Class-12th

COORDINATION COMPOUNDS

WERNER'S THEORY OF COORDINATION COMPOUNDS

✤ INTRODUCTION

- (a) The concept of co-ordination compounds arises from the complex formation tendency of transition elements.
- (b) These compounds play a vital role in our lives, as chlorophyll of plants, vitamin B₁₂ and hemoglobin of animal blood are the co-ordination compounds of Mg, Co and Fe respectively.
- (c) The co-ordination compounds play important role in analytical chemistry, polymerisation reactions, metallurgy and refining of metals, photography, water purification etc.
- (d) Co-ordination compounds also find many applications in electroplating, textile dyeing and medicinal chemistry.

Werner's Co-ordination Theory:

Alfred Werner put forward his concept of secondary valency for advancing a correct explanation for the characteristics of the coordination compounds. The fundamental postulates of Werner's theory are as follows.

- Metal possesses two types of valencies, namely, primary (principal or ionizable) valency and secondary (auxiliary or non-ionizable) valency.
 In modern terminology, the primary valency corresponds to oxidation number and secondary valency to coordination number. According to Werner primary valencies are shown by dotted lines and secondary valencies by thick lines.
- (ii) Every metal cation in complex compound has a fixed number of secondary valencies for example Pt⁴⁺ cation has its six secondary valency.
- (iii) Primary valency is satisfied by negative ions, whereas secondary valency is satisfied either by negative ions or by neutral molecules.

- (iv) Primary valency has non-directional character, where as secondary valency has directional character, therefore a complex ion has its definite geometry e.g. [Co $(NH_3)_6$]³⁺ octahedron.
- (v) It is the directional nature of secondary valency due to which co-ordination compound exhibits the phenomenon of isomerism.

Werner's Representation of Complexes

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

	Werner	Modern	Ionisation	Secondary	Primary
	complexes	formula		valency satisfied	valency
				by	satisfied by
А	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) ₅ Cl] ²⁺ +2Cl ⁻	five (NH ₃) and one (Cl [.])	three (Cl ⁻) including one (Cl ⁻) with dual nature
C	CoCl ₃ .4NH ₃	[Co(NH ₃) ₄ Cl ₂]Cl	[Co(NH ₃) ₄ Cl ₂]++Cl-	four (NH ₃) and two (Cl ⁻)	three (Cl ⁻) including two (Cl ⁻) with dual nature
D	CoCl ₃ .3NH ₅	[Co(NH ₃) ₃ Cl] ₃	[Co(NH ₃) ₃]Cl ₃	three (NH ₃) and three (Cl [.])	three (CI [.]) all with dual nature

= 6. Various structures are summarized in Table.

- 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.

$$KCl + MgCl_2 + 6H_2O \rightarrow KCl.MgCl_2.6H_2O$$

carnallite

$$K_2SO_4 + Al_2(SO_4)_3 + 24 H_2O \rightarrow K_2SO_4.Al_2(SO_4)_3.24H_2O_4$$

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

When crystals of carnallite are dissolved in water, the solution shows properties of K^+ , Mg^{2+} and Cl^- ions. In a similar way, a solution of potassium alum shows the properties of K^+ , Al^{3+} and SO_4^{2-} ions. These are both examples of double salts which exist only in the crystalline state. When the other two examples of coordination compounds are dissolved, they do not form simple ions, Cu^{2+} / Fe^{2+} and CN^- , but instead their complex ions are formed.

Representation of Complex Ion:

 $[\mathrm{ML}_{\mathrm{X}}]^{\mathrm{n}\pm}$

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.