perfect and imperfect complexes:

⊛ The complex compounds whose complex ions are highly stable and almost remain undissociated in solution are called perfect complex compound and the complex ions are called perfect complex ion.

e.g; $K_3[Cu(CN)_4] \rightleftharpoons 3K^{\oplus} + [Cu(CN)_4]^{3-}$

(Potassium cupro cyanide)

When H_2S is passed no ppt of Cu_2S is obtained. Hence free Cu^{2+} ions are absent in the solution i.e; the $[Cu(CN)_4]^{3-}$ ion remain undissociated in solution. Thus $[Cu(CN)_6]^{3-}$ is an example of perfect complex.

⊛ The complex compound whose complex ions are less stable and partially dissociates in solution are called imperfect complex compound and the complex ions are called imperfect complex ion.

e.g; $K_2[Cd(CN)_4] \rightleftharpoons 2K^{\oplus} + [Cd(CN)_4]^{2-}$

$\downarrow$

$CdS\downarrow \xleftarrow{H_2S} Cd^{2+} + 4CN^-$

(yellow ppt)

Aqueous solution of $K_2[Cd(CN)_4]$ contains free cadmium ions (Cd^{2+}) because yellow ppt of CdS is obtained when H_2S is passed into this solution.

But the existance of complex ion $[Cd(CN)_4]^{2-}$ in the solution has also been proved. Hence the complex ion partially dissociates in solution. Thus $[Cd(CN)_4]^{2-}$ is an example of imperfect complex ion.

B. Give example of imperfect complex.

B. cu(CN)₂ & cd(CN)₂ are complexed with excess KCN soln justify the different properties of CN⁻ ion with reason.

Differences among perfect salt, imperfect complex salt and double salt:

The main differences among perfect complexes, imperfect complex and double salt depends on the extent of dissociation of the salt in solution. In perfect complex salt, the complex ion remains completely undissociated but in imperfect complex salt, the complex ion partially dissociates while in double salt the constituent ions

completely dissociates i.e; no existance of complex ion in solution.

e.g; In $K_3[Cu(CN)_4]$, the $[Cu(CN)_4]^{3-}$ ion is a perfect complex ion. Because it remains undissociated in the aqueous solution of $K_3[Cu(CN)_4]$.

But in $K_2[Cd(CN)_4]$, the $[Cd(CN)_4]^{2-}$ ion is an imperfect complex ion. Because it partially dissociates in solution i.e; an aqueous solution of $K_2[Cd(CN)_4]$ contains $3K^{\oplus}$, Cd^{2+}, CN^- and $[Cd(CN)_4]^{2-}$ ions.

Mohr's salt is a double salt because the constituent ions of this salt completely dissociates in aq. soln. An aqueous solution of $FeSO_4$, $(NH_4)_2SO_4 \cdot 6H_2O$ contains free Fe^{2+}, NH_4^+, SO_4^{2-} ions i.e; these solution does not contain any complex ion.

Ligands

The neutral molecules or ions which are attached with the central metal ion of the complex compound are called ligands. e.g; in the complex ion $[Fe(CN)_6]^{3-}$, the six CN^- ions are the ligands.

In most of complexes a ligand acts as a donor partner i.e; it donates electron pair to the central metal ion. In $[Cu(NH_3)_4]^{2+}$ complex ion, the four NH_3 molecules are the ligands.

Co-ordination no. (C.N):

Co-ordination no. is the total no. of atoms of the ligand that can co-ordinate to the central metal ion. i.e; co-ordination no. represents the total no. of the chemical bonds formed betn the central metal ion and the donor atoms of the ligands.

Thus in $[Cu(NH_3)_4]^{2+}$ ion, the co-ordination no. of Cu^{2+} ion

is four while in $[Ni(en)_3]^{2+}$ ion, the co-ordination no of Ni^{2+} is six. Since 'en' molecule has two donor atoms

en = ethylene di-amine

$= (NH_2-CH_2-CH_2-NH_2)$.

The no. of ligands in $[Ni(en)_3]^{2+}$ ion is only three

In $[Ca(EDTA)]^{2-}$ ion, the co-ordination no. of Ca^{2+} ion is six but the no. of ligand is one.

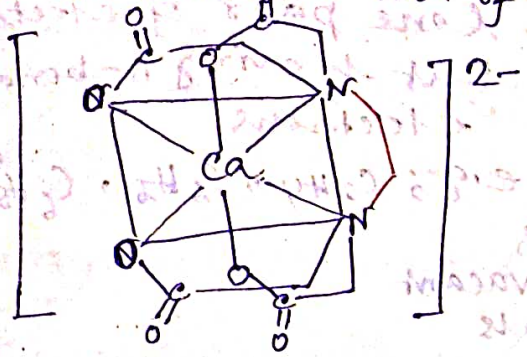

fig: str. of $[Ca(EDTA)]^{2-}$ ion.

Inner sphere or co-ordination sphere and outer sphere or ionisation sphere:

While writing the structural formula of a given complex compound. The central metal atom and the ligands attached with it are always written in a square bracket []. This square braeket is called inner sphere or co-ordination sphere.

The portion outside the inner sphere is called outer sphere or ionisation sphere.

Thus in $[Co(NH_3)_5Cl]Cl_2$, the square braeket which contain the central metal atom (Co^{3+}) and the ligands (5 NH_3 molecules and one Cl^- ion) is called inner sphere and the portion that contains two Cl^- ions is called outer sphere.

Neutral complex:

A complex which has no charge on it is called neutral complex. It is a non electrolyte, does not undergo ionisation and hence does not give any ions in aqueous solution.

⊛ Classification of ligands based on donor and acceptor properties of the ligands:

- Ligands having lone pair of electrons
  - Ligands which contain vacant π-type orbitals
    e.g; CO, $NO^{\oplus}$, CN^- etc.
  - Ligands which do not have vacant π-type orbitals
    e.g; H_2O, NH_3 etc.
- Ligands having no lone pair of electrons but having π-bonding electrons.
  e.g; C_2H_4, C_6H_6, $C_6H_5^{\ominus}$ etc.

⊛ Classification of ligands based on the no. of donor atoms present in the ligand.

- Monodentate ligands
  - Neutral: H_2O, NH_3 etc.
  - negative: CN^-, Cl^-, OH^- etc.
  - positive: NO^+, $NH_2-\overset{\oplus}{N}H_3$ etc.
- Bidentate ligands
  - polydentate ligands

⊛ Bidentate ligands:
en (ethylene di-amine), $CO_3^{=}$ (carbonate), oxalate ($C_2O_4^{=}$)
gly, EAA, bpy, DMG.

⊛ Tridentate ligands: $H_2N-CH_2-CH_2-NH-CH_2-CH_2-NH_2$
di-en (di ethylene tri amine)

⊛ Hexa dentate ligands:
$(EDTA)^{4-}$ (ethylene di-amine tetra acetate anion)