Chemistry Study Materials for Class 12
(NCERT Based Notes of Chapter - 09)
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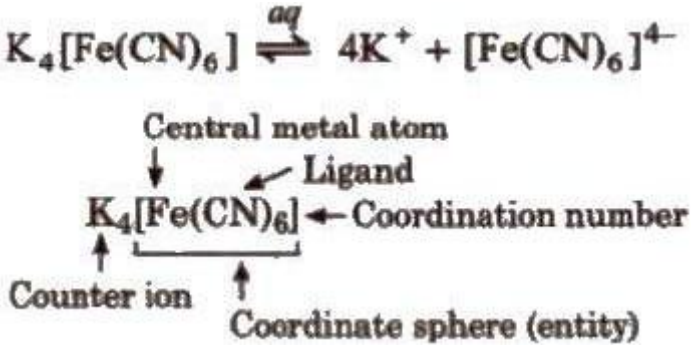
Co-ordination Compounds

Coordination Compounds

Coordination compounds are those addition molecular compounds which retain their identity in solid state as well as in dissolved state. In these compounds, the central metal atom or ion is linked by ions or molecules with coordinate bonds. e.g., Potassium ferrocyanide, K_4 $[Fe(CN)_6]$.



Double Salt

These are the addition molecular compounds which are stable in solid state but dissociate into constituent ions in the solution. e.g., Mohr'S salt, $[FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$ get dissociated into Fe^{2+}, NH^+ and SO^{2-} ions.

Terms Related to Coordination Compounds

1.Complex ion or Coordination Entity

It is an electrically charged species in which central metal atom or ion is surrounded by number of ions or neutral molecules.

(i) **Cationic complex entity** It is the complex ion which carries positive charge.

e.g., $[Pt(NH_3)_4]^{2+}$

(ii) **Anionic complex entity** It is the complex ion which carries negative charge.

e.g., $[Fe(CN)_6]^{4-}$

2.Central Atom or Ion

The atom or ion to which a fixed number of ions or groups are bound is called central atom or ion. It is also referred as Lewis acid. e.g., in $(NiCl_2(H_2O)_4]$. Ni is central metal atom. It is generally transition element or inner-transition element.

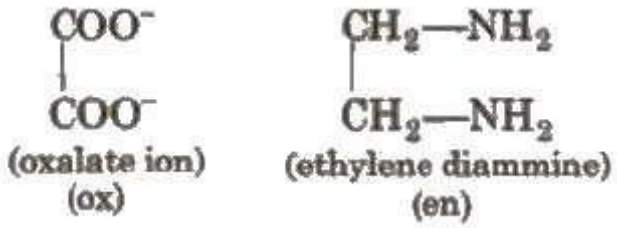
3.Ligands

Ligands are electron donating species (ions or molecules) bound to the Central atom in the coordination entity.

These may be charged or neutral. Ligands are of the following types:

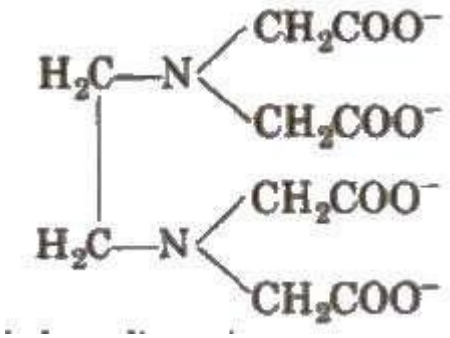
(i)Unidentate It is a ligand, which has one donor site, i.e., the ligand bound to a metal ion through a single donor site. e.g., H_2O, NH_3, etc.

(ii)Bidentate It is the ligands, which have two donor sites.



(iii)Polydentate It is the ligand, which have several donor sites.

e.g., $[EDTA]^{4-}$ is hexadentate ligand.



(iv) Ambidentate ligands These are the monodentate ligands which can ligate through two different sites, e.g., NO_2^{-1}, SCN^{2-}, etc.

(v) Chelating ligands Di or polydentate ligands cause cyclisation around the metal atom which are known as chelate ligands, such ligands uses' two or more donor atoms to bind a single metal ion and are known as chelating ligands.

More the number of chelate rings more are the stability of complex.

The stabilization of coordination compounds due to chelation is known as **chelate effect**.

4.Coordination Number

It is defined as the number of coordinate bonds formed by central metal atom, with the ligands.

e.g., in $[PtCl_6]^{2-}$, Pt has coordination number 6. In case of monodentate ligands,

Coordination number = number of ligands in polydentate ligands.

Coordination number = number of ligands x denticity

5.Coordination Sphere

The central ion and the ligands attached to it are enclosed in square bracket which is known as coordination sphere. The ionisable group written outside the bracket is known as counter ions.

6.Coordination Polyhedron

The spatial arrangement of the ligands which are directly attached to the central atom or ion is called coordination polyhedron around the central atom or ion.

7.Oxidation Number of Central Atom

The charge of the complex if all the ligands are removed along with the electron pairs that are shared with the central atom is called oxidation number of central atom.

e.g., $[CU(CN_4)_{3-}$, oxidation number of copper is +1, and represented as Cu(I).

Types of Complexes

1. Homoleptic complexes

Complexes in which the metal atom or ion is linked to only one kind of donor atoms, are called homoleptic complexes e.g., $[Co(NH_3)_6]^{3+}$

2. Heteroleptic complexes

Complexes in which the metal atom or ion is linked to more than one kind of donor atoms are called heteroleptic complexes e.g., $[Co(NH_3)_4Cl_2]^{+}$

3. Labile and Inert complexes

Complexes in which the ligand substitution is fast are known as labile complexes and in which ligand substitution is slow, are known as inert complexes.

Effective Atomic Number (EAN)

This concept was proposed by Sidgwick. In a complex, the EAN of metal atom is equal to the total number of electrons present in it.

EAN = Z – ON of metal + 2 x CN

(Where, Z = atomic number of metal atom ON = oxidation number of metal and CN = coordination number of complex)

An ion with central metal atom having EAN equal to next inert gas will be more stable.

IUPAC Naming of Complex Compounds

Naming is based on set of rules given by IUPAC.

1. Name of the compound is written in two parts;

   (i) name of cation and (ii) name of anion.

2. The cation is named first in both positively and negatively charged coordination complexes.

3. The dissimilar ligands are named in an alphabetical order before the name of central metal atom or ion.

4. For more than one similar ligand, the prefixes di, tri, tetra, etc are added before its name. If the di, tri, etc already appear in the complex then bis, tris, tetrakis are used.

5. If the complex part is anion, the name of the central metal ends with suffix 'ate'.

6. Names of the anionic ligands end in '0', names of positive ligands end with 'ium' and names of neutral ligands remain as such. But exceptions are there as we use aqua for H_2O, ammine for NH_3, carbonyl for CO and nitrosyl for NO.

7. Oxidation state for the metal in cation, anion or neutral coordination compounds is indicated by Roman numeral in parentheses.

8. The name of the complex part is written as one word.

9. If the complex ion is a cation, the metal is named same as the element.

10. The neutral complex molecule is named similar to that of the complex cation.

Some examples are

Co-ordination Compounds	IUPAC Name
(i) $[Cr(NH_3)_3(H_2O)_3]Cl_3$	triamminetrichlorochromium (III) chloride
(ii) $[Co(H_2CH_2CH_2H_2)_3]_2(SO_4)_3$	tris (ethane-l,2-diamine) cobalt (III) sulphate
(iii) $[Ag(NH_3)_2]$ $[Ag(CN)_2]$	diamminesilver (I) dicyanoargentate(I)
(iv) K_4 $[Fe(CN)_6]$	potassium hexacyanoferrate (II)

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