Name of the Teacher-SUTAPA CHAKRABARTY

Subject: Chemistry

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Paper: C9T:Inorganic Chemistry

Topic: Coordination Chemistry

PART 2

Nomenclature (IUPAC) of Co-ordination compounds

Cordination compounds are named according to the rules suggested by International Union of Pure and Applied Chemistry. There rules are given below.

i) Order of naming cations and anions of an ionic complex compound:

If a compound is ionic ie if a complex compound is composed of cations and anions the name of the cation is mentioned first and then the name of anion is written.

eg: On naming $K_2[Pt(Cl)_6]$, the name of the cation K^+ is written first and then the name of the anion $[Pt(Cl_6)]^{2-}$ is mentioned

* If the complex compound is non ionic, the name of the complex compound is written as one word. $[Ni(CO_4)]$

ii) Naming of the species present in Co-ordination sphere:

On naming the species present in coordination sphere the ligands are named first and then the name of the central metal atom mentioned.

Naming of the ligands:-

Ligands are named according to the following rules;

a) Naming of the neutral ligands

Neutral ligands are called by special names like

H_2O → Aqua , NH_3 → Ammine , CO → Carbonyl

NO → Nitrosyl etc.

The ligands N_2 and O_2 are called dinitrogen and dioxygen.

b) Naming of the negative ligands.

The names of the ligands end in 'o' eg O^{2-} → Oxo,

O_2^{2-} → Peroxo, N^{3-} → Nitrido. , OH^- → Hydroxo ,

CN^- → Cyano, NO_2^- → Nitro F^- → Fluoro

Cl^- → Chloro Br^- → Bromo I^- → Iodo

SO_4^- → Sulphato, $S^=$ → Sulphido H^- → Hydrido.

NH_2^- → Amido N_3^- → Azido. NO_3^- → Nitrito

c) Naming of positive ligands.

For cationic ligands the names end in 'ium'

NO^+ → Nitrosylium , $N_2H_5^+$ → hydraziniumm

H_3O^+ → Hydronium , NO_2^+ → Nitronium.

d) Naming of the organic ligands :

Organic ligands are given their common name. Phenyl → C_6H_5, Methyl → CH_3, Ethylene diamine → en Pyridine → C_5H_5N Triphenylphosphene → Ph_3P, Hydrazine → NH_2-NH_2

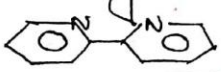
e) Indication of the no. of ligands :

If a complex contains two or more simple ligands of the same type their no. is indicated by putting prefixes, di → for 2, tri → for 3. Tetra → for 4, Penta → for 5, Hexa → 6, Hepta → 7 Octa → 8. etc. before their names

The terms bis for 2, tris for 3, Tetrakis → 4 Pentakis → for 5. etc are used for organic ligands where the prefixes di, tri, etc are already used in naming the ligands or where use of prefixes di, tri may change the name of the ligands. The name of the ligands is written in bracket.

Complex	Name of organic li.
$[Pt(en)_2]Cl_2$	Bis (ethylene diamine
$[Cu(Py)_2]Cl_2$	Bis (Pyridine)

** Use of dipyridine may indicate the bidentate ligand di-pyridine.



f) Order of naming ligands :

When writing the name of a complex the ligands are name in alphabical order, regardless of their charge. The prefixes di, tri, etc are not considered, while determing this alphabatical order.

g) Naming of the bridging ligands

The ligands which bridges more than one central metal ion are called bridging ligands. The prefix 'μ' is used to designate such a ligand. For more than one bridging ligands for the same kind μ-di, μ-tri are used. If a bridging or bridges more than two metal atoms, it is written as μ_3, μ_4, μ_5 or μ_6 to indicate how many atom it is bonded to. When the same ligand is present as a bridging ligand and as anon bridging ligand the bridging ligands are written first.

Compounds	Name of the bridging li
$[(NH_3)_5Cr-OH-Cr(NH_3)_5]Cl_5$	μ-hydroxo
$[(NH_3)_4Co\langle^{NH_2}_{OH}\rangle Co(NH_3)_4]Cl_4$	μ-Amido, -μ-hydroxo

h) Naming of the Ambidentate ligands.

Such ligands are either named by special names such as thiocyanato $\longrightarrow SCN^-$ (S-donor) Isothiocyanato $\longrightarrow NCS^-$ (N-donor), Nitro $\longrightarrow -NO_2^-$ (N-donor) Nitrito $\longrightarrow ONO^-$ (O-donor)

or The symbol of the element coordinated with the metal ion is written after the name of the ligand Thiocyanato-S (S-donor), or Thiocyanato-N (N-donor) for SCN- ligand.

i) Name of the Central metal ion:-

Different rules are used for different complexes

a) Cationic and neutral complexes:

In cation and neutral complexes name of the metal is used followed by the oxidation no. of the metal in Roman neumerals (0, I, II, III, -I, -II etc) in parenthesis.

eg Nickel (II), Cobalt (III) etc.

b) Anionic Complexes :

To name the central metal ion the suffix 'ate' is attached to its name and the oxidation no is before.

eg: Cr → chromalē (III)
Cu → Cupperate
Fe → Ferrale
Os → Osmalē
Zn → Zincate
Ag → Argentalē
Co → Cobaltate
Ni → Nicklalē
Pd → Palladalē
Cd → Cadmalē
Pt → Platinalē
Au → Auralē.

vi) Metal to metal bonding :

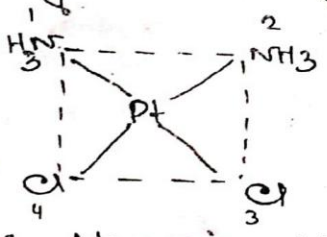
In complexes containing metal-metal bonds, the prefix 'bi' is used before the name of the metals forming metal to metal bond.

eg: $[CH_3(NH_2)_4(Cl)Pt-Pt(Cl)(NH_2-CH_3)]Cl_2 \longrightarrow$

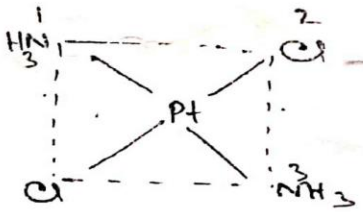
Dichloro octakish (methyl ammine) bi - platinum (II) - Chloride

vi) Geometrical isomers :

Geometrical isomers are named either by using the prefixes 'cis' for adjacent position and trans for opposite positions before the name of the ligands or by numbering system followed by a hyphen (-)



Cis - diammine dichloro platinum (II)
or (1,2) diammine - (3,4) - di chloro platinum (II)



Trans diammine dichloro platinum (II)
or (1,3)-diammine (2,4) - dichloro platinum (II)

vii) Optical Isomers : Dextro levorotory complexes are resp. designated either by (+) or (−) or by 'd' or 'l'

eg $d\text{-}K_3[Ir(C_2O_4)_3]$ → d-potlacium d-trioxalato-iridiate (III)
or Potlacium (+) trioxatato idiate (III)

viii) Writing the formula of complexes :
When writing the formula of complexes, the complex ion should be enclosed by square bracket [ ]. The metal is written first then the coordinated groups are listed in the order : Negative ligand, Neutral ligands, positive lig. Alphabatically according to the 1st symbol within each gr.

// Write the names of the following complex compound according to IUPAC system of nomenclature :-

i) $Ca_2[Fe(CN)_6]$ → Calcium (II) hexacyano ferrate (II)

ii) $[Co(NH_3)_5Cl]Cl_2$ → Pentaammine chloro Cobalt(III) Chloride

iii) $[Fe(H_2O)_6]SO_4$ → Hexaaqua ioron (II) Sulphate.

iv) $[PtCl_2(NH_3)_2]$ → Diammine dichloro platinum (II)

v) $[(C_2O_4)_2Cr\langle^{OH}_{OH}\rangle Cr(C_2O_4)_2]^{4-}$ → Dioxalato chromate (III) - μ dihydroxo dioxalato chromate (III) anion.

vi) $[Pt(Py)_4][PtCl_4]$ → Tetrapyridine platinum (II) tetra chloro platinate (II)

vii) $[Ir(en)_2Cl_2]^{+}$ → Dichloro bis (ethylene diamine) Iridium (III) ion

viii) $[Ni(NH_3)_2(en)](CH_3COO)_2$ → Diammine ethylene diamine nickel (II) acetate

ix) $[PdI_2(ONO)_2(H_2O)_2]^{2-}$ → Diaqua diiodo dinitrito palladate (II) ion

x) $[Co(en)_3]_2(SO_4)_3$ → Tris (ethylene diamine) cobalt (III) Sulphate.

xi) $[Cr(H_2O)_5Cl]Cl_2 \cdot H_2O$ → Pentaaquachlorochromium (III) chloride - monohydrate.

xii) $[Cr(H_2O)_4Cl_2]Cl \cdot 2H_2O$ → Tetraaqua dichloro chromium (III) Chloride - dihydrate.

xiii) $(CH_3)_4N[Cr(SCN)_4(NO)_2]$ → Tetramethyl ammonium dinitrosyl tetra thiocyanato chromate (III).

xiv) $Na[Au(CN)_2]$ → Sodium dicyano aurate (I)

5. $[Co(en)_2(ONO)Cl]Cl$ → Chloro bis (ethylene diamine) nitrito-cobalt (III) chloride.

6. $[(NH_3)_4Co\langle^{NH_2}_{OH}\rangle Co(NH_3)_4](NO_3)_4$ → Tetraammine cobalt (III) amido. μ hydroxo tetraammine cobalt (III) nitrate

7. $[Cr(NH_3)_6][CoF_6]$ → Hexaammine chromium (III) hexa fluro cobaltate (III)

8. $[Co(NH_2)_2(NH_3)_4]OC_2H_5$ → Diamido tetraammine cobalt (III) ethoxide.

9. $[(NH_3)_5Cr-OH-Cr(NH_3)_5]Cl_5$ → Pentaammine chromium (III) μ-hydroxo pentaammine chromium (III) chloride.

10. $[Cr(en)_3][Ni(CN)_5]$ → Tris (ethylenediamine) Chromium (III) penta cyano nickelate (II)

11. $[Co(NH_3)_2(H_2O)_2(CN)_2]Cl$ → Diammine diaqua dicyano cobalt (III) chloride.

12. $[Fe(NH_3)_6]^{3+}[Fe(CN)_6]^{3-}$ → Hexaammine Ioron (III) - hexacyano ferrate (III)

13. $[Cr(NH_3)_5(NCS)]^{2+}[ZnCl_4]^{2-}$ → Pentaammine isothiocyanato chromium (III) tetrachlorozincate (II).

14. $[Fe(C_5H_5)_2]^{\circ}$ → Bis(cyclopentadienyl) Ioron (II)

15. $[Mn_3(CO)_{12}]$ → Dodeca carbonyl trimanganese. (0)

16. $[Pt(NH_3)_3(Br)NO_2]Cl$ → Triammine bromonitro platinum (IV) chloride.

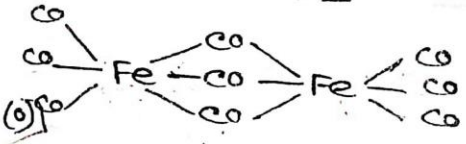
17. $Li[AlH_4]$ → Lithium tetrahydrido alluminate (III)

18. $K_2[OsCl_5N]$ → Pottassium pentachloronitridoosmate (VI)

19. $Na_3[Ag(S_2O_3)_2]$ → Sodium dithiosulphatoargentate (I)

20. $Fe_2(CO)_9$

μ-tricarbonyl bis (tricarbonyl) Ioron (0)



21. $\left[Co\langle^{OH}_{OH}\rangle Co(NH_3)_4\right]_3^{6+}$ – Tris [tetraamine — μ dihydroxo cobalt (III)] — cobalt (III) ion

[Optically active pure compound] [inorganic]

22. $Ni(O_2C_2S_2)_2$ – Bis(dithiooxalato-O, O') Nickel (IV)

Write the formula of the following compounds :

i) Tetraaqua dichlorochromium (III) nitrate $\rightarrow [Cr Cl_2 (H_2O)_4] NO_3$

ii) Pottacium Tetracyanonickelate (II) $\rightarrow K_2[Ni(CN)_4]$

iii) Hexaammine cobalt (III) Hexacyanochromate (III) $\rightarrow [Co(NH_3)_6][Cr(CN)_6]$

iv) Tetrachloro (ethylene diamine) platinum (IV) $\rightarrow [Pt Cl_4 (en)]$

v) μ-dicarbonyl bis {tetracarbonyl iron (0)} $\rightarrow (CO)_4 Fe \begin{matrix} CO \\ CO \end{matrix} Fe(CO)_4$

vi) Ammonium aqua pentafluronickelate (IV) $\rightarrow NH_4[Ni F_5 (H_2O)]$

vii) Tetraammineaquabromo cobalt (III) chloride $\rightarrow [Co(Br)(NH_3)_4 H_2O] Cl_2$

viii) Bromo dichloro iodo paladate (III) ion $\rightarrow [Pd(Br)Cl_2 I]^-$

x) Tetraammine carbonato cobalt (III) chloride $\rightarrow [Co(CO_3)(NH_3)_4] Cl$.

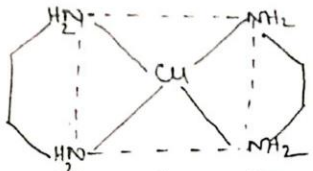
Chelate Complex :

When a bidentate or polydentate ligands simultaneously occupy two or more co-ordination positions of the same central metal ion, A complex is formed containing a ring stru^r such ligands are called chelating ligand and the complex is called chelate complex.

When two moles of 'en' which is a bidentate lig. get attached with one Cu^{+2} ion through its two N- donor atoms of each molecule, $[Cu(en)_2]^{2+}$ which contains two 5-membered rings is ~~obtained~~ stru^r

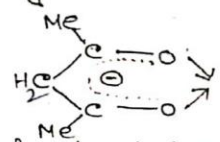
This complex ion is called a chelate complex.

$Cu^{2+} + 2en \longrightarrow [Cu(en)_2]^{2}$

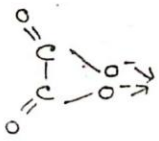


Some examples of chelating ligands and chelates formed by them are given below

Ligands



acetylacetonato (acac),



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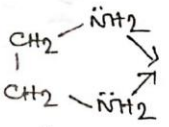
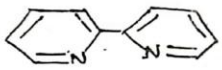
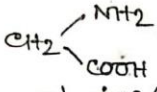


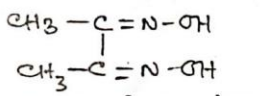
(en),



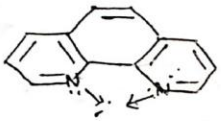
2-2'-bipyridine



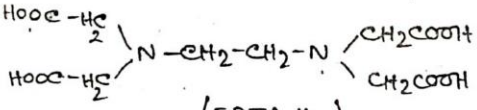
glycine (gly-H)



Dimethyl glyoxime (DMG)



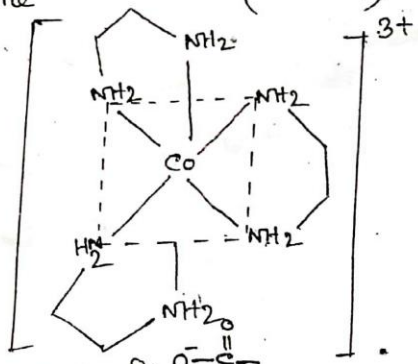
o-phenanthroline



(EDTA-H4)

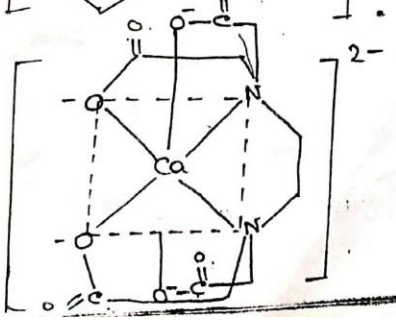
Chelates :

$Co[(en)_3]^{3+}$

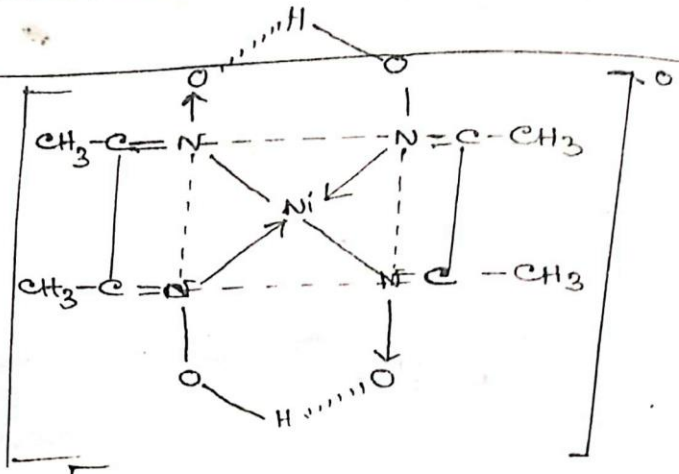


Chelated

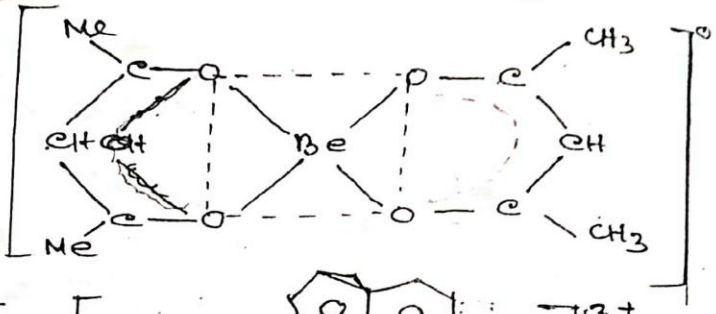
$[Ca(EDTA)]^{2-}$



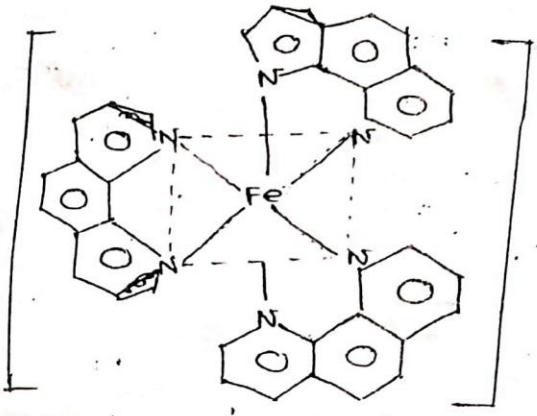
≈ $[Ni(DMG)_2]$



≈ $[Be(acac)_2]$



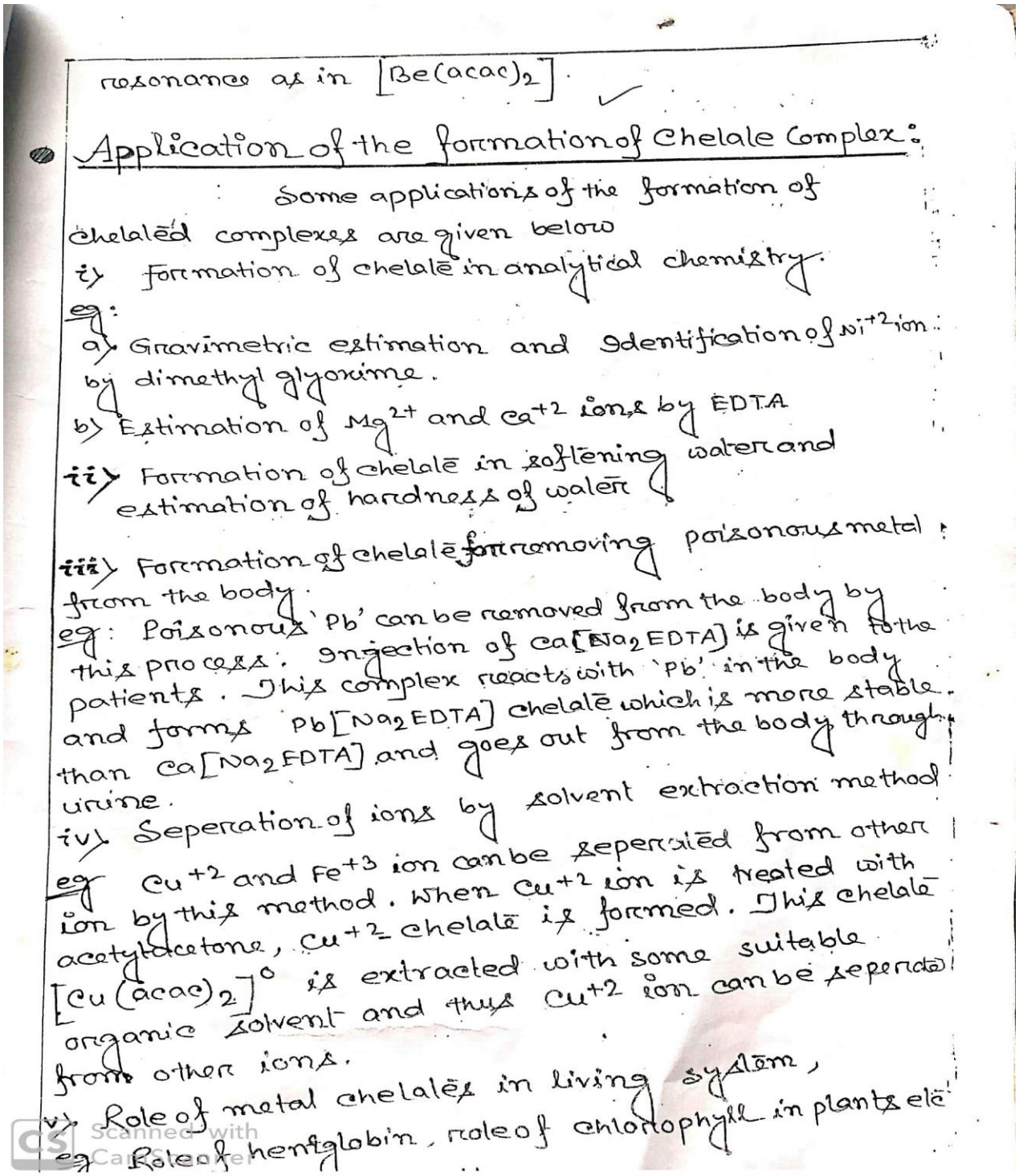
≈ $[Fe(o\text{-}phen)_3]^{3+}$



The formation of a chelate is called chelation or cyclisation. Chelation enhances the stability of a complex.

eg $[Co(NH_3)_6]Cl_3$ is much less stable than $[Co(en)_3]Cl_3$

The chelate ring stur containing 5 and 6 membered including the metal ion are the more stable, may be due to reduced steric strain in such ring. Stability of a chelate increases with increase in the no. of such ring. Chelate containing alternate single and double bond are even more stable. In such cases the π-e density is delocalise and spread over the ring which is stabilised by



resonance as in $[Be(acac)_2]$.

Application of the formation of Chelate Complex:

Some applications of the formation of chelated complexes are given below

i) Formation of chelate in analytical chemistry.

eg:

a) Gravimetric estimation and identification of Ni^{+2} ion by dimethyl glyoxime.

b) Estimation of Mg^{2+} and Ca^{+2} ions by EDTA

ii) Formation of chelate in softening water and estimation of hardness of water

iii) Formation of chelate for removing poisonous metal from the body.

eg: Poisonous 'Pb' can be removed from the body by this process. Injection of $Ca[Na_2EDTA]$ is given to the patients. This complex reacts with 'Pb' in the body and forms $Pb[Na_2EDTA]$ chelate which is more stable than $Ca[Na_2EDTA]$ and goes out from the body through urine.

iv) Seperation of ions by solvent extraction method

eg Cu^{+2} and Fe^{+3} ion can be seperated from other ion by this method. When Cu^{+2} ion is treated with acetylacetone, Cu^{+2} chelate is formed. This chelate $[Cu(acac)_2]^0$ is extracted with some suitable organic solvent and thus Cu^{+2} ion can be seperated from other ions.

v) Role of metal chelates in living system,

eg Role of hemoglobin, role of chlorophyll in plants etc

[N.B.- Acknowledgement of indebtedness to Mr.Sibshankar Das,my respected Teacher regarding collection of study materials in Inorganic Chemistry**]**