms), - A is the cross-sectional area of the column, - L is the length of the column.

Step 2: Calculate the Cross-Sectional Area.

The area of the column is given by the formula for the area of a circle:

$$A = \pi r^2$$

where r is the radius of the column. The diameter is 2.0 cm, so the radius $r = 1.0\,\text{cm} = 0.01\,\text{m}$. Thus,

$$A = \pi \times (0.01)^2 = 3.14 \times 10^{-4}\,\text{m}^2$$

Step 3: Calculate Resistivity.

Now, substitute the values into the resistivity formula:

$$\rho = (5.55 \times 10^3) \times \frac{3.14 \times 10^{-4}}{1.0} = 1.74\,\Omega\,\text{m}$$

Step 4: Calculate Conductivity.

Conductivity κ is the reciprocal of resistivity:

$$\kappa = \frac{1}{\rho} = \frac{1}{1.74} = 0.574\,\text{S/m}$$

Step 5: Calculate Molar Conductivity.

Molar conductivity Λ_m is given by:

$$\Lambda_m = \kappa \times \frac{1000}{C}$$

where C is the molar concentration of NaOH (0.05 mol L^{-1}). Substituting the values:

$$\Lambda_m = 0.574 \times \frac{1000}{0.05} = 11.48\,\text{S}\,\text{m}^2\,\text{mol}^{-1}$$

Quick Tip

Resistivity is inversely related to conductivity. Molar conductivity is directly related to the concentration of the solution.

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b. Write short notes on the following:

(i) Tyndall Effect

(ii) Brownian Movement

(iii) Coagulation

Solution:

(i) Tyndall Effect:

The Tyndall effect refers to the scattering of light by colloidal particles in a medium. When a beam of light passes through a colloidal solution, the particles scatter the light, making the path of the beam visible. This effect is used to distinguish between a true solution and a colloidal solution. The scattering is more intense in colloidal solutions due to the larger particle size compared to true solutions.

(ii) Brownian Movement:

Brownian movement is the random motion of particles suspended in a fluid (liquid or gas) due to collisions with molecules of the surrounding medium. This erratic movement was first observed by Robert Brown in 1827 and provides evidence of the kinetic nature of matter. The movement is more prominent in smaller particles and decreases as the size of the particles increases.

(iii) Coagulation:

Coagulation refers to the process in which colloidal particles aggregate to form larger particles. This occurs when the charges on the colloidal particles are neutralized or when the stability of the colloidal dispersion is disturbed, typically by adding an electrolyte. Coagulation can result in the separation of the colloidal particles from the dispersion medium, as seen in the formation of a precipitate.

> Quick Tip
>
> The Tyndall effect helps differentiate colloids from true solutions, while Brownian movement provides evidence of the kinetic nature of particles.

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c. Write the structural formula of fructose. How is it different from the structure of glucose?

Solution:

The structural formula of fructose is:

$$CH_2OH - C(OH) - C(OH) - C(O) - CH_2OH$$

Fructose is a monosaccharide and a ketose sugar, meaning it contains a ketone group at the second carbon atom. Glucose, on the other hand, is an aldose sugar, which means it contains an aldehyde group at the first carbon atom. Both sugars are isomers, but they differ in the functional group present and their structural configurations. While glucose forms a six-membered ring in its cyclic form, fructose forms a five-membered ring.

Quick Tip

Fructose and glucose differ in the functional groups they contain: glucose is an aldose, and fructose is a ketose.

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d. Give a chemical test for differentiating the following couple of compounds:

(i) Secondary and Tertiary Amines
(ii) Methyl Amine and Dimethyl Amine
(iii) Ethylamine and Aniline

Solution:
(i) Secondary and Tertiary Amines:
Secondary and tertiary amines can be differentiated by the reaction with nitrous acid. When secondary amines react with nitrous acid, they form a diazonium salt, which can be further tested. Tertiary amines, however, do not form a diazonium salt with nitrous acid. Instead, they produce a different set of products, such as aliphatic products due to the absence of a hydrogen atom attached to nitrogen in tertiary amines.
(ii) Methyl Amine and Dimethyl Amine:
Methyl amine (CHNH) and dimethyl amine (CHNHCH) can be differentiated by their reaction with acetic acid. Methyl amine reacts with acetic acid to form methylammonium acetate, while dimethyl amine reacts to form dimethylammonium acetate. The difference in the products can be identified by their physical properties or by further chemical reactions, such as protonation.

(iii) Ethylamine and Aniline:

Ethylamine and aniline can be differentiated by their reaction with ferric chloride. Aniline, being an aromatic amine, reacts with ferric chloride to form a deep red or purple complex, while ethylamine, being an aliphatic amine, does not form such a complex. This is a distinctive test for differentiating aromatic and aliphatic amines.

Quick Tip

Reactions with nitrous acid, acetic acid, and ferric chloride can help differentiate between various types of amines.

5.a What do you understand by elevation in boiling point? Boiling point of a liquid is 350 K. On dissolving 2.0 g of a non-volatile solute in 100 g liquid, the boiling point of solution becomes 350.50 K. Calculate the molar mass of the solute. K_b for the liquid is 2.50 K kg mol^{-1}.

Solution:

Step 1: Formula for Elevation in Boiling Point.

The elevation in boiling point ΔT_b is given by the formula:

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

where: - ΔT_b is the change in boiling point, - K_b is the ebullioscopic constant of the solvent (2.50 K kg mol^{-1}), - m is the molality of the solution.

Step 2: Calculate the Change in Boiling Point.

Given that the boiling point of the solution is 350.50 K and the boiling point of the pure liquid is 350 K:

$$\Delta T_b = 350.50 - 350 = 0.50\,\text{K}$$

Step 3: Calculate the Molality.

Rearranging the formula to solve for molality:

$$m = \frac{\Delta T_b}{K_b} = \frac{0.50}{2.50} = 0.20\,\text{mol/kg}$$

Step 4: Calculate the Moles of Solute.

Molality is also defined as:

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

The mass of the solvent is 100 g = 0.1 kg. Substituting the values:

$$\text{moles of solute} = m \times \text{mass of solvent} = 0.20 \times 0.1 = 0.02\,\text{mol}$$

Step 5: Calculate the Molar Mass of the Solute.

The molar mass M is given by:

$$M = \frac{\text{mass of solute (g)}}{\text{moles of solute}} = \frac{2.0}{0.02} = 100\,\text{g/mol}$$

Quick Tip

The elevation in boiling point is directly proportional to the molality and the ebullioscopic constant of the solvent.

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b. What do you understand by order of reaction? What is the difference between the first order and zero order reaction? Following data was obtained on first order thermal decomposition of N_2O_5 (g) at fixed volume:

$2N_2O_5$ (g) $\rightarrow$ $2N_2O_4$ (g) + O_2 (g)

Solution:

Step 1: Understanding the Order of Reaction.

The order of a reaction is the sum of the powers of the concentration terms in the rate law expression. A first-order reaction has a rate that is directly proportional to the concentration of one reactant, while a zero-order reaction has a rate that is independent of the concentration of the reactant.

Step 2: First Order Reaction vs Zero Order Reaction.

- **First Order Reaction:** The rate of reaction depends on the concentration of one reactant raised to the first power. The rate law is:

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

where k is the rate constant and $[A]$ is the concentration of the reactant. The half-life of a first-order reaction is constant, independent of the concentration.
- **Zero Order Reaction:** The rate of reaction is constant and does not depend on the concentration of the reactant. The rate law is:

$$\text{Rate} = k$$

The half-life of a zero-order reaction is directly proportional to the initial concentration of the reactant.

Step 3: Calculate the Velocity Constant.

Using the data provided: - Initial pressure at time $t = 0$ is 0.5 atm, - Pressure after 100 seconds is 0.512 atm. The change in pressure is $\Delta P = 0.512 - 0.5 = 0.012$ atm. For a first-order reaction, the velocity constant k can be calculated using:

$$k = \frac{\text{Change in pressure}}{t} = \frac{0.012}{100} = 1.2 \times 10^{-4}\,\text{s}^{-1}$$

Quick Tip

The rate constant of a first-order reaction can be calculated by using the rate of pressure change for gas-phase reactions.

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c. What are transition elements? Write the names and electronic configuration of the elements of the first transition series. Transition metals and their maximum compounds are paramagnetic. Explain.

Solution:

Step 1: Definition of Transition Elements.

Transition elements are the elements found in the d-block of the periodic table. They are characterized by having partially filled d-orbitals in at least one of their oxidation states. These elements tend to form colored compounds, exhibit variable oxidation states, and are often good conductors of electricity.

Step 2: Electronic Configuration of the First Transition Series.

The elements of the first transition series are from Scandium (Sc) to Zinc (Zn). Their electronic configurations are as follows:

- Scandium (Sc): [Ar] $3d^1$ $4s^2$ - Titanium (Ti): [Ar] $3d^2$ $4s^2$ - Vanadium (V): [Ar] $3d^3$ $4s^2$ - Chromium (Cr): [Ar] $3d^5$ $4s^1$ - Manganese (Mn): [Ar] $3d^5$ $4s^2$ - Iron (Fe): [Ar] $3d^6$ $4s^2$ - Cobalt (Co): [Ar] $3d^7$ $4s^2$ - Nickel (Ni): [Ar] $3d^8$ $4s^2$ - Copper (Cu): [Ar] $3d^9$ $4s^1$ - Zinc (Zn): [Ar] $3d^1$ $4s^2$

Step 3: Paramagnetism of Transition Metals.

Transition metals are often paramagnetic because they have unpaired electrons in their d-orbitals, which make them attracted to an external magnetic field. The paramagnetism in transition metals is due to the presence of these unpaired electrons in the metal's electronic configuration. The number of unpaired electrons determines the strength of the paramagnetism.

> **Quick Tip**
>
> The presence of unpaired electrons in transition metals' d-orbitals makes them paramagnetic.

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d. Write the formulas of the following coordination compounds:

(i) Tetracarbonyl nickel (0)

(ii) Dichlorobis(ethan-1, 2-diamine) cobalt(III) chloride

(iii) Pentamine carbonato cobalt(III) chloride

(iv) Tetramine aquachloro cobalt(III) chloride

Solution:

(i) Tetracarbonyl nickel (0): The formula is $[Ni(CO)_4]$.

(ii) Dichlorobis(ethan-1, 2-diamine) cobalt(III) chloride: The formula is $[Co(C_2H_8N_2)_2Cl_2]Cl$.

(iii) Pentamine carbonato cobalt(III) chloride: The formula is $[Co(NH_3)_5CO_3]Cl$.

(iv) Tetramine aquachloro cobalt(III) chloride: The formula is $[Co(NH_3)_4Cl(H_2O)]Cl_2$.

Quick Tip

When writing formulas of coordination compounds, remember that ligands are named before the metal, and oxidation states are indicated in Roman numerals.

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

(i) Concentrated H_2SO_4 is added in calcium fluoride?

(ii) SO_3 is passed in water?

(iii) Calcium hydroxide reacts with ammonium chloride?

(iv) Concentrated sulphuric acid and copper metal is heated?

(v) Chlorine gas is passed in cold caustic soda solution?

Solution:

(i) Concentrated H_2SO_4 is added in calcium fluoride:

When concentrated sulfuric acid is added to calcium fluoride, it reacts to form calcium bisulfate and hydrogen fluoride gas:

$$\mathrm{CaF_2}(s) + \mathrm{H_2SO_4}(aq) \rightarrow \mathrm{Ca(HSO_4)_2}(aq) + \mathrm{HF}\ \mathrm{(g)}$$

(ii) SO_3 is passed in water:

Sulfur trioxide reacts with water to form sulfuric acid:

$$\mathrm{SO_3}(g) + \mathrm{H_2O}(l) \rightarrow \mathrm{H_2SO_4}(aq)$$

(iii) Calcium hydroxide reacts with ammonium chloride:

Calcium hydroxide reacts with ammonium chloride to form calcium chloride, water, and ammonia gas:

$$\mathrm{Ca(OH)_2}(aq) + 2\mathrm{NH_4Cl}(aq) \rightarrow \mathrm{CaCl_2}(aq) + 2\mathrm{NH_3}(g) + \mathrm{H_2O}(l)$$

(iv) Concentrated sulphuric acid and copper metal is heated:

When concentrated sulfuric acid reacts with copper metal, it forms copper(II) sulfate and sulfur dioxide gas:

$$\mathrm{Cu}\ \mathrm{(s)} + 2\mathrm{H_2SO_4}(aq) \rightarrow \mathrm{CuSO_4}(aq) + \mathrm{SO_2}(g) + 2\mathrm{H_2O}(l)$$

(v) Chlorine gas is passed in cold caustic soda solution:

When chlorine gas is passed through cold caustic soda (sodium hydroxide), it forms sodium chloride and sodium hypochlorite:

$$\text{Cl}_2(g) + 2\text{NaOH}(aq) \rightarrow \text{NaCl}(aq) + \text{NaOCl}(aq) + \text{H}_2\text{O}(l)$$

Quick Tip

In many reactions with sulfuric acid, it acts as a dehydrating agent, while chlorine and sodium hydroxide react to form bleaching powder (NaOCl).

OR

6.a Describe the method of preparation of dinitrogen in the laboratory and also write the chemical equations of the reactions. Write the reactions of dinitrogen with (i) oxygen and (ii) magnesium at high temperature. What is its reaction with hydrogen in presence of catalyst at 773 K temperature?

Solution:

Step 1: Preparation of Dinitrogen.

Dinitrogen is prepared in the laboratory by heating ammonium nitrite (NH_4NO_2) or by passing ammonia gas over heated copper oxide. The chemical equations for these processes are:

$$\text{NH}_4\text{NO}_2(aq) \rightarrow \text{N}_2(g) + 2\text{H}_2\text{O}(l)$$

or

$$2\text{NH}_3(g) + 3\text{CuO}(s) \rightarrow \text{N}_2(g) + 3\text{Cu}(s) + 3\text{H}_2\text{O}(g)$$

Step 2: Reaction of Dinitrogen with Oxygen.

When dinitrogen reacts with oxygen at high temperatures, it forms nitrogen monoxide (NO):

$$\text{N}_2(g) + \text{O}_2(g) \rightarrow 2\text{NO}(g)$$

Step 3: Reaction of Dinitrogen with Magnesium.

At high temperatures, dinitrogen reacts with magnesium to form magnesium nitride (Mg_3N_2):

$$N_2(g) + 3Mg(s) \rightarrow Mg_3N_2(s)$$

Step 4: Reaction of Dinitrogen with Hydrogen.

At 773 K, in the presence of a catalyst (such as iron), dinitrogen reacts with hydrogen to form ammonia:

$$N_2(g) + 3H_2(g) \xrightarrow{\text{catalyst}} 2NH_3(g)$$

Quick Tip

The Haber process, which uses a catalyst at 773 K to combine nitrogen and hydrogen, is essential for industrial ammonia production.

6.b Write IUPAC names of the following:

(i) CH_3CH = CH-CH_3 Br

(ii) $(CH_3)_3$-C-CH_2(Br)

(iii) CH_3CH_2-C-CH(Cl)CH_2CH_3

(iv) $(CH_3)_2CBrCH_2CH_3$

(v) $(CH_3)_3Cl$

Solution:

(i) CH_3CH = CH-CH_3 Br:

This compound is a bromine-substituted alkene. The IUPAC name is **1-bromo-2-butene**.

(ii) $(CH_3)_3$-C-CH_2(Br):

This is a bromoalkane. The IUPAC name is **2-bromo-3-methylbutane**.

(iii) CH_3CH_2-C-CH(Cl)CH_2CH_3:

This compound is a chloroalkane with a substituent on the second carbon. The IUPAC name is **2-chloro-3-methylpentane**.

(iv) $(CH_3)_2CBrCH_2CH_3$:

This is a bromoalkane. The IUPAC name is **3-bromo-2-methylbutane**.

(v) $(CH_3)_3Cl$:

This is a simple chloroalkane. The IUPAC name is **tert-butyl chloride**.

Quick Tip

In IUPAC naming, the longest carbon chain is identified first, and the position of substituents is specified by the lowest possible numbers.

OR

6.b Explain with reasons:

(i) Sulphuric acid is not used in the reaction of alcohol and KI.
(ii) Haloalkanes form alkyl cyanide as chief product on reaction with KCN, while isocyanide as chief product on reaction with AgCN.
(iii) Although chlorine is an electron withdrawing group, even then it is ortho- and para-directing in aromatic electrophilic substitution reactions.

Solution:
(i) Sulphuric Acid is not used in the reaction of alcohol and KI:
Sulfuric acid is not used in the reaction of alcohol and KI because it is a strong acid and can react with the iodine, forming sulfur dioxide and water. This would reduce the amount of iodine available for the reaction with the alcohol. A mild acid like acetic acid is used instead to promote the reaction without interfering with iodine.
(ii) Haloalkanes form alkyl cyanide as chief product on reaction with KCN, while isocyanide as chief product on reaction with AgCN:
When haloalkanes react with KCN, the cyanide ion (CN^-) directly attacks the electrophilic carbon in the haloalkane, leading to the formation of alkyl cyanide. In contrast, when the same reaction occurs with AgCN, the silver ion (Ag^+) coordinates with the cyanide ion, causing a rearrangement to form an isocyanide (also known as isonitrile). This rearrangement is facilitated by the interaction of the cyanide ion with the silver ion.
(iii) Chlorine is an electron withdrawing group, yet it is ortho- and para-directing in aromatic electrophilic substitution reactions:

Chlorine is an electron-withdrawing group via induction (due to its electronegativity), but it is also an electron-donating group through resonance (due to the lone pair of electrons on the chlorine atom). This electron donation via resonance makes the ortho- and para-positions of the aromatic ring more reactive to electrophilic substitution reactions, which is why chlorine is ortho- and para-directing in these reactions.

> **Quick Tip**
>
> Electron-withdrawing groups are usually meta-directing, but chlorine's lone pair allows it to also be ortho- and para-directing.

7.a Give chemical equation for the following reactions:

(i) Oxidation of propan-1-ol with alkaline KMnO$_4$:

Solution:

When propan-1-ol is oxidized with alkaline potassium permanganate (KMnO$_4$), it is oxidized to acetic acid (CH$_3$COOH):

$$\mathrm{CH_3CH_2OH} + [O] \xrightarrow{\mathrm{KMnO_4}} \mathrm{CH_3COOH}$$

(ii) Reaction of phenol with chloroform in presence of aqueous NaOH:

Solution:

When phenol reacts with chloroform (CHCl$_3$) in the presence of aqueous NaOH, it forms phenol-formaldehyde (a part of the reaction is the formation of the phenoxide ion):

$$\mathrm{C_6H_5OH} + \mathrm{CHCl_3} + \mathrm{NaOH} \rightarrow \mathrm{C_6H_4ClOH} + \mathrm{NaCl} + \mathrm{H_2O}$$

(iii) Reaction of phenol with dilute HNO$_3$:

Solution:

Phenol reacts with dilute nitric acid to form a mixture of ortho- and para-nitrophenol:

$$\mathrm{C_6H_5OH} + \mathrm{HNO_3} \rightarrow \mathrm{C_6H_4(OH)NO_2} \text{ (ortho and para isomers)}$$

(iv) Reaction of hydrogen iodide with methoxybenzene:

Solution:

Methoxybenzene (anisole) reacts with hydrogen iodide (HI) to form iodobenzene and methanol:

$$C_6H_5OCH_3 + HI \rightarrow C_6H_5I + CH_3OH$$

(v) Formation of propoxypropane from propan-1-ol:

Solution:

When propan-1-ol reacts with an alkyl halide (e.g., propyl chloride), it forms propoxypropane (an ether):

$$CH_3CH_2OH + CH_3CH_2Cl \rightarrow CH_3CH_2OCH_2CH_3 + HCl$$

Quick Tip

In reactions involving phenols, electrophilic aromatic substitution usually leads to the formation of ortho and para products, while reactions with halides form aryl halides.

OR

7.a How can the following changes be done? (Give chemical equations only)

(i) Propan-1-ol from ethyl magnesium chloride:

Solution:

Propan-1-ol can be prepared from ethyl magnesium chloride (a Grignard reagent) by reacting it with formaldehyde ($H_2C{=}O$) followed by hydrolysis:

$$C_2H_5MgCl + H_2C{=}O \xrightarrow{H_2O} C_3H_7OH$$

(ii) 2-methyl propan-2-ol from methyl magnesium bromide:

Solution:

2-methyl propan-2-ol can be synthesized from methyl magnesium bromide by reacting it with acetone (CH_3COCH_3) followed by hydrolysis:

$$CH_3MgBr + CH_3COCH_3 \xrightarrow{H_2O} (CH_3)_{3})_{3})_{3})_{3}COH$$

(iii) Benzoic acid from benzyl alcohol:

Solution:

Benzoic acid can be prepared from benzyl alcohol by oxidation with potassium permanganate ($KMnO_4$):

$$C_6H_5CH_2OH + [O] \xrightarrow{KMnO_4} C_6H_5COOH$$

(iv) Picric acid from phenol:

Solution:

Picric acid (2,4,6-trinitrophenol) is obtained by nitration of phenol with a mixture of concentrated nitric and sulfuric acids:

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

(v) Dehydration of propan-2-ol:

Solution:

Dehydration of propan-2-ol (isopropanol) using concentrated sulfuric acid gives propene (C_3H_6):

$$CH_3CH(OH)CH_3 \xrightarrow{H_2SO_4} CH_2CH_2CH_3 + H_2O$$

Quick Tip

Grignard reagents are used to form alcohols from carbonyl compounds, and dehydration of alcohols typically produces alkenes.

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

(i) Acetaldehyde reacts with dilute NaOH:

Solution:

When acetaldehyde reacts with dilute sodium hydroxide (NaOH), an aldol condensation reaction takes place, leading to the formation of -hydroxy aldehyde (acetaldol):

$$\mathrm{CH_3CHO + NaOH \rightarrow CH_3CH(OH)CHO}$$

(ii) Acetone is heated with solid barium hydroxide:

Solution:

When acetone is heated with solid barium hydroxide, it undergoes aldol condensation, forming mesityl oxide:

$$\mathrm{3CH_3COCH_3 \xrightarrow{Ba(OH)_2} CH_3COCH_2COCH_3\ (mesityl\ oxide)}$$

(iii) Formaldehyde reacts with concentrated NaOH solution:

Solution:

When formaldehyde reacts with concentrated sodium hydroxide, it undergoes the Cannizzaro reaction, forming formate and alcohol:

$$\mathrm{2CH_2O + NaOH \rightarrow HCOONa + CH_3}OH\mathrm{CH_3}OH\mathrm{CH_3}OH_{\mathrm{CH_3}OH}$$

(iv) Acetic acid reacts with ethanol in the presence of H_2SO_4:

Solution:

When acetic acid reacts with ethanol in the presence of sulfuric acid, it undergoes esterification to form ethyl acetate (an ester):

$$\mathrm{CH_3COOH + CH_3CH_2OH \xrightarrow{H_2SO_4} CH_3COOCH_2CH_3}$$

(v) Acetaldehyde reacts with phenyl hydrazine:

Solution:

When acetaldehyde reacts with phenyl hydrazine, it forms an aldol condensation product known as hydrazone:

$$CH_3CHO + C_6H_5NH\text{-}NH_2 \rightarrow CH_3CH\text{=}N\text{-}NH_2$$

Quick Tip

In aldol condensation, an enolate ion forms and attacks the carbonyl carbon of another molecule, leading to -hydroxy aldehyde or ketone formation.

OR

7.b Write short notes on the following:

(i) Kolbe Electrolysis:

Solution:

Kolbe electrolysis is a method of preparing alkyl radicals from carboxylic acids by applying an electric current. When a carboxylate salt (usually sodium or potassium salt of a carboxylic acid) is electrolyzed, it undergoes decarboxylation, forming an alkane:

$$RCOONa \xrightarrow{\text{electrolysis}} R\text{-}H + CO_2$$

For example, sodium acetate under Kolbe electrolysis gives ethane.

(ii) Aldol Condensation:

Solution:

Aldol condensation is a reaction where an aldehyde or a ketone with a hydrogen atom on the -carbon reacts with another molecule of the same compound or a different one to form a -hydroxy aldehyde or ketone. Upon heating, this product undergoes dehydration to form an ,-unsaturated carbonyl compound. For example, acetaldehyde under basic conditions gives -hydroxy aldehyde:

$$CH_3CHO + CH_3CHO \xrightarrow{\text{NaOH}} CH_3CH(OH)CHO \xrightarrow{\Delta} CH_3CH\text{=}CHCHO$$

(iii) Rosenmund Reduction:

Solution:
Rosenmund reduction is a catalytic hydrogenation process that selectively reduces acyl chlorides to aldehydes. In this reaction, acyl chloride is treated with hydrogen gas in the presence of palladium on barium sulfate ($Pd/BaSO_4$) and quinoline as a poison:

$$RCOCl + H_2 \xrightarrow{Pd/BaSO_4} RCHO$$

For example, benzoyl chloride is reduced to benzaldehyde under these conditions.

Quick Tip

Aldol condensation and Kolbe electrolysis are both useful for forming carbon-carbon bonds in organic synthesis.
