Class-12th

COORDINATION COMPOUNDS

WERNER'S THEORY OF COORDINATION COMPOUNDS

✤ INTRODUCTION

- (a) The idea of coordination compounds originates from the propensity of transition elements to form complexes.
- (b) These compounds hold a significant place in our daily lives, with examples like chlorophyll in plants, vitamin B₁₂, and hemoglobin in animal blood, which are coordination compounds involving Mg, Co, and Fe, respectively.
- (c) Coordination compounds play pivotal roles in analytical chemistry, polymerization reactions, metallurgy, metal refining, photography, water purification, and more.
- (d) Coordination compounds are also widely utilized in electroplating, textile dyeing, and medicinal chemistry.

Werner's Co-ordination Theory:

Alfred Werner introduced his theory of secondary valency to provide a more accurate explanation for the characteristics of coordination compounds.

The fundamental principles of Werner's theory can be summarized as follows:

- (i) Metals possess two types of valencies: primary (principal or ionizable) valency and secondary (auxiliary or non-ionizable) valency. In modern terminology, the primary valency corresponds to the oxidation number, and the secondary valency corresponds to the coordination number. According to Werner, primary valencies are represented by dotted lines, and secondary valencies are represented by thick lines.
- (ii) Each metal cation in a complex compound has a fixed number of secondary valencies.
 For example, the Pt⁴⁺ cation has six secondary valencies.
- (iii) Primary valency is satisfied by negative ions, while secondary valency is satisfied by either negative ions or neutral molecules.
- (iv) Primary valency exhibits a non-directional character, whereas secondary valency has a directional character. Consequently, a complex ion assumes a specific geometric arrangement, such as the octahedral structure in [Co(NH₃)₆]³⁺.

(v) The directional nature of secondary valency is responsible for the phenomenon of isomerism observed in coordination compounds.

Werner's Representation of Complexes

Consider the case of CoCl₃.xNH₃ where primary valency = +3 and secondary valency

= 6. Various structures are summarized in Table.

	Werner	Modern	Ionisation	Secondary	Primary
	complexes	formula		valency	valency
				satisfied by	satisfied by
A	CoCl ₃ .6NH ₃	[Co(NH ₃) ₆]Cl ₃	$[Co(NH_3)_6]^{3+} + 3Cl^{-}$	six (NH ₃)	three (Cl ⁻)
В	CoCl ₃ .5NH ₃	[Co(NH ₃) ₅ Cl]Cl ₂	$[Co(NH_3)_5Cl]^{2+}+2Cl^{-}$	five (NH ₃)	three (Cl ⁻)
				and one (Cl ⁻)	including one
					(Cl ⁻) with dual
					nature
C	CoCl ₃ .4NH ₃	[Co(NH ₃) ₄ Cl ₂]Cl	$[Co(NH_3)_4Cl_2]^++Cl^-$	four (NH ₃)	three (Cl ⁻)
				and two (Cl ⁻)	including two
					(Cl ⁻)
					with dual
					nature
D	CoCl ₃ .3NH ₅	$[Co(NH_3)_3Cl]_3$	[Co(NH ₃) ₃]Cl ₃	three (NH ₃)	three (CI ⁻) all
				and three (Cl ⁻)	with dual
					nature

- > From Table, It is clear that conduction of the complexes will be in the order D < C < B < A.
- > They are represented as



Chemistry

ADDITION COMPOUNDS

They are formed by the combination of two or more stable compounds in stoichiometric ratio.

Addition Compounds

Double salts

Coordination compounds (Complexes)

Molecular / Addition Compound:

Molecular / Addition compounds are formed when stoichiometric amounts of two or more simple compounds join together. Molecular / Addition compounds are of two types.

Double salts: Those which retain their identity in solutions are called double salts. For example.

$$\text{KCl} + \text{MgCl}_2 + 6\text{H}_2\text{O} \rightarrow \text{KCl}.\text{MgCl}_2.6\text{H}_2\text{O}$$

carnallite

 $K_2SO_4 + Al_2(SO_4)_3 + 24 H_2O \rightarrow K_2SO_4.Al_2(SO_4)_3.24H_2O$

potash alum

Complex compounds: Those which lose their identity in solution (complexes). For example.

 $CuSO_4 + 4 NH_3 \longrightarrow CuSO_4.4 NH_3 \text{ or } [Cu(NH_3)_4]SO_4$ tetramine copper (II) sulphate $Fe(CN_2) + 4 KCN \longrightarrow Fe (CN_2). 4KCN \text{ or } K_4[Fe(CN)_6]$ potassium ferrocyanide

Upon dissolving crystals of carnallite in water, the resulting solution exhibits characteristics of K⁺, Mg²⁺ and Cl⁻ ions. Likewise, a solution of potassium alum displays properties of K⁺, Al³⁺ and SO₄²⁻ ions. These are instances of double salts, which are solely present in their crystalline form. In contrast, when the other two coordination compounds are dissolved, they do not produce simple ions (Cu²⁺/ Fe²⁺ and CN⁻); instead, they form complex ions.

Chemistry

Representation of Complex Ion:

 $[ML_x]^{n\pm}$

where M = Central Metal atom /ion (usually of d-block)

L = Ligand

x = No. of ligands

 $n\pm$ = charge on coordination

Outside region apart from coordination sphere is called ionisation sphere.