Class 12 Chemistry – Coordination Compounds | Study Guide

1. Theory in Simple Words with Visuals

1.1 What are Coordination Compounds?

- **Definition:** Compounds in which a **central metal atom/ion is bonded to molecules or ions called ligands**.
- **Analogy:** Think of the metal as a "king" and ligands as "loyal knights" surrounding it.

General Formula:

$$[Metal\ (Ligand)_n]^{charge}$$

Example: $[Fe(CN)_6]^{3-}$

Flowchart – How Coordination Compounds Form:

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Metal Ion → attracts Ligands → forms Complex → gets Charge → Coordination Compound
```

1.2 Ligands

- **Definition:** Molecules/ions donating a pair of electrons to the metal.
- **Types of Ligands:**

Type	Donor Atoms	Example	Notes
Monodentate	1	NH_3, Cl^-	Binds through 1 atom
Bidentate	2	Ethylenediamine (en)	Forms chelate
Polydentate	≥2	EDTA	"Ligand with multiple hands"

Mnemonic: "M-B-P → Many Beautiful People" → Monodentate, Bidentate, Polydentate

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1.3 Coordination Number & Geometry

Coordination Number	Geometry	Example
2	Linear	$[Ag(NH_3)_2]^+$
4	Tetrahedral / Square planar	$[Ni(CO)_4]$ (tetra), $[Pt(NH_3)_2Cl_2]$ (square planar)

Coordination Number	Geometry	Example
6	Octahedral	$[Fe(CN)_6]^{3-}$

1.4 Isomerism in Coordination Compounds

- **Structural Isomerism:** Different **connectivity**
  - Ionization isomerism
  - Coordination isomerism
  - Linkage isomerism
- **Stereoisomerism:** Different **arrangement in space**
  - Geometrical: cis/trans
  - Optical: non-superimposable mirror images

Visual Aid: Draw cis/trans and octahedral shapes with colored ligands.

1.5 Bonding

- **Valence Bond Theory (VBT):** Hybridization of metal orbitals
  - e.g., $[Ni(CO)_4]$ → dsp^2 → Tetrahedral
- **Crystal Field Theory (CFT):** Splitting of d-orbitals
  - Octahedral → t_2g & e_sg

Tip: Think of d-orbitals as **"rooms" with energy levels splitting when ligands enter**.

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2. Key Concepts & Formulas

Concept	Formula/Definition	Tip / Mnemonic
Werner's Theory	Metal + fixed # of ligands → coordination number	"King & Knights"
Coordination Number	# of ligand atoms attached	Count "hands of ligands"
Stability Constant	$K_{stability} = \frac{[ML]}{[M][L]}$	Higher K → more stable
CFSE (Octahedral)	$-0.4\Delta_0 n_{t2g} + 0.6\Delta_0 n_{eg}$	Crystal Field Stabilization Energy
Magnetic Moment	μ = √(n(n+2)) BM	n = unpaired electrons

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3. Solved Numerical Problems

Example 1: Magnetic Moment

Problem: Calculate μ for $[Fe(CN)_6]^{3-}$.
Solution:

- $Fe^{3+} \rightarrow d^5 \rightarrow$ all paired in low-spin complex (strong field CN^-) → n = 0
- μ = √(0(0+2)) = 0 BM → diamagnetic

Example 2: Stability Constant

Problem: If [ML] = 0.1 M, [M] = 0.01 M, [L] = 0.2 M, calculate K.
Solution:

$$K = \frac{[ML]}{[M][L]} = \frac{0.1}{0.01 \times 0.2} = 50$$

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4. Previous Years' Board Questions (Solved)

- Geometrical & optical isomerism → frequently asked (2015–2022)
- Bonding theories → 1–2 marks, common for definitions
- CFSE & magnetic moment → numerical
- IUPAC nomenclature of complexes
- Stability constants & formation reactions

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5. Quick Revision Notes / Important Points

- **Metal = King, Ligands = Knights**
- **Coordination Number:** 2,4,6 → linear, tetra, octahedral
- **Isomerism:** Structural & Stereoisomerism
- **Bonding:** VBT (hybridization), CFT (d-orbital splitting)
- **Magnetism:** μ = √(n(n+2))

Visual Table for Quick Recall:

#	Key Concept	Example
1	Coordination Number 2	$[Ag(NH_3)_2]^+$
2	Coordination Number 4	$[Ni(CO)_4]$, $[Pt(NH_3)_2Cl_2]$
3	Coordination Number 6	$[Fe(CN)_6]^{3-}$
4	Strong field ligands	CN^-, CO → Low-spin, diamagnetic

#	Key Concept	Example
5	Weak field ligands	H_2O, F^- → High-spin, paramagnetic

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6. Predicted / Likely Questions

1. Types of ligands & examples
2. CN^- vs H_2O → low-spin vs high-spin
3. Geometrical & optical isomerism diagrams
4. CFSE & magnetic moment calculation
5. Nomenclature of coordination compounds
6. Stability constant numericals

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7. Exam Tips & Tricks

- **Draw diagrams:** Always visualize octahedral/tetrahedral complexes
- **Mnemonic for ligands: "Some Big Cats Never Chase Mice" → SO_4^{2-}, Br^-, CN^-, NO_2^-, Cl^-, NH_3**
- **Always check:** Strong vs weak field ligand → affects spin & color
- **Time-saving:** Use formula sheets for magnetic moment & CFSE

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8. Visual & Kid-Friendly Learning Style

- Use **colorful drawings** of complexes with ligands as "flags"
- **Flowcharts** for isomerism → easy memorization
- Think **magnetism** as "number of unpaired knights"
- Highlight **strong vs weak field ligands** with colors (CN^- → blue, H_2O → green)