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Title: Coordination Compound

Coordination Compound

Coordination compounds consist of a central atom or ion surrounded by a set of molecules or ions, called ligands, forming a complex structure. These compounds play significant roles in both industrial and biological systems.

Common Terminology in Complexes

- **Metal Centre:** The main ion or atom (often a transition metal) to which ligands are bonded.
- **Ligands:** Species that donate a lone pair to the central metal. They may be charged or neutral.
- **Coordination Number (CN):** Number of donor atoms directly attached to the central ion.
- **Oxidation State:** Hypothetical charge on the central metal if all ligands are removed.
- **Coordination Entity:** The metal ion and the ligands directly bonded to it.
- **Coordination Sphere:** Enclosed in brackets, it comprises the metal ion and its ligands. Anything outside is typically a counter ion.

Nature of Bonding: Valence Bond Theory (VBT)

VBT offers a basic model to describe bonding in coordination compounds. Key ideas include:

1. Ligands contribute lone pair electrons to vacant metal orbitals.
2. Metal orbitals hybridize to match the coordination number (e.g., sp^3, dsp^2, d^2sp^3).
3. The geometry of the complex depends on hybridization: tetrahedral, square planar, or octahedral.
4. The resulting bonds are directional and have a specific strength.

Types of Isomerism

Coordination compounds can show different forms of isomerism depending on ligand arrangement or bonding type.

Structural Variants

- **Ionization Isomerism:** Different ions are released in solution due to interchange of ligands inside and outside the coordination sphere.
- **Hydrate Isomerism:** Water molecules may exist inside the coordination sphere or be present as water of crystallization. Example:
  - $[Cr(H_2O)_6]Cl_3$: Purple
  - $[Cr(H_2O)_5Cl]Cl_2 \cdot H_2O$: Green
  - $[Cr(H_2O)_4Cl_2]Cl \cdot 2H_2O$: Dark green

- **Coordination Isomerism:** Found in compounds where both cationic and anionic parts are complexes and ligands swap between them.
- **Linkage Isomerism:** A single ligand binds through different donor atoms. Example: NO_2^- can bind via N or O.
- **Coordination Position Isomerism:** In polynuclear complexes, ligands switch positions between metal centres.
- **Polymerisation Isomerism:** Compounds with identical empirical formulas but different molecular masses due to polymerization.

Stereo Isomerism

- **Geometrical Isomerism:** Cis-trans forms arise in square planar and octahedral structures.
- **Optical Isomerism:** Non-superimposable mirror images (enantiomers) rotate plane-polarized light differently.

Real-Life Applications of Coordination Compounds

In Metallurgical Extraction

- Complex formation helps in extracting metals like gold and silver via cyanide complexes.
- Nickel is purified by Mond's process:

$$Ni + 4CO \rightarrow Ni(CO)_4 \xrightarrow{\text{Heat}} Ni + 4CO$$

Role in Photography

Silver bromide left unreacted on photographic films is removed using hypo solution:

$$AgBr + 2Na_2S_2O_3 \rightarrow Na_3[Ag(S_2O_3)_2] + NaBr$$

Use in Electroplating

Coordination compounds of silver, gold, and copper are used for uniform and controlled metal deposition.

Significance in Biology

- **Haemoglobin:** Iron-containing complex responsible for oxygen transport.
- **Chlorophyll:** Contains magnesium at its centre, vital for photosynthesis.
- **Vitamin B_{12}:** Has cobalt as the central metal; crucial for metabolic activity.

Other Uses

- **Medical Field:** Cisplatin is a platinum-based anti-cancer drug.
- **Water Testing:** EDTA-based titration detects hardness of water.
- **Catalysis:** Complexes such as Wilkinson's catalyst help in hydrogenation reactions.