B.Sc. Semester-IV
Core Course-VIII (CC-VIII)
Inorganic Chemistry

I. Coordination Chemistry
1. Werner's Theory

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I. Coordination Chemistry: 20 Lectures

Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of 10 Dq (Δo), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq (Δo, Δt). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory.

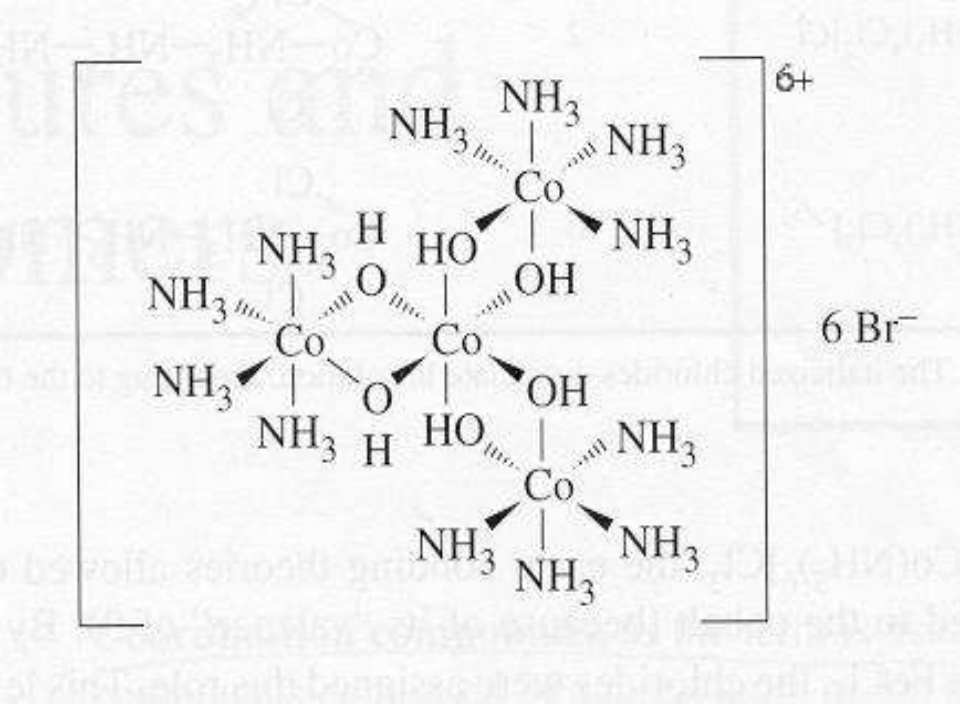
IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, polynuclear complexes, Labile and inert complexes.

Coverage:

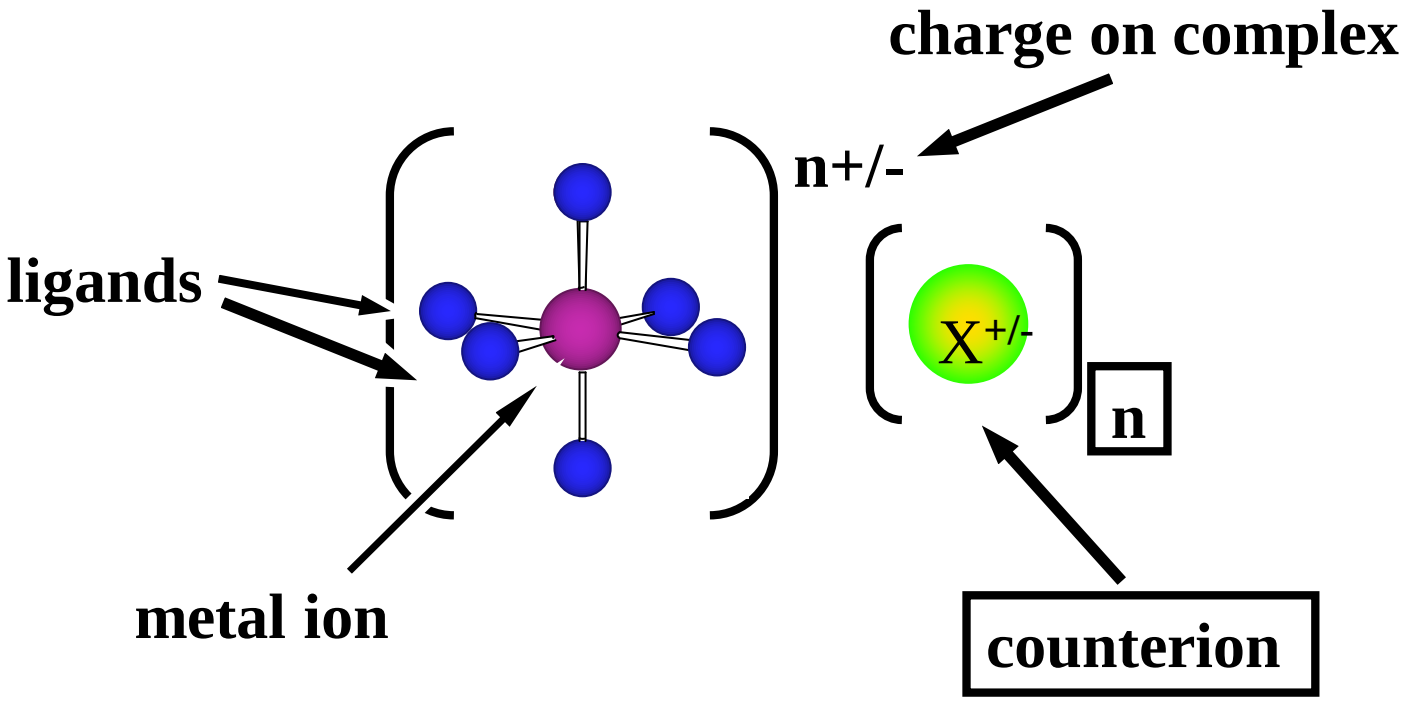
1. Coordination Compounds
2. Werner's Theory

Coordination Compounds

- Coordination compounds : compounds composed of a metal atom or ion and one or more ligands.
  - $[Co(Co(NH_3)_4(OH_2)_3]Br_6$
  - Ligands usually donate electrons to the metal
  - Includes organometallic compounds



Werner's totally inorganic optically active compound.



- Central metal ion or atom surrounded by a set of ligands
- The ligand donates two electrons to the d-orbitals around the metal forming a dative or coordinate bond

- **A Coordination CompoundTypically consists of a complex ion and counterions (anions or cations as needed to produce a neutral compound):**

$$[Co(NH_3)_5Cl]Cl_2$$

$$[Fe(en)_2(NO_2)_2]_2SO_4$$

$$K_3Fe(CN)_6$$

Coordination Number

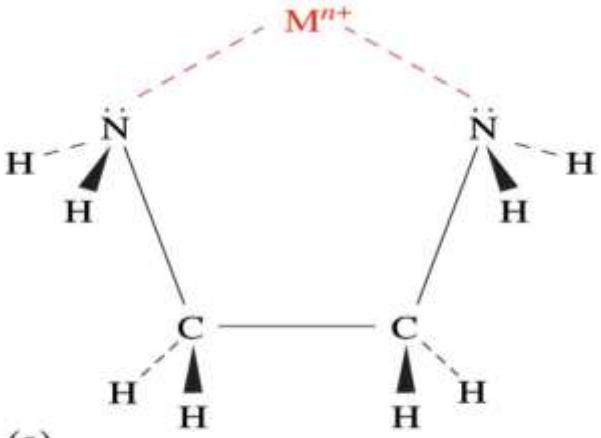
- **Number of bonds formed between the metal ion and the ligands in the complex ion.**
  - **6 and 4 (most common)**
  - **2 and 8 (least common)**

Ligands

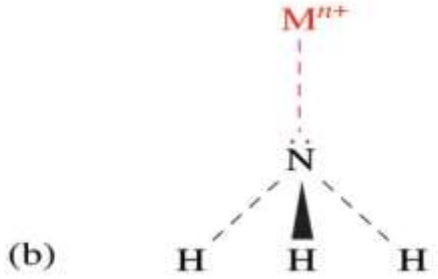
- **Neutral molecule or ion having a lone electron pair that can be used to form a bond to a metal ion.**
  - **Monodentate ligand – one bond to a metal ion**
  - **Bidentate ligand (chelate) – two bonds to a metal ion**
  - **Polydentate ligand – more than two bonds to a metal ion**

Coordinate Covalent Bond

- **Bond resulting from the interaction between a Lewis base (the ligand) and a Lewis acid (the metal ion).**

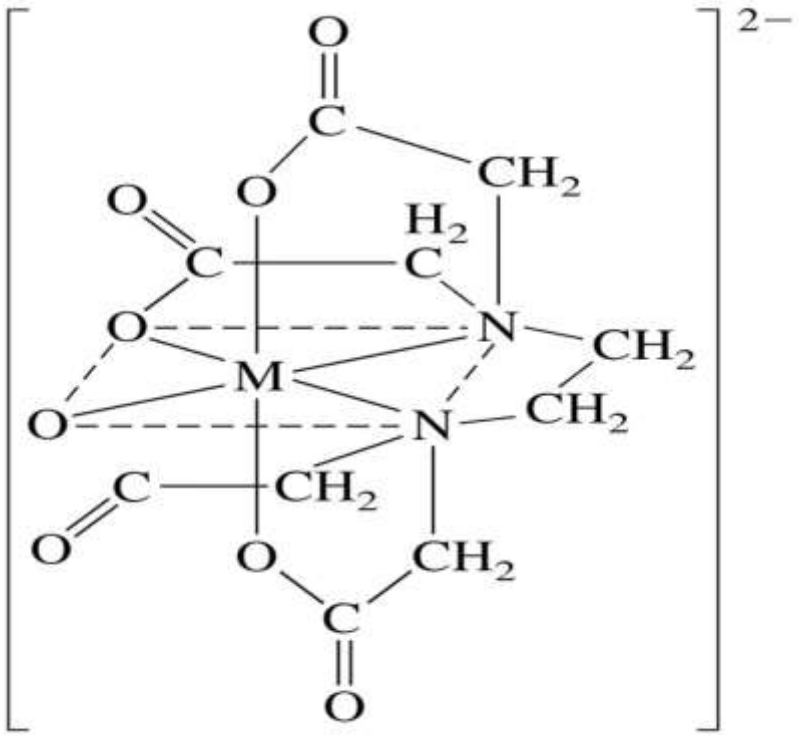


(a) **The Bidentate Ligand Ethylenediamine**



Monodentate Ligand Ammonia

The Coordination of EDTA with a 2+ Metal Ion



Ethylenediaminetetraacetate

Bonding in Coordination Compounds

$CoCl_3 . 6NH_3$ Yellow

$CoCl_3 . 5NH_3$ Purple

$CoCl_3 . 4NH_3$ Green

$CoCl_3 . 3NH_3$?

Alfred Werner
(1866-1919)
Nobel Prize 1913

Werner's Coordination Chemistry

- Performed systematic studies to understand bonding in coordination compounds.

  Organic bonding theory and simple ideas of ionic charges were not sufficient.

- Two types of bonding

  Primary – positive charge of the metal ion is balanced by negative ions in the compound.

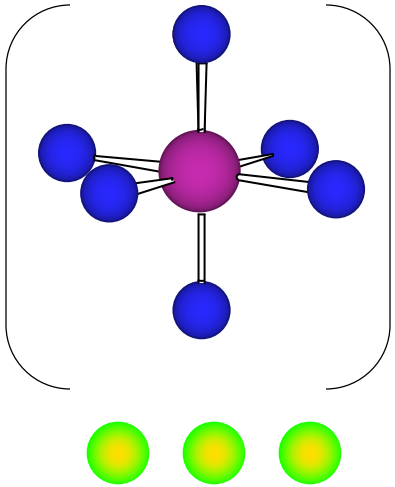
  Secondary – molecules or ion (ligands) are attached directly to the metal ion.

  - Coordination sphere or complex ion.
  - Look at complex on previous slide (primary and secondary)

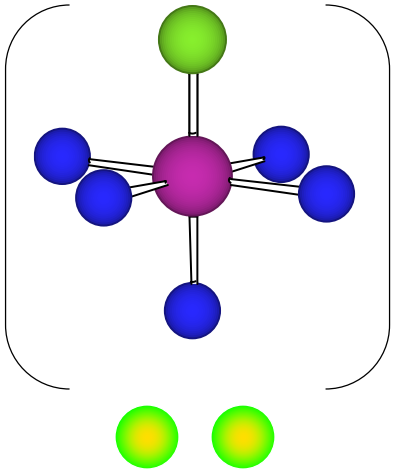
Werner's Coordination Chemistry

- He largely studied compounds with four or six ligands.
  Octahedral and square-planar complexes.
- It was illustrated that a theory needed to account for bonds between ligands and the metal.
  The number of bonds was commonly more than accepted at that time.
  - 18-electron rule.
- New theories arose to describe bonding.
  Valence bond, crystal field, and ligand field.

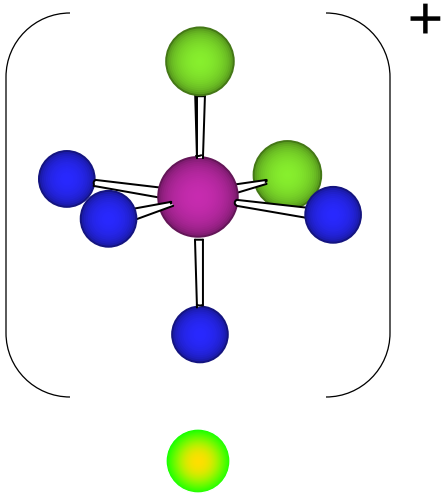
$[Co(NH_3)_6]Cl_3$



$[Co(NH_3)_5Cl]Cl_2$



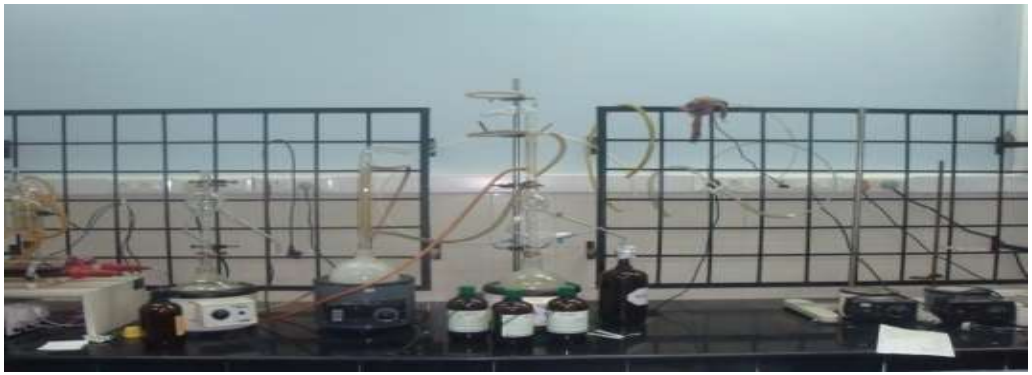
$[Co(NH_3)_4Cl_2]Cl$



Werner's conclusions

- The metal is in a particular oxidation state (primary valancy)
- The complex has a fixed coordination number (secondary valancy)
- The ligands are bound to the metal *via* a bond which resembles a covalent bond

Thank You



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