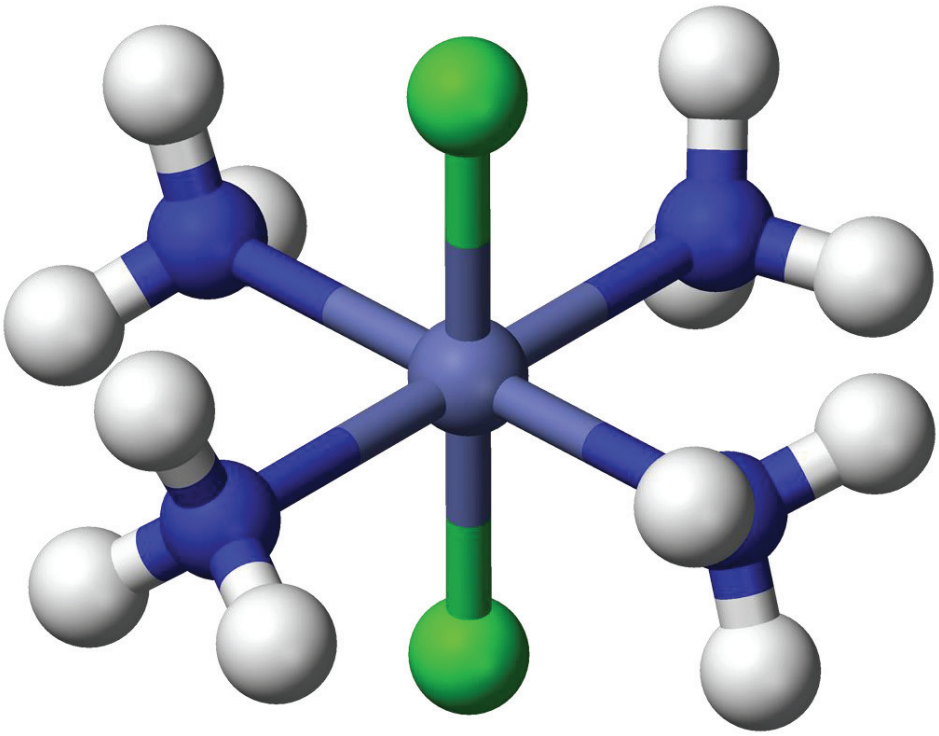
COORDINATION COMPOUNDS



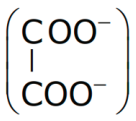
COORDINATION COMPOUNDS

• Differences between coordination compound and double bond

Coordination compound	Double salt
A coordination compound contains a central metal atom or ion surrounded by several oppositely charged ions or neutral molecules. These ions or molecules re-bonded to the metalatom or ion by a coordinate bond.	When two salts in stoichiometric ratio are crystallised together from their saturated solution, they are called double salts.
Example: $K_4[Fe(CN)_6]$	**Example:** $FeSO_4.(NH_4)_2SO_4.6H_2O$ (Mohr's salt)
They do not dissociate into simpleions when dissolved in water.	They dissociate into simple ions when dissolved in water.

- **Coordination entity:** A coordination entity constitutes a central metal atom or ion bonded to a fixednumber of ions or molecules. Example: In $K_4[Fe(CN)_6]$, $[Fe(CN)_6]^{4-}$ represents a coordination entity.
- **Central atom or ion:** In a coordination entity, the atom/ion to which a fixed number of ions/groups are bound in a definite geometrical arrangement is called the central atom or ion. Example: In $K_4[Fe(CN)_6]$,Fe^{2+} is the central metal ion.
- **Ligands:** A molecule, ion or group which is bonded to the metal atom or ion in a complex or coordination compound by a coordinate bond is called a ligand. It may be neutral, positively ornegatively charged. Examples: H_2O, CN^-, NO^+ etc.
- **Donor atom:** An atom of the ligand attached directly to the metal is called the donor atom. Example:In the complex $K_4[Fe(CN)_6]$, carbon is a donor atom.
- **Coordination number:** The coordination number (CN) of a metal ion in a complex can be defined asthe number of ligand donor atoms to which the metal is directly bonded. Example: In the complex $K_4[Fe(CN)_6]$, the coordination number of Fe is 6.
- **Coordination sphere**: The central atom/ion and the ligands attached to it are enclosed in squarebracket and is collectively termed the coordination sphere. Example: In the complex $K_4[Fe(CN)_6]$,$[Fe(CN)_6]^{4-}$ is the coordination sphere.
- **Counter ions:** The ions present outside the coordination sphere are called counter ions. Example: Inthe complex $K_4[Fe(CN)_6]$, K^+ is the counter ion.
- **Coordination polyhedron:** The spatial arrangement of the ligand atoms which are directly attached tothe central atom/ion defines a coordination polyhedron about the central atom. The most common coordination polyhedra are octahedral, square planar and tetrahedral. Examples: $[PtCl_4]^{2-}$ is square planar, $Ni(CO)_4$ is tetrahedral and $[Cu(NH_3)_6]^{3+}$ is octahedral.
- **Charge on the complex ion:** The charge on the complex ion is equal to the algebraic

sum of thecharges on all the ligands coordinated to the central metal ion.

- **Denticity:** The number of ligating (linking) atoms present in a ligand is called denticity.
- **Unidentate ligands:** The ligands whose only donor atom is bonded to a metal atom are calledunidentate ligands. Examples: H_2O, NH_3, CO, CN^-
- **Didentate ligands:** The ligands through which they are bonded to  which contain two donor atoms or ions the metal ion. Example: Ethylene diamine ($H_2NCH_2CH_2NH_2$) has two nitrogen atoms, and oxalate ion has two oxygen atoms which can bind with the metal atom.
- **Polydentate ligand:** When several donor atoms are present in a single ligand, the ligand is called a polydentate ligand. Example: In $N(CH_2CH_2NH_2)_3$, the ligand is said to be polydentate. Ethylenediaminetetraacetate ion ($EDTA^{4-}$) is an important hexadentate ligand. It can bind through twonitrogen and four oxygen atoms to a central metal ion.
- **Chelate:** An inorganic metal complex in which there is a close ring of atoms caused by attachment ofa ligand to a metal atom at two points. An example is the complex ion formed between ethylene diamine and cupric ion $[Cu(NH_2CH_2NH_2)_2]^{2+}$.
- **Ambidentate ligands:** Ligands which can ligate (link) through two different atoms present in it are called ambidentate ligands. Examples: NO^- and SCN^-. NO^- can link through N as well as O, while SCN^- can link through S as well as N.
- **Werner's coordination theory:** Werner was able to explain the nature of bonding in complexes. The postulates of Werner's theory are

  - Metal shows two kinds of valencies—primary valence and secondary valence.

Primary valence	Secondary valence
This valence is normally ionisable.	This valence is non-ionisable.
It is equal to the positive chargeon the central metal atom.	The secondary valency equals to the number of ligand atoms coordinated to the metal. It is also called the coordination number of the metal.
These valencies are satisfied by negatively charged ions.	It is commonly satisfied by neutral and negatively charged, sometimes by positively charged ligands.
Example: In $CrCl_3$, the primaryvalency is three. It is equal to the oxidation state of the centralmetal ion.	

  - The ions/groups bound by secondary linkages to the metal have characteristic spatial arrangements corresponding to different coordination numbers.
  - The most common geometrical shapes in coordination compounds are octahedral, square planarand tetrahedral.

- **Oxidation number of the central atom:** The oxidation number of the central atom

in a complex is defined as the charge it would carry if all the ligands are removed along with the electron pairs whichare shared with the central atom.

- **Homoleptic complexes:** Those complexes in which metal or ion is coordinately bonded to only onekind of donor atom. Example: $[Co(NH_3)_6]^{3+}$
- **Heteroleptic complexes:** Those complexes in which metal or ion is coordinately bonded to more thanone kind of donor atom. Example: $[CoCl_2(NH_3)_4]^+$, $[Co(NH_3)_5Br]^{2+}$
- **Isomers:** Two or more compounds which have the same chemical formula but different arrangementof atoms are called isomers.
- Types of isomerism
  - Structural isomerism
    - Linkage isomerism
    - Solvate isomerism or hydrate isomerism
    - Ionisation isomerism
    - Coordination isomerism
  - Stereoisomerism
    - Geometrical isomerism
    - Optical isomerism
- **Structural isomerism:** This type of isomerism arises due to the difference in structures of coordination compounds. Structural isomerism, or constitutional isomerism, is a form of isomerism inwhich molecules with the same molecular formula have atoms bonded together in different orders.
  - **Ionisation isomerism:** This form of isomerism arises when the counter ion in a complex salt isitself a potential ligand and can displace a ligand which can then become the counter ion.

    Examples: $[Co(NH_3)_5Br]\ SO_4$ and $[Co(NH_3)_5\ SO_4]\ Br$
  - **Solvate isomerism:** It is isomerism in which the solvent is involved as the ligand. If the solvent iswater, then it is called hydrate isomerism. Example: $[Cr(H_2O)_6]Cl_3$ and $[CrCl_2(H_2O)_4]\ Cl_2.2H_2O$
  - **Linkage isomerism:** Linkage isomerism arises in a coordination compound containing an ambidentate ligand. In the isomerism, a ligand can form linkage with metal through different atoms.

    Examples: $[Co(NH_3)_5ONO]Cl_2$ and $[Co(NH_3)_5NO_2]Cl_2$
  - **Coordination isomerism:** This type of isomerism arises from the interchange of ligands betweencationic and anionic entities of different metal ions present in a complex. Examples: $[Co(NH_3)_6][Cr(C_2O_4)_3]$ and $[Cr(NH_3)_6][Co(C_2O_4)_3]$
- **Stereoisomerism:** This type of isomerism arises because of different spatial arrangement.
  - **Geometrical isomerism:** It arises in heteroleptic complexes due to different possible geometricalarrangements of ligands.
  - **Optical isomerism:** Optical isomers are those isomers which are non-superimposable mirrorimages.

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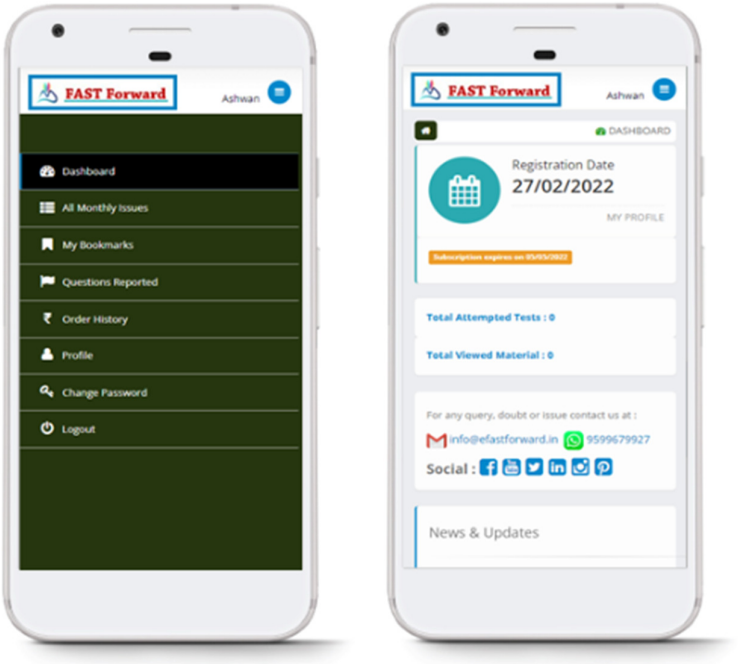

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