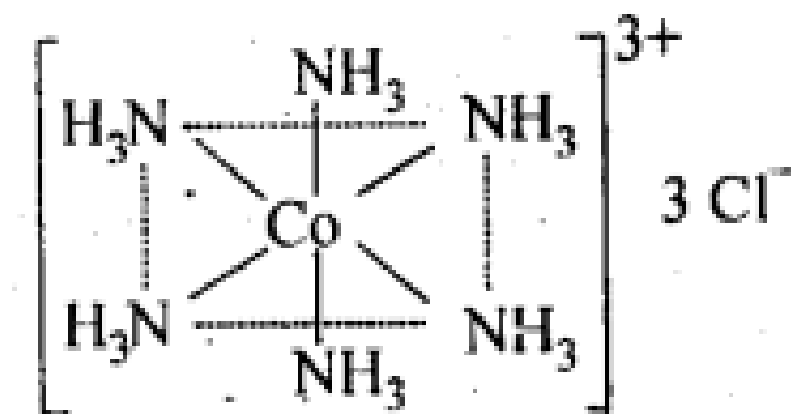




9.1. Explain the bonding in coordination compounds in terms of Werner's postulates.

Ans: The main postulates of Werner's theory of coordination compounds are as follows:

- (a) Metals possess two types of valencies called
  - (i) primary valency which are ionisable;
  - (ii) secondary valency which are non- ionisable
- (b) Primary valency is satisfied by the negative ions and it is that which a metal exhibits in the formation of its simple salts.
- (c) Secondary valencies are satisfied by neutral ligand or negative ligand and are those which metal exercises in the formation of its complex ions. Every cation has a fixed number of secondary valencies which are directed in space about central metal ion in certain fixed directions, e.g. In  $\text{CoCl}_3 \cdot 6\text{NH}_3$ , valencies between Co and Cl are primary valencies and valencies between Co and  $\text{NH}_3$  are secondary. In  $\text{CoCl}_3 \cdot 6\text{NH}_3$ , six ammonia molecules linked to Co by secondary valencies are directed to six corners of a regular octahedron and thus account for structure of  $\text{CoCl}_3 \cdot 6\text{NH}_3$  as follows:



In modern theory, it is now referred as coordination number of central metal atom or ion.

9.2.  $\text{FeSO}_4$  solution mixed with  $(\text{NH}_4)_2\text{SO}_4$  solution in 1:1 molar ratio gives the test of  $\text{Fe}^{2+}$  ion but  $\text{CuSO}_4$  solution mixed with aqueous ammonia in 1:4 molar ratio does not give the test of  $\text{Cu}^{2+}$  ion. Explain why.

Ans.:  $\text{FeSO}_4$  solution mixed with  $(\text{NH}_4)_2\text{SO}_4$  solution in 1 : 1 molar ratio forms a double salt,  $\text{FeSO}_4 (\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$  (Mohr's salt) which ionizes in the solution to give  $\text{Fe}^{2+}$  ions. Hence it gives the tests of  $\text{Fe}^{2+}$  ions.  $\text{CuSO}_4$  solution mixed with aqueous ammonia in 1:4 molar ratio forms a complex salt, with the formula  $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4$ . The complex ion  $[\text{Cu}(\text{NH}_3)_4]^{2+}$  does not ionize to give  $\text{Cu}^{2+}$  ions. Hence, it does not give the tests of  $\text{Cu}^{2+}$  ion.

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

Ans: Coordination entity: It constitutes of a central atom/ion bonded to fixed number of ions or molecules by coordinate bonds

e.g.  $[\text{CoCl}_3(\text{NH}_3)_3]$ ,  $[\text{Ni}(\text{CO})_4]$  etc.

Ligand: The ions/molecules bound to central atom/ion in coordination entity are called ligands. Ligands in above examples are  $\text{Cl}$ ,  $\text{NH}_3$ ,  $\text{CO}$  Coordination number : This is the number of bond formed by central atom/ion with ligands. Coordination polyhedron : Spatial arrangement of ligands defining the shape of complex. In above cases  $\text{Co}$  and  $\text{Ni}$  polyhedron are octahedral and tetrahedral in  $[\text{CoCl}_3(\text{NH}_3)_3]$  and  $[\text{Ni}(\text{CO})_4]$  respectively.

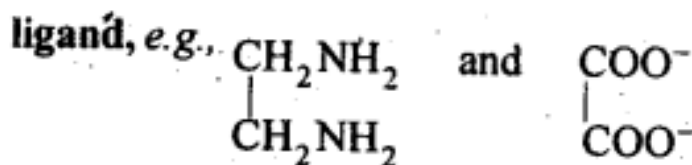
Homoleptic Metal is bound to only one kind of ligands eg:  $\text{Ni}$  in  $[\text{Ni}(\text{CO})_4]$

Heteroleptic Metal is bound to more than one kind of ligands eg:  $\text{Co}$  in  $[\text{CoCl}_3(\text{NH}_3)_3]$

9.4. What is meant by unidentate didentate and ambidentate ligands? Give two examples for each.

Ans: A molecule or an ion which has only one donor atom to form one coordinate bond with the central metal atom is called unidentate ligand, e.g.,  $\text{Cl}^-$  and  $\text{NH}_3$ .

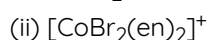
A molecule or ion which contains two donor atoms and hence forms two coordinate bonds with the central metal atom is called didentate



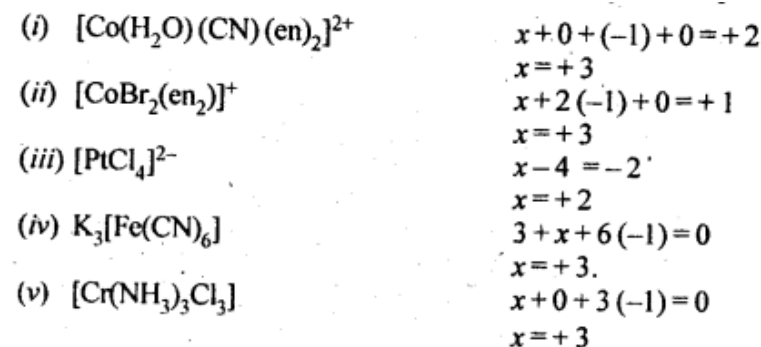
A molecule or an ion which contains two donor atoms but only one of them forms a coordinate bond at a time with the central metal atom is called

**ambidentate ligand, e.g.,  $:\text{CN}^-$  or  $\text{NC}^-$  and  $\text{NO}_2^-$  or  $\text{ONO}^-$**

9.5. Specify the oxidation numbers of the metals in the following coordination entities:



Ans:



9.6. Using IUPAC norms write the formulas for the following:

(i) Tetrahydroxozincate(II)

(ii) Potassium tetrachloridopalladate (II)

(iii) Diamminedichlorido platinum (II)

(iv) Potassium tetracyanonickelate (II)

(v) Pentaamminenitrito-O-cobalt(III)

(vi) Hexaamminecobalt (III) sulphate

- (vii) Potassium tri(oxalato) chromate (III)
- (viii) Hexaammineplatinum (IV)
- (ix) Tetrabromidocuprate(II)
- (x) Pentaamminenitrito-N-cobalt (III)

Ans:

- (i)  $[\text{Zn}(\text{OH})_4]^{2-}$
- (ii)  $\text{K}_2[\text{PdCl}_4]$
- (iii)  $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$
- (iv)  $\text{K}_2[\text{Ni}(\text{CN})_4]$
- (v)  $[\text{Co}(\text{NH}_3)_5(\text{ONO})]^{2+}$
- (vi)  $[\text{Co}(\text{NH}_3)_6]^{2+}(\text{SO}_4)_3$
- (vii)  $\text{K}_3[\text{Cr}(\text{C}_2\text{O}_4)_3]$
- (viii)  $[\text{Pt}(\text{NH}_3)_6]^{4+}$
- (ix)  $[\text{CuBr}_4]^{2-}$
- (x)  $[\text{Co}(\text{NH}_3)_5(\text{NO}_2)]^{2+}$

9.7. Using IUPAC norms write the systematic names of the following:

- (i)  $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$ ,
- (ii)  $[\text{Pt}(\text{NH}_3)_2\text{Cl}(\text{NH}_2\text{CH}_3)] \text{Cl}$
- (iii)  $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$
- (iv)  $[\text{Co}(\text{NH}_3)_4\text{Cl}(\text{NO}_2)]\text{Cl}$
- (v)  $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$
- (vi)  $[\text{NiCl}_4]^{2-}$
- (vii)  $[\text{Ni}(\text{NH}_3)_6]\text{Cl}_2$
- (viii)  $[\text{Co}(\text{en})_3]^{3+}$
- (ix)  $[\text{Ni}(\text{CO})_4]$

Ans:

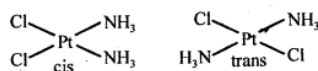
- (i) Hexaammine cobalt (III) chloride.
- (ii) Diammine chlorido (methylamine) platinum (II) chloride.
- (iii) Hexaaquatitanium (III) ion.
- (iv) Tetraammine chlorido nitrito-N-cobalt (IV) chloride.
- (v) Hexaaquamanganese (II) ion.
- (vi) Tetrachloridonickelate (II) ion.
- (vii) Hexaammine nickel (II) chloride.
- (viii) Tris (ethane -1,2-diamine) cobalt (III) ion.
- (ix) Tetra carbonyl nickel (0).

9.8. List various types of isomerism possible for coordination compounds, giving an example of each.

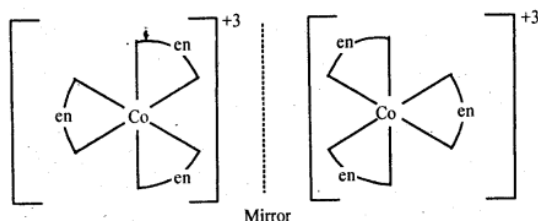
Ans. Coordination compounds exhibit stereo isomerism and structural isomerism.

Two types of stereoisomerism and their examples are as follows.

- (i) **Geometrical isomerism**



- (ii) **Optical isomerism.**



Four types of structural isomerism are as follows:

- (i) Linkage isomerism  $[\text{Co}(\text{NH}_3)_5\text{NO}_2]\text{Cl}_2$  and  $[\text{Co}(\text{NH}_3)_5\text{ONO}]\text{Cl}_2$
- (ii) Coordination isomerism  $[\text{Co}(\text{NH}_3)_6][\text{Cr}(\text{CN})_6]$  and  $[\text{Cr}(\text{NH}_3)_6][\text{Co}(\text{CN})_6]$
- (iii) Ionisation isomerism  $[\text{Co}(\text{NH}_3)_5\text{SO}_4]\text{Br}$  and  $[\text{Co}(\text{NH}_3)_5\text{Br}]\text{SO}_4$
- (iv) Solvate or hydrate isomerism  $[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_2$  and  $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl} \cdot \text{H}_2\text{O}$

9.9. How many geometrical isomers are possible in the following coordination entities?

\*\*\*\*\*END\*\*\*\*\*