Chemistry Class 12 NCERT Solutions: Chapter 9 Coordination Compounds Part 1

Q: 1. Explain the bonding in coordination compounds in terms of Werner's postulates.

Answer

Werner's postulates explain the bonding in coordination compounds as follows:

(i) A metal exhibits two types of valencies namely, primary and secondary valencies. Primary valencies are satisfied by negative ions while secondary valencies are satisfied by both negative and neutral ions.

In modern terminology, the primary valency corresponds to the oxidation number of the metal ion, whereas the secondary valency refers to the coordination number of the metal ion.

(ii) A metal ion has a definite number of secondary valencies around the central atom. Also, these valencies project in a specific direction in the space assigned to the definite geometry of the coordination compound.

(iii) Primary valencies are usually ionizable, while secondary valencies are non-ionizable

Q: 2. $FeSO_4$ solution mixed with $(NH_4)_2\mathrm{SO}_4$ solution in $1:1$ molar ratio gives the test of Fe^{2+}io but$CuSO_4$ solution mixed with aqueous ammonia in $1:4$ molar ratio does not give the test of $Cu^{2+} ion$. Explain why?

Answer:

$$(NH_4)_2\mathrm{SO}_4 + FeSO_4 + 6H_2O \rightarrow \underset{Mohr's\text{salt}}{FeSO_4 \ .(NH_4)_2\mathrm{SO}_4. \ 6H_2O}$$

$$CuSO_4 + 4NH_3 + 5H_2O \rightarrow \underset{\text{tetraamminocopper}\,(ii)\text{ sulphate}}{\left[Cu(NH_3)_4\right]\mathrm{SO}_4.5H_2O}$$

Both the compounds $i.e.,$ $FeSO_4 \ .(NH_4)_2\mathrm{SO}_4. \ 6H_2O$ and $\left[Cu(NH_3)_4\right]\mathrm{SO}_4.5H_2O$ fall under the category of addition compounds with only one major difference i.e.., the former is an example of a double salt, while the latter is a coordination compound. A double salt is an addition compound that is stable in the solid state but that which breaks up into its constituent ions in the dissolved state. These compounds exhibit individual properties of their constituents. For e. g. $FeSO_4.(NH_4)_2\mathrm{SO}_4.6H_2O$ breaks into Fe^{2+}, NH^{4+} , and SO_4^{2-} ions. Hence, it gives a positive test for Fe^{2+} ions. A coordination compound is an addition compound which retains its identity in the solid as well as in the dissolved state. However, the individual properties of the constituents are lost. This happens because $\left[Cu(NH_3)_4\right]\mathrm{SO}_4.5H_2O$ does not show the test for Cu^{2+} .

The ions present in the solution of $\left[Cu(NH_3)_4\right]\mathrm{SO}_4.5H_2O$ are $\left[Cu(NH_3)_4\right]^{2+}$ and SO_4^{2-} .

Q: 3. Explain with two examples each of the following: coordination entity, ligand, coordination number, coordination polyhedron, homoleptic and heteroleptic.

Answer

(i) Coordination Entity

A coordination entity is an electrically charged radical or species carrying a positive negative charge. In a coordination entity, the central atom or ion is surrounded by suitable number of neutral molecules or negative ions (called ligands) . For example:

$\left[Ni(NH_3)_6\right]^{2+}$, $\left[Fe(CN)_6\right]^{4+}$ = cationic cmplex

$[PtCl_4]^{2-}$, $\left[Ag(CN)_2\right]^{-}$ = anionic complex

$\left[Ni(CO)_4\right]$, $\left[Co(NH_3)_4Cl_2\right]$ = neutral omplex

(ii) Ligands

The neutral molecules or negatively charged ions that surround the metal atom in a coordination entity or a coordinal complex are known as ligands. For example,

$N\ddot{H}_3, H_2\ddot{O}$, Cl^- , ^-OH . Ligands are usually polar in nature and possess at least one unshared pair of valence electrons.

(iii) Coordination Number:

The total number of ligands (either neutral molecules or negative ions) that get attached to the central metal atom in the coordination sphere is called the coordination number of the central metal atom. It is also referred to as its ligancy.

For example:

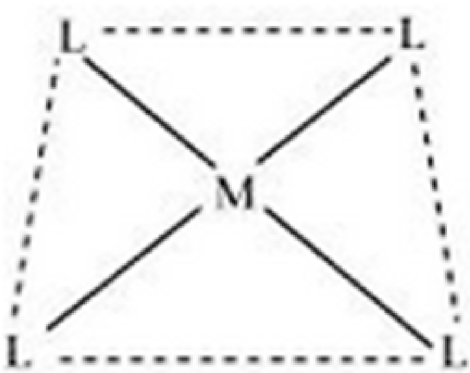
(A) In the complex, $K_2\,[PtCl_6]$, there as six chloride ions attached to Pt in the coordinate sphere. Therefore, the coordination number of Pt is .

(B) Similarly, in the complex $\left[Ni(NH_3)_4\right]Cl_2$, the coordination number of the central atom (Ni) is .

(vi) Coordination Polyhedron:

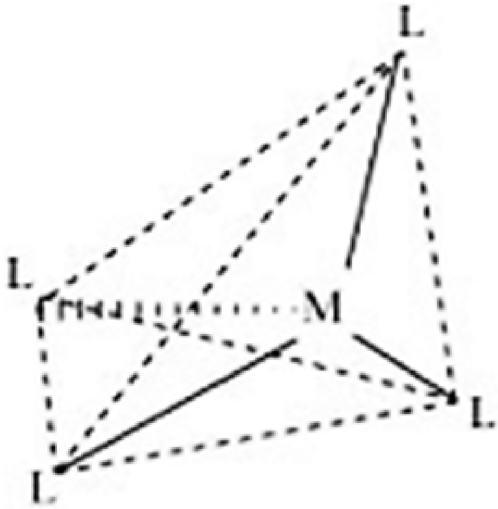
Coordination polyhedrons about the central atom can be defined as the spatial arrangement of the ligands that are directly attached to the central metal ion in the coordination sphere. For example:

(A) Square Planar



Square Planar

(b) Tetrahedral



Tetrahedral

(v) Homoleptic complexes: These are those complexes in which the metal ion is bound to only one kind of a donor group. For eg: $\left[Co(NH_3)_6\right]^{3+}, [PtCl_4]^{2-}$ etc.

(vi) Heteroleptic complexes: Heteroleptic complexes are those complexes where the central metal ion is bound to more than one type of a donor group. For e. g. : $\left[Co(NH_3)_4Cl_2\right]^+, \left[Co(NH_3)_5Cl\right]^{2+}$