CBSE Class 12 Chemistry Set 56/2/3 Question Paper 2026 with Solutions

| Time Allowed :3 Hours | Maximum Marks :30 | Total Questions :16 |

General Instructions

1. This question paper contains 33 questions. All questions are compulsory.

2. This question paper is divided into five sections - Section A, B, C, D and E.

3. Section A - questions number 1 to 16 are multiple choice type questions. Each question carries 1 mark.

4. Section B - questions number 17 to 21 are very short answer type questions. Each question carries 2 marks.

5. Section C - questions number 22 to 28 are short answer type questions. Each question carries 3 marks.

6. Section D - questions number 29 and 30 are case-based questions. Each question carries 4 marks.

7. Section E - questions number 31 to 33 are long answer type questions. Each question carries 5 marks.

8. There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the sections except Section -A.

9. Kindly note that there is a separate question paper for Visually Impaired candidates.

10. Use of calculator is NOT allowed.

1. Identify the correct statement:
(A) Molecularity of a reaction is an experimental quantity.
(B) For complex reactions molecularity has no meaning.
(C) Molecularity of a reaction can be zero or even a fraction.
(D) Molecularity more than three is very common in chemical reactions.

Correct Answer: (B) For complex reactions molecularity has no meaning.

Solution: Concept: Molecularity is defined as the number of reacting species (atoms, ions, or molecules) that collide simultaneously in an elementary step of a reaction. Key properties:

- It is defined only for **elementary reactions**.

- It is always a **positive integer** (1, 2, or rarely 3).

- It is a **theoretical concept**, not experimentally determined.

- It has **no meaning for complex (multi-step) reactions**.

Step 1: Check each statement.
Option (A): Molecularity is not an experimental quantity. It is derived from the reaction mechanism. Hence, incorrect.

Option (B): Complex reactions occur in multiple elementary steps, and molecularity is defined only for individual elementary steps. Thus, for complex reactions, molecularity has no meaning. Hence, correct.

Option (C): Molecularity cannot be zero or fractional. It must be a whole number. Hence, incorrect.

Option (D): Reactions with molecularity greater than 3 are extremely rare because simultaneous collision of many particles is unlikely. Hence, incorrect.

> **Quick Tip**
>
> Molecularity is always a whole number and applies only to elementary reactions. If a reaction is complex (multi-step), molecularity is not defined.

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2. Consider the following reaction:

$$Zn_{(s)} + Ag_2O_{(s)} + H_2O_{(l)} \rightarrow Zn^{2+}_{(aq)} + 2Ag_{(s)} + 2OH^-_{(aq)}$$
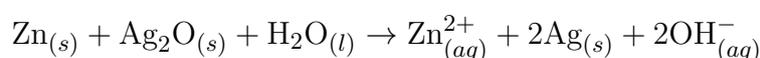
Given:

$$E^\circ_{Ag^+/Ag} = 0.80 \text{ V}$$

$$E^\circ_{Zn^{2+}/Zn} = -0.76 \text{ V}$$

$$1F = 96500 \text{ C mol}^{-1}$$

ΔG° for above reaction is:
(A) -301.080 kJ mol^{-1}
(B) $+310.080$ kJ mol^{-1}
(C) -326.070 kJ mol^{-1}
(D) 375.060 kJ mol^{-1}

Correct Answer: (A) -301.080 kJ mol^{-1}

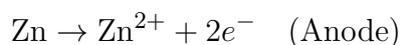**Solution: Concept:** The relationship between standard Gibbs free energy and cell potential is:

$$\Delta G^\circ = -nFE^\circ_{cell}$$

where:

- n = number of electrons transferred

- F = Faraday constant (96500 C mol^{-1})

- E°_{cell} = standard cell potential

Step 1: Identify oxidation and reduction reactions.
Zinc is oxidized:

$$Zn \rightarrow Zn^{2+} + 2e^- \quad \text{(Anode)}$$

Silver ion (from Ag_2O) is reduced:

$$Ag^+ + e^- \rightarrow Ag \quad \text{(Cathode)}$$

Step 2: Calculate standard cell potential.

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

$$E^{\circ}_{\text{cell}} = 0.80 - (-0.76) = 1.56 \text{ V}$$

Step 3: Find number of electrons transferred.
From Zn $\rightarrow$ Zn^{2+}, 2 electrons are transferred. So, $n = 2$.
Step 4: Calculate ΔG°.

$$\Delta G^{\circ} = -nFE^{\circ}_{\text{cell}}$$

$$\Delta G^{\circ} = -(2)(96500)(1.56)$$

$$\Delta G^{\circ} = -301080 \text{ J mol}^{-1}$$

$$\Delta G^{\circ} = -301.080 \text{ kJ mol}^{-1}$$

> **Quick Tip**
>
> Use $\Delta G^{\circ} = -nFE^{\circ}_{\text{cell}}$. If E°_{cell} is positive, ΔG° is negative, indicating a spontaneous reaction.

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3. Electronic configuration of chromium is:
(A) [Ar] $3d^4 \, 4s^1$
(B) [Ar] $3d^4 \, 4s^2$
(C) [Ar] $3d^5 \, 4s^1$
(D) [Ar] $3d^5 \, 4s^2$

Correct Answer: (C) [Ar] $3d^5 \, 4s^1$

Solution: Concept: Electronic configuration follows the Aufbau principle, but some transition elements show exceptions due to extra stability of:

- Half-filled subshells (d^5)

- Completely filled subshells (d^{10})

This stability arises from exchange energy and symmetrical electron distribution.
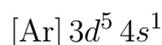**Step 1:** Write expected configuration using Aufbau principle.
Chromium has atomic number 24. Expected configuration:

$$[\text{Ar}] \, 3d^4 \, 4s^2$$
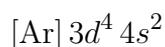
Step 2: Apply stability of half-filled subshell.
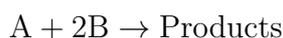A half-filled $3d^5$ configuration is more stable than $3d^4$. So, one electron from $4s$ shifts to $3d$.
Step 3: Write actual configuration.

$$[\text{Ar}]\, 3d^5\, 4s^1$$

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4. The order for the given reaction is:

$$A + 2B \rightarrow \text{Products}$$

$$\text{Rate} = k[\text{A}]^{1/2}[\text{B}]^1$$

(A) 1.5
(B) 1
(C) 0.5
(D) 2

Correct Answer: (A) 1.5

Solution: Concept: The order of a reaction is the sum of the powers of concentration terms in the rate law.

$$\text{Order} = \text{Sum of exponents in rate equation}$$

It is determined experimentally and may not match stoichiometric coefficients.
Step 1: Write the given rate law.

$$\text{Rate} = k[\text{A}]^{1/2}[\text{B}]^1$$

Step 2: Add the powers of concentrations. Order with respect to A = 1/2 Order with respect to B = 1
Step 3: Calculate overall order.

$$\text{Overall order} = \frac{1}{2} + 1 = \frac{3}{2} = 1.5$$

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5. Which of the following is heteroleptic complex?
(A) $[\text{Co(NH}_3)_6]^{3+}$
(B) $[\text{Cr(NH}_3)_6]^{3+}$
(C) $[\text{Ni(H}_2\text{O)}_6]^{2+}$
(D) $[\text{Co(NH}_3)_4\text{Cl}_2]^+$

Correct Answer: (D) $[Co(NH_3)_4Cl_2]^+$

Solution: Concept: Coordination complexes are classified as:

- **Homoleptic complexes:** Contain only one type of ligand.

- **Heteroleptic complexes:** Contain more than one type of ligand.

Step 1: Check each option.
Option (A): $[Co(NH_3)_6]^{3+}$ Contains only NH_3 ligands $\rightarrow$ Homoleptic.
Option (B): $[Cr(NH_3)_6]^{3+}$ Only NH_3 ligands $\rightarrow$ Homoleptic.
Option (C): $[Ni(H_2O)_6]^{2+}$ Only H_2O ligands $\rightarrow$ Homoleptic.
Option (D): $[Co(NH_3)_4Cl_2]^+$ Contains two different ligands: NH_3 and Cl^-. Hence, heteroleptic complex.

> **Quick Tip**
>
> Homoleptic = one type of ligand. Heteroleptic = more than one type of ligand (mixed ligands).

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6. The correct IUPAC name of the complex $[Pt(NH_3)_2Cl_2]$ is:
(A) diamminedichloridoplatinum (IV)
(B) diamminedichloridoplatinum (II)
(C) dichloridodiammineplatinum (IV)
(D) dichloridodiammineplatinum (II)

Correct Answer: (B) diamminedichloridoplatinum (II)

Solution: Concept: Rules for IUPAC naming of coordination compounds:

- Name ligands alphabetically before the metal.

- Neutral ligands: NH_3 = ammine.

- Anionic ligands: Cl^- = chlorido.

- Oxidation state of metal is written in Roman numerals.

Step 1: Identify ligands. $NH_3 \rightarrow$ ammine (neutral ligand) $Cl^- \rightarrow$ chlorido (anionic ligand)
Step 2: Arrange ligands alphabetically. Ammine (a) comes before chlorido (c). So, name begins with:

$$\text{diammine dichlorido}$$

Step 3: Find oxidation state of Pt.
Let oxidation state of Pt $= x$ NH_3 is neutral, $Cl = -1$

$$x + 2(0) + 2(-1) = 0$$
$$x - 2 = 0 \Rightarrow x = +2$$

Step 4: Write final IUPAC name.

$$\text{diamminedichloridoplatinum (II)}$$

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7. Identify the correct increasing order of boiling points of the given compounds:
(A) Propan-1-ol < butan-1-ol < butan-2-ol < pentan-1-ol
(B) Pentan-1-ol < butan-1-ol < butan-2-ol < propan-1-ol
(C) Propan-1-ol < butan-2-ol < butan-1-ol < pentan-1-ol
(D) Butan-1-ol < butan-2-ol < propan-1-ol < pentan-1-ol

Correct Answer: (C) Propan-1-ol < butan-2-ol < butan-1-ol < pentan-1-ol

Solution: Concept: Boiling points of alcohols depend on:

- Hydrogen bonding (present in all alcohols)

- Molecular mass (higher mass $\Rightarrow$ higher boiling point)

- Branching (more branching $\Rightarrow$ lower boiling point due to less surface area)

Step 1: Compare carbon chain length. Higher carbon chain $\Rightarrow$ stronger van der Waals forces $\Rightarrow$ higher boiling point. So:

$$\text{propan-1-ol} < \text{butanol isomers} < \text{pentan-1-ol}$$

Step 2: Compare branching among butanol isomers. Butan-1-ol = primary alcohol (less branched) Butan-2-ol = secondary alcohol (more branched)
More branching $\Rightarrow$ lower boiling point. So:

$$\text{butan-2-ol} < \text{butan-1-ol}$$

Step 3: Combine both trends.

$$\text{Propan-1-ol} < \text{butan-2-ol} < \text{butan-1-ol} < \text{pentan-1-ol}$$

> **Quick Tip**
>
> Boiling point trends in alcohols: Longer chain ↑ BP More branching ↓ BP All alcohols have hydrogen bonding, so size and branching dominate comparisons.

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8. Which of the following molecule is chiral in nature?
(A) Propan-2-ol
(B) Butan-2-ol
(C) 1-Bromobutane
(D) 2-Bromopropane

Correct Answer: (B) Butan-2-ol

Solution: Concept: A molecule is chiral if it contains a carbon atom bonded to four different groups (asymmetric carbon). Such molecules are non-superimposable on their mirror images.

Step 1: Check each option for asymmetric carbon.

Option (A): Propan-2-ol Central carbon is attached to: CH_3, CH_3, OH, H Two identical groups present → Achiral.

Option (B): Butan-2-ol Second carbon is attached to: CH_3, C_2H_5, OH, H All four groups are different → Chiral.

Option (C): 1-Bromobutane Terminal carbon bonded to Br has two hydrogens → Not asymmetric → Achiral.

Option (D): 2-Bromopropane Central carbon attached to two CH_3 groups → Achiral.

> **Quick Tip**
>
> Chirality rule: Look for a carbon with four different substituents. If any two groups are identical, the molecule is achiral.

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9. The base which is present in DNA but not in RNA is:
(A) Guanine
(B) Cytosine
(C) Thymine
(D) Adenine

Correct Answer: (C) Thymine

Solution: Concept: DNA and RNA differ in one nitrogenous base:

- DNA contains: Adenine (A), Guanine (G), Cytosine (C), Thymine (T)

- RNA contains: Adenine (A), Guanine (G), Cytosine (C), Uracil (U)

Thymine in DNA is replaced by uracil in RNA.

Step 1: Compare bases of DNA and RNA.

Common bases in both: Adenine, Guanine, Cytosine

Unique bases: DNA → Thymine RNA → Uracil

Step 2: Identify the correct option. The base present in DNA but not in RNA is Thymine.

> **Quick Tip**
>
> DNA = A, G, C, T RNA = A, G, C, U Remember: Thymine (T) is replaced by Uracil (U) in RNA.

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10. Identify the compound produced by the reduction of ethanenitrile with lithium aluminium hydride:
(A) Ethylamine
(B) Ethanal

(C) Propylamine
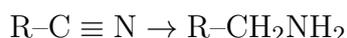(D) Methylamine

Correct Answer: (A) Ethylamine

Solution: Concept: Lithium aluminium hydride (LiAlH$_4$) is a strong reducing agent that reduces:
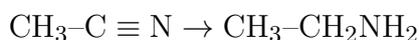
- Nitriles (–C≡N) → Primary amines (–CH$_2$NH$_2$)

The carbon chain length remains the same during reduction.
Step 1: Identify the starting compound. Ethanenitrile = CH$_3$–C≡N It contains two carbon atoms.
Step 2: Apply reduction rule. Nitrile $\xrightarrow{\text{LiAlH}_4}$ Primary amine

$$R\text{–}C \equiv N \to R\text{–}CH_2NH_2$$

Step 3: Write product.

$$CH_3\text{–}C \equiv N \to CH_3\text{–}CH_2NH_2$$

This is ethylamine.

> **Quick Tip**
>
> LiAlH$_4$ reduction rules: Nitrile → Primary amine Amide → Amine Carbon chain length remains unchanged.

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11. Which of the following reactions is not explained by the open chain structure of glucose?
(A) Glucose on prolonged heating with HI forms n-hexane.
(B) Glucose reacts with hydroxylamine to form an oxime.
(C) Glucose gets oxidized to gluconic acid on reaction with bromine water.
(D) Glucose exists in two different crystalline forms, alpha (α) and beta (β).

Correct Answer: (D) Glucose exists in two different crystalline forms, alpha (α) and beta (β).

Solution: Concept: Glucose exists in both open-chain and cyclic (ring) forms. The open-chain structure explains reactions involving the aldehyde group (–CHO), while cyclic structure explains stereoisomerism like α and β forms.
Step 1: Check which reactions are explained by open-chain structure.
Option (A): Formation of n-hexane with HI shows presence of straight carbon chain. Explained by open-chain structure.
Option (B): Reaction with hydroxylamine forming oxime indicates presence of aldehyde group. Explained by open-chain structure.
Option (C): Oxidation to gluconic acid with bromine water confirms aldehyde group. Explained by open-chain structure.
Option (D): Existence of α and β forms arises due to cyclic hemiacetal ring structure and anomerism. Not explained by open-chain structure.

12. Proteins are polymers of α-amino acids which are joined to each other by:
(A) Covalent Bond
(B) Peptide Bond
(C) Glycosidic Bond
(D) Coordinate Bond

Correct Answer: (B) Peptide Bond

Solution: Concept: Proteins are formed by the polymerization of α-amino acids. The linkage between amino acids occurs through a peptide bond.
Step 1: Understand peptide bond formation. A peptide bond is formed between:

- Carboxyl group (–COOH) of one amino acid

- Amino group (–NH$_2$) of another amino acid

This occurs with the elimination of a water molecule (condensation reaction).
Step 2: Analyze options.
Option (A): Covalent bond → Too general.
Option (B): Peptide bond → Specific linkage in proteins. Correct.
Option (C): Glycosidic bond → Found in carbohydrates.
Option (D): Coordinate bond → Not responsible for protein backbone formation.

13. Assertion (A): Zinc, cadmium and mercury are not considered as transition elements.
Reason (R): These elements have completely filled d orbitals in their ground state as well as in their common oxidation states.
Choose the correct option:
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).
(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).
(C) Assertion (A) is true, but Reason (R) is false.
(D) Assertion (A) is false, but Reason (R) is true.

Correct Answer: (A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

Solution: Concept: Transition elements are defined as elements that have:

- Partially filled d orbitals in the atomic state, or

- Form at least one ion with partially filled d orbitals.

Step 1: Check Assertion (A). Zinc (Zn), Cadmium (Cd), and Mercury (Hg) have completely filled d^{10} configurations. They do not form ions with partially filled d orbitals. Hence, they are not considered transition elements. Assertion is true.

Step 2: Check Reason (R). These elements have:

$$d^{10} \text{ configuration in ground state and common oxidation states}$$

So, reason is also true.

Step 3: Check if Reason explains Assertion. Since the definition of transition elements requires partially filled d orbitals, having completely filled d orbitals explains why Zn, Cd, Hg are not transition elements.

Thus, Reason correctly explains Assertion.

> **Quick Tip**
>
> Transition element rule: Must have partially filled d orbitals in atom or ion. Zn, Cd, Hg $= d^{10} \rightarrow$ Not transition elements.

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14. Assertion (A): The molecularity of the given reaction is 2.

$$2HI \rightarrow H_2 + I_2$$
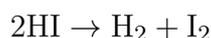
Reason (R): Two molecules of the reactants are involved in simultaneous collision between them.
**Choose the correct option:**
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).
(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).
(C) Assertion (A) is true, but Reason (R) is false.
(D) Assertion (A) is false, but Reason (R) is true.

Correct Answer: (A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

Solution: Concept: Molecularity is defined as the number of reacting species that collide simultaneously in an elementary reaction step. It is always a whole number.
Step 1: Check Assertion (A). Given reaction:

$$2HI \rightarrow H_2 + I_2$$
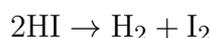
Two HI molecules are involved in the reaction step. Hence, molecularity = 2 (bimolecular reaction). Assertion is true.

Step 2: Check Reason (R). Molecularity depends on the number of molecules colliding simultaneously. Here, two molecules of HI collide. Reason is true.

Step 3: Check if Reason explains Assertion. Since molecularity is defined based on simultaneous collisions, the reason correctly explains why molecularity is 2.

> **Quick Tip**
>
> Molecularity = number of molecules colliding in an elementary step. $1 \rightarrow$ Unimolecular $2 \rightarrow$ Bimolecular $3 \rightarrow$ Termolecular (rare)

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15. Assertion (A): Glucose gets oxidized to six carbon gluconic acid on reaction with bromine water.

Reason (R): The carbonyl group is absent in the open chain structure of glucose.

Choose the correct option:

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false, but Reason (R) is true.

Correct Answer: (C) Assertion (A) is true, but Reason (R) is false.

Solution: Concept: Bromine water is a mild oxidizing agent that oxidizes aldehydes (–CHO) to carboxylic acids (–COOH) without affecting other functional groups.

Step 1: Check Assertion (A). Glucose contains an aldehyde group in its open-chain form. Bromine water oxidizes the aldehyde group to gluconic acid, which still contains six carbon atoms. Hence, Assertion is true.

Step 2: Check Reason (R). In the open-chain structure of glucose, a carbonyl group (aldehyde) is present. So, the statement that carbonyl group is absent is incorrect. Reason is false.

Step 3: Choose correct option. Assertion is true but Reason is false.

> **Quick Tip**
>
> Glucose reactions: Bromine water $\rightarrow$ oxidizes aldehyde to gluconic acid Shows presence of carbonyl group in open-chain form.

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16. Assertion (A): Aromatic primary amines can be prepared by Gabriel phthalimide synthesis.

Reason (R): Aryl halides do not undergo nucleophilic substitution with phthalimide ion.

Choose the correct option:

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).
(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).
(C) Assertion (A) is true, but Reason (R) is false.
(D) Assertion (A) is false, but Reason (R) is true.

Correct Answer: (D) Assertion (A) is false, but Reason (R) is true.

Solution: Concept: Gabriel phthalimide synthesis is used to prepare primary amines by nucleophilic substitution of alkyl halides using phthalimide ion.
Step 1: Check Assertion (A). Gabriel synthesis works well with alkyl halides. Aryl halides do not undergo nucleophilic substitution easily due to resonance stabilization of the C–X bond. Hence, aromatic primary amines cannot be prepared by Gabriel synthesis. Assertion is false.
Step 2: Check Reason (R). Aryl halides resist nucleophilic substitution with phthalimide ion. This is a true statement.
Step 3: Select correct option. Assertion is false, Reason is true.

> **Quick Tip**
>
> Gabriel synthesis works only for aliphatic primary amines. It does not work for aryl halides → Aromatic amines cannot be prepared this way.

17(a). Define coordination number.

Correct Answer: The total number of coordinate bonds between ligands and the central metal ion.

Solution: Concept: In a coordination complex, a central metal atom or ion is surrounded by ligands that donate lone pairs to form coordinate covalent bonds. The coordination number depends on the number of donor atoms directly bonded to the metal, not the number of ligands.
Step 1: Define coordination number. The coordination number (C.N.) of a metal ion is the total number of ligand donor atoms directly bonded to the central metal ion in a coordination sphere.
Step 2: Understand the role of ligand denticity. Coordination number depends on how many donor atoms each ligand provides:

- Monodentate ligands donate one donor atom each (e.g., NH_3, Cl^-).

- Bidentate ligands donate two donor atoms (e.g., ethylenediamine, en).

Step 3: Illustrative examples.

- Six monodentate ligands $\Rightarrow$ C.N. = 6

- Three bidentate ligands $\Rightarrow$ C.N. = $3 \times 2 = 6$

Step 4: Final conclusion. Coordination number is the number of donor atoms from ligands directly attached to the central metal ion.

> **Quick Tip**
>
> Coordination number counts only sigma bonds between ligands and metal. Pi interactions, if present, are not included in the coordination number.

17(b). Indicate the type of isomerism exhibited by the following complex: $[Co(en)_3]Cl_3$

Correct Answer: Optical Isomerism

Solution: Concept: Isomerism in coordination compounds occurs when complexes have the same molecular formula but differ in spatial arrangement of ligands. One important type is optical isomerism, where compounds exist as non-superimposable mirror images (enantiomers).
Step 1: Identify the nature of the complex. The complex $[Co(en)_3]Cl_3$ contains the tris(ethylenediamine)cobalt cation. Here, 'en' (ethylenediamine) is a chelating bidentate ligand.
Step 2: Analyze geometry and symmetry. The complex is of the type $[M(aa)_3]$, which forms an octahedral structure. Due to the propeller-like arrangement of three bidentate ligands:

- No plane of symmetry
- No center of inversion

Hence, the molecule becomes chiral.
Step 3: Determine type of isomerism. The complex exists as two non-superimposable mirror images:

- Dextro (d) form
- Laevo (l) form

These are optical isomers (enantiomers).
Step 4: Final conclusion. The complex $[Co(en)_3]Cl_3$ exhibits optical isomerism.

> **Quick Tip**
>
> Complexes of the type $[M(aa)_3]$ and cis-$[M(aa)_2b_2]$ are usually chiral and show optical isomerism. Trans forms of $[M(aa)_2b_2]$ are generally optically inactive due to symmetry.

18(a). Define Effective collision.

Correct Answer: Collisions that lead to the formation of product molecules.

Solution: Concept: According to collision theory, chemical reactions occur due to collisions between reactant molecules. However, only a fraction of these collisions actually lead to product formation.

Step 1: Define effective collision. An effective collision is a collision between reactant molecules that results in the formation of products.

Step 2: Conditions for an effective collision. For a collision to be effective, two requirements must be satisfied simultaneously:

- **Energy factor:** Molecules must possess minimum energy called threshold energy (equal to or greater than activation energy) to break existing bonds.

- **Orientation factor:** Molecules must collide with proper spatial orientation so that bond breaking and bond formation can occur.

Step 3: Final conclusion. An effective collision is one in which reactant molecules collide with sufficient kinetic energy and correct orientation to form products.

> **Quick Tip**
>
> Only a small fraction of total collisions are effective. Increasing temperature increases the number of effective collisions by raising molecular energy.

18(b). Write the unit of (i) second order reaction and (ii) zero order reaction.

Correct Answer: (i) $\text{L mol}^{-1} \text{ s}^{-1}$ and (ii) $\text{mol L}^{-1} \text{ s}^{-1}$

Solution: Concept: The units of the rate constant (k) depend on the overall order of the reaction (n). From the rate law:

$$\text{Rate} = k[\text{Concentration}]^n$$

Since rate has units of $\text{mol L}^{-1} \text{ s}^{-1}$, the unit of k becomes:

$$\text{Unit of } k = (\text{mol L}^{-1})^{1-n} \text{ s}^{-1}$$

Step 1: Second order reaction $(n = 2)$. Substitute $n = 2$:

$$(\text{mol L}^{-1})^{1-2} \text{ s}^{-1} = (\text{mol L}^{-1})^{-1} \text{ s}^{-1}$$

$$= \text{L mol}^{-1} \text{ s}^{-1}$$

Step 2: Zero order reaction $(n = 0)$. Substitute $n = 0$:

$$(\text{mol L}^{-1})^{1-0} \text{ s}^{-1} = \text{mol L}^{-1} \text{ s}^{-1}$$

For zero-order reactions, the unit of rate constant is the same as the unit of rate.

Step 3: Final answers.

- Second order reaction: $\textbf{L mol}^{-1} \textbf{ s}^{-1}$

- Zero order reaction: **mol L^{-1} s^{-1}**

> **Quick Tip**
>
> Quick rule: Unit of rate constant $=$ (mol L^{-1})$^{1-n}$ s^{-1}. For first order ($n = 1$), unit becomes s^{-1}.

19(a). Why second ionization enthalpies of chromium and copper are exceptionally higher than those of their neighbouring elements?

Correct Answer: Due to the removal of electrons from stable half-filled ($3d^5$) and fully-filled ($3d^{10}$) subshells.

Solution: Concept: Ionization enthalpy is the energy required to remove an electron from an atom or ion. It depends strongly on the stability of the electronic configuration, especially the presence of half-filled or fully-filled subshells.
Step 1: Write electronic configurations.

$$\text{Cr}(Z = 24) : [Ar]\, 3d^5\, 4s^1$$

$$\text{Cu}(Z = 29) : [Ar]\, 3d^{10}\, 4s^1$$
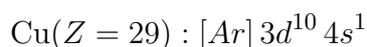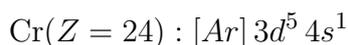
Step 2: Remove the first electron (formation of M^+). The first ionization removes the $4s$ electron:

$$\text{Cr}^+ : [Ar]\, 3d^5 \quad \text{(half-filled)}$$

$$\text{Cu}^+ : [Ar]\, 3d^{10} \quad \text{(fully-filled)}$$
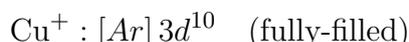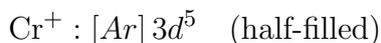
Step 3: Analyze second ionization enthalpy (IE_2). The second electron must now be removed from the d-subshell:

- In Cr$^+$: removal from stable half-filled $3d^5$

- In Cu$^+$: removal from highly stable fully-filled $3d^{10}$

Both configurations are exceptionally stable due to symmetry and high exchange energy.
Step 4: Conclusion. Breaking these stable half-filled and fully-filled configurations requires extra energy. Hence, the second ionization enthalpy is unusually high for both Cr and Cu.

> **Quick Tip**
>
> Stability trend: Fully-filled > Half-filled > Partially-filled. Always consider the configuration of the ion after the first electron is removed when analyzing IE_2.

19(b). Why transition elements form interstitial compounds?

Correct Answer: Because small atoms can fit into the voids of their crystal lattice.

Solution: Concept: Transition metals form metallic crystal lattices (FCC, BCC, or HCP) made of closely packed metal atoms. These lattices naturally contain small empty spaces known as interstitial sites.

Step 1: Understand interstitial sites. When metal atoms arrange in a crystal lattice, small voids are left between them. These voids are called interstitial spaces.

Step 2: Incorporation of small atoms. Small non-metal atoms such as:

$$H, C, N, B$$

can easily occupy these interstitial sites without significantly disturbing the metal lattice.

Step 3: Formation of interstitial compounds. This leads to the formation of interstitial compounds such as:

$$TiC, \ Mn_4N, \ Fe_3H$$
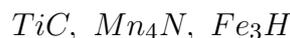
These compounds are often non-stoichiometric and retain metallic characteristics.

Step 4: Final conclusion. Transition metals form interstitial compounds because their crystal lattices contain empty interstitial spaces where small atoms can be accommodated.

> **Quick Tip**
>
> Interstitial compounds are usually very hard, have high melting points, and retain metallic conductivity while becoming more chemically inert.

20(A). The concentration of the reactant is reduced from 0.6 mol L^{-1} to 0.2 mol L^{-1} in 5 minutes in a first order reaction. Calculate rate constant of the reaction. $(\log 3 = 0.48)$

Correct Answer: $k \approx 0.221$ min^{-1}

Solution: Concept: For a first-order reaction, the rate constant is given by:

$$k = \frac{2.303}{t} \log \left(\frac{[R]_0}{[R]} \right)$$

where $[R]_0$ is initial concentration, $[R]$ is concentration after time t.

Step 1: Calculate concentration ratio.

$$\frac{[R]_0}{[R]} = \frac{0.6}{0.2} = 3$$

Step 2: Substitute values into formula. Given $t = 5$ min:

$$k = \frac{2.303}{5} \log(3)$$

Step 3: Calculate numerical value. Given $\log 3 = 0.48$:

$$k = \frac{2.303}{5} \times 0.48$$

$$k = \frac{1.10544}{5} = 0.221088 \text{ min}^{-1}$$

Step 4: Final answer. The rate constant is approximately:

$$\mathbf{0.221 \text{ min}^{-1}}$$

> **Quick Tip**
>
> For first-order reactions, the unit of k is always time^{-1} (e.g., s^{-1}, min^{-1}). Concentration units cancel inside the logarithmic term.

20(B). Rate constant k for the first order reaction is 2.54×10^{-3} s^{-1}. Calculate the time required for three-fourth of the reactant to decompose. ($\log 4 = 0.60$)

Correct Answer: $t \approx 544$ s

Solution: Concept: For a first-order reaction:

$$t = \frac{2.303}{k} \log\left(\frac{[R]_0}{[R]}\right)$$

If three-fourth of the reactant has reacted, then one-fourth remains:

$$\frac{[R]_0}{[R]} = 4$$

Step 1: Identify remaining fraction. If 3/4 decomposes, remaining fraction = 1/4. So:

$$\frac{[R]_0}{[R]} = \frac{1}{1/4} = 4$$

Step 2: Substitute given values. Given:

$$k = 2.54 \times 10^{-3} \text{ s}^{-1}, \quad \log 4 = 0.60$$

$$t = \frac{2.303}{2.54 \times 10^{-3}} \log(4)$$

Step 3: Calculate numerical value.

$$t = \frac{2.303 \times 0.60}{2.54 \times 10^{-3}}$$

$$t = \frac{1.3818}{2.54} \times 10^3$$

$$t \approx 0.544 \times 10^3 = 544 \text{ s}$$

Step 4: Final answer. The time required is approximately:

$$\mathbf{544 \text{ s}}$$

> **Quick Tip**
>
> For first-order reactions, decomposition of 3/4 corresponds to two half-lives: $t_{3/4} = 2t_{1/2}$, where $t_{1/2} = 0.693/k$.