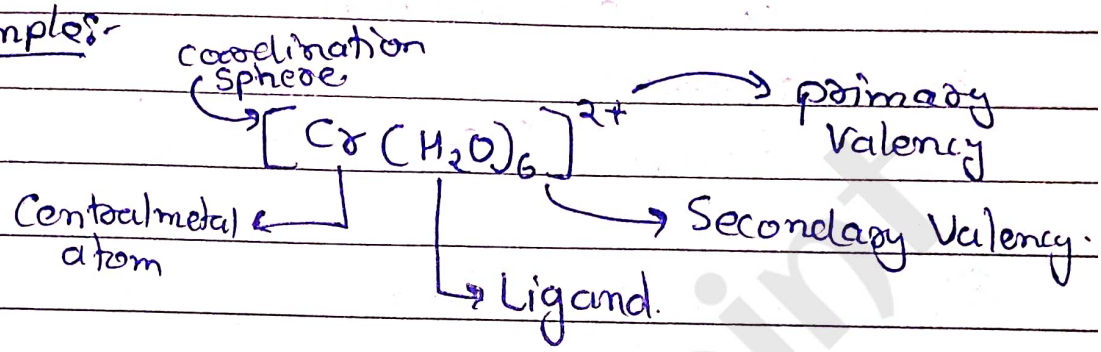
CO-ORDINATION COMPOUND

Metal → Lewis acid / e^- pair acceptor
Ligands → lewis base / e^- pair donar

Example:-



Nature of Salt:

① **Double Salt**:- They loose their identity in aquous solution.

Example- $FeSO_4 \cdot (NH_4)_2 SO_4 \cdot 6H_2O$

② **Co-ordinated Salt**:- They did not loose their identity in aq. Solution.

Example:- $K_4[Co(CN)_6]$

S-block

$\downarrow$

$4K^+ + [Co(CN)_6]^{-2}$

Co-ordination Number.

$[Cr(H_2O)_4Cl_2]^{-4}$	CN = 6
$[Ag(CN)_2]^+$	CN = 2
$[Fe(CN)_6]$	CN = 6
$[Fe(CO)_5]$	CN = 5
$[Fe(ox)(H_2O)_4]$	CN = 6
$[Co(gly)_3]^{3+}$	CN = 6

Edustudy point

Classification of ligand

① Depending on the nature of ligand

(a) Homoleptic

Example - $[Co(NH_3)_6]^{2+}$

(b) Heteroleptic

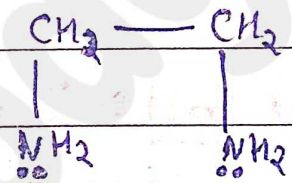
Example - $[Co(NH_3)_2Cl_4]^{-}$

② Depending on the no. of donor atom

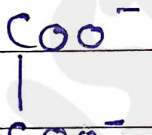
(a) Monodentate

Example - Cl^-, F^-, Br^-, I^-, OH^-, CN^-, H_2O, NH_3, CO, NO^+ etc.

(b) Bidentate

Example - (i) 

ethylene diammine (en)

(ii) 

oxalato (ox)

(iii) $NH_2-CH_2-COO^-$ glycinato (gly)

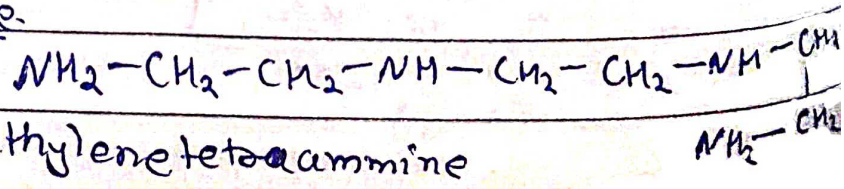
(c) Polydentate ligand

(a) Tridentate

$NH_2-CH_2-CH_2-NH-CH_2-CH_2-NH_2$

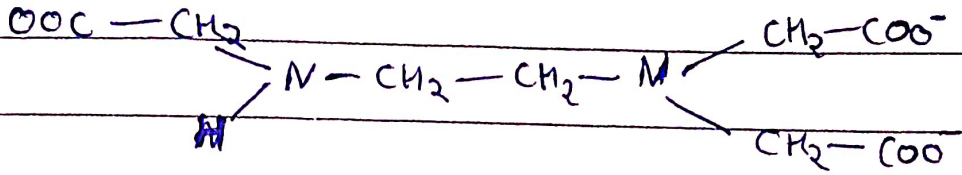
diethylenetriammine

(b) Tetradentate

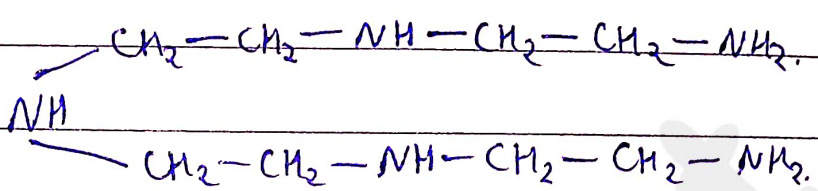


Triethylenetetraammine

(c) Pentadentate

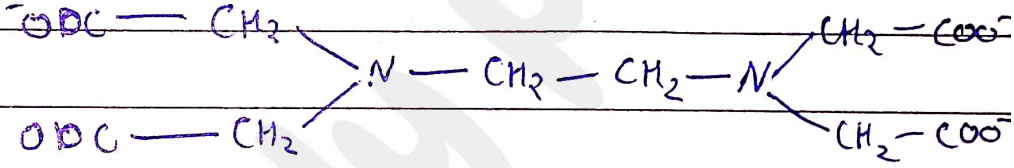


ethylenediammine triacetato - H (H-EDTA)$^{3-}$



tetraethylene pentaammine.

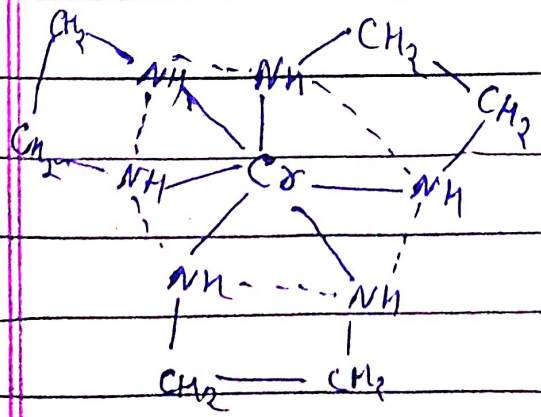
(d) Hexadentate

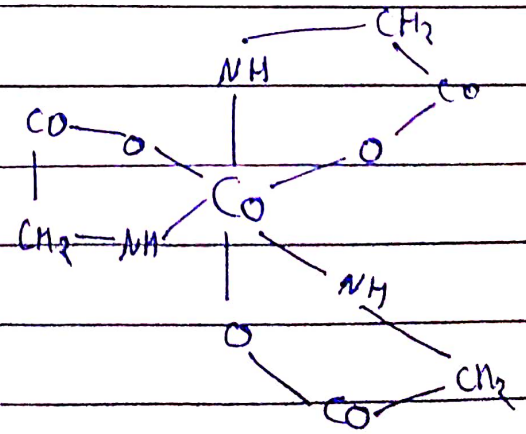


ethylenediaminetetraacetato (EDTA)$^{4-}$

Chelating ligand:- A Bidentate or polydentate ligand attached to central Metal atom (CMA) to form ring is called chelating ligand & the process is called chelation.

Example:- $[Cr(en)_3]^{2+}$, $[Co(gly)_3]^{3+}$





⇒ **Ambidentate ligand**:- A monodentate ligand having two donar atom but at one time only one atom donate a pair of e^- to central metal atom to form coordinate bond & that ligand is called Ambidentate.

Ex:- $M \leftarrow NO_2$ Nitrito – N $M \leftarrow ONO$ Nitrito – O

$M \leftarrow SCN$ Thiocyanato $M \leftarrow NCS$ Isothiocyanato

⇒ **Flexidentate ligand** :- SO_4^{2-}, CO_3^{2-}, NO_3^-

$[Co(NH_3)_5SO_4]Cl$

$[Co(en)_2SO_4]Cl_2$

Werner's theory

Primary Valency	Secondary Valency
→ Ionisable	→ Non-Ionisable
→ It define ON of C.M.A	→ Define C.N of CMA
→ Can't desicide the geometry of Complex	→ It can decide the geometry of Complex

IUPAC Nomenclature

1. $[Co(NH_3)_6]Cl_3$ ⟶ Hexammine cobalt (III) chlori

2. $[Co(NH_3)_4ClNO_3]Cl_2$ ⟶ Tetrammine chloride nitrito -N Cobalt (III) chloride

3. $[Pt(NH_3)_2Cl(NH_2CH_3)]Cl$

→ diamminechloridomethylammine (II) chloride

4. $[Mn(H_2O)_6]^{2+}$

→ Hexaaqua Manganese (II)

5. $[Co(en)_2]^{3+}$

→ bis (ethan-1,2-diammine) Cobalt (III)

6. $[Ti(H_2O)_6]^{3+}$

→ hexaqua titanium (III)

7. $[NiCl_4]^{2-}$

→ Tetrachloridonicket (II)

8. $[Ni(CO)_4]$

→ tetracarboxy nickel (0)

9. $K_3[Cr(C_2O_4)_3]$

→ Potassium trioxalatochromate (III)

10. $[CoCl_2(en)_2]Cl$

→ Dichloridobis (ethane-1,2-diamine) cobalt (III) chloride

11. $[Co(NH_3)_5CO_3]Cl$

→ Pentaamminecarbonato cobalt (III) chloride

Easystudy point

Isomerism

- Structural Isomerism
  - Ionisation
  - Solvation
  - Linkage
  - Co-ordination
- Stereoisomers
  - Geometrical
  - Optical

⇒ **Structural Isomerism**:- The compound which having Same molecular formula but different Structure.

① **Ionisation**:- The exchange of ligand b/w Coordination sphere & Ionisation sphere.

Ex- $[Co(NH_3)_4 SO_4]Br_2$ & $[Co(NH_3)_4 Br_2]SO_4$

Ex- $[Co(NH_3)_4 Cl_2]Br_2$ & $[Co(NH_3)_4 Br_2]Cl_2$

② **Solvation Isomerism**:- The exchange of water molecule with another ligand & between Co-ordination Sphere & ionisation sphere.

Ex- $[Cr(NH_3)_4 H_2O Cl]Cl_2$ & $[Cr(NH_3)_4 (Cl_2)] H_2O.Cl$

③ **Linkage isomerism**:- This isomerism are obtained by Ambidentate ligand

Ex- $[Co(NH_3)_5 NO_2]$ & $[Co(NH_3)_5 ONO]$

Ex- $[Co(CO)_5 SCN]^+$ & $[Co(CO)_5 NCS]^+$

(4) **Co-ordination Isomerism** :- The exchange of ligand b/w Co-ordination cation & Co-ordination Anion Complex.

Ex- $[Co(NH_3)_6]^{2+}[Cr(CN)_6]^{4-}$ & $[Cr(NH_3)_6]^{2+}[Co(CN)_6]^{4-}$

Ex- $[Cr(NH_3)_6]^{2+}[Cr(CN)_6]^{4-}$ & $[Cr(NH_3)_4(CN)_2]$

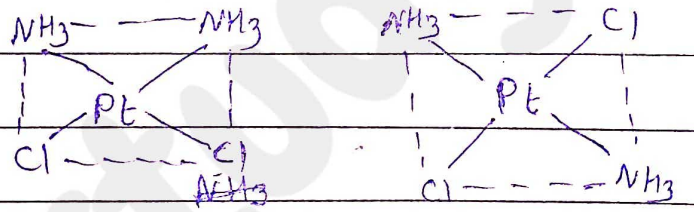
$[Cr(NH_3)_2(CN)_4]$

⇒ **Steroisomers** :- They have same molecule formula, but differ position of ligand.

(1) **Geometrical** :- The ligands occupy different positions around the central metal ion

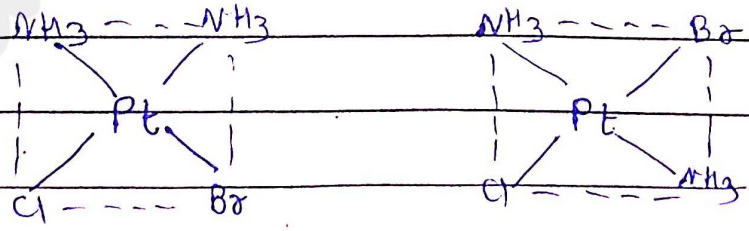
Square planar Complex (CN=4)

(a) $[Pt(NH_3)_2Cl_2]$



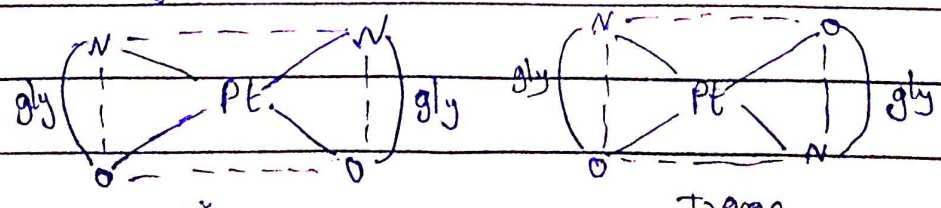
cis Trans

(b) $[Pt(NH_3)_2ClBr]$



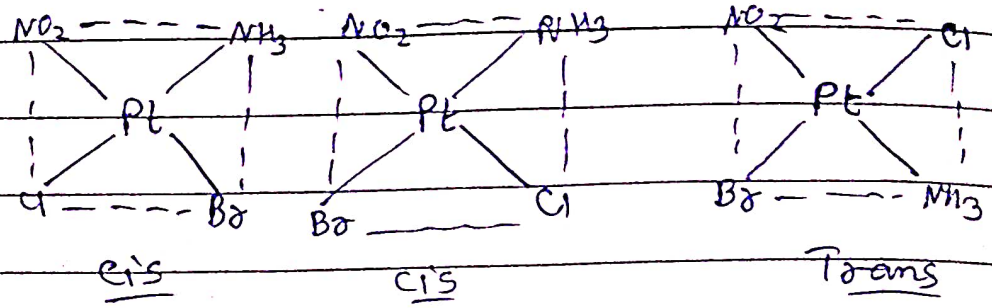
cis Trans

(c) $[Pt(gly)_2]$



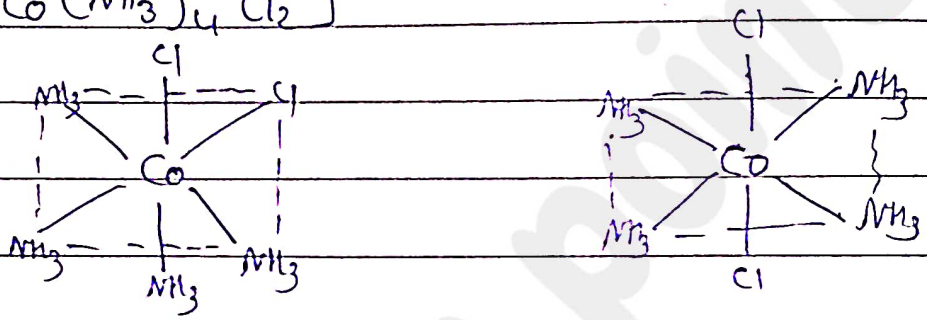
cis Trans

(d) $[Pt(NH_3)(NO_2)ClBr]$

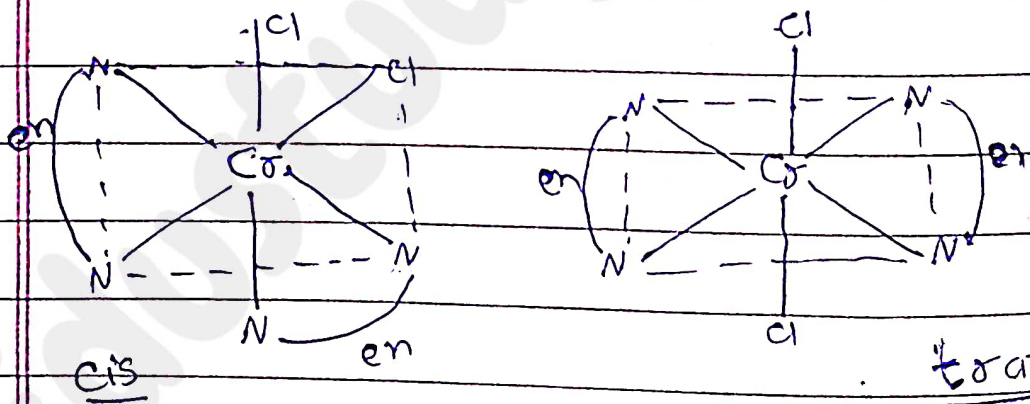


Octahedral Complex (CN=6)

(a) $[Co(NH_3)_4Cl_2]^+$



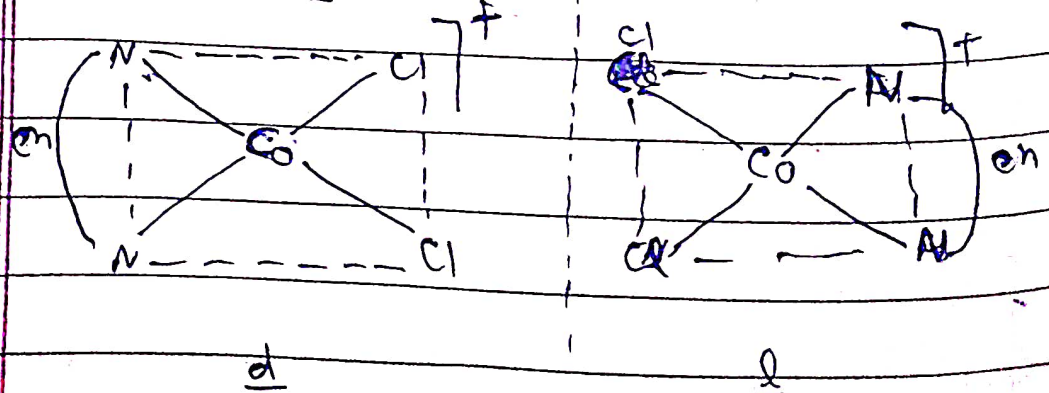
(b) $[Cr(en)_2Cl_2]^+$



(2) Optical isomerism :-

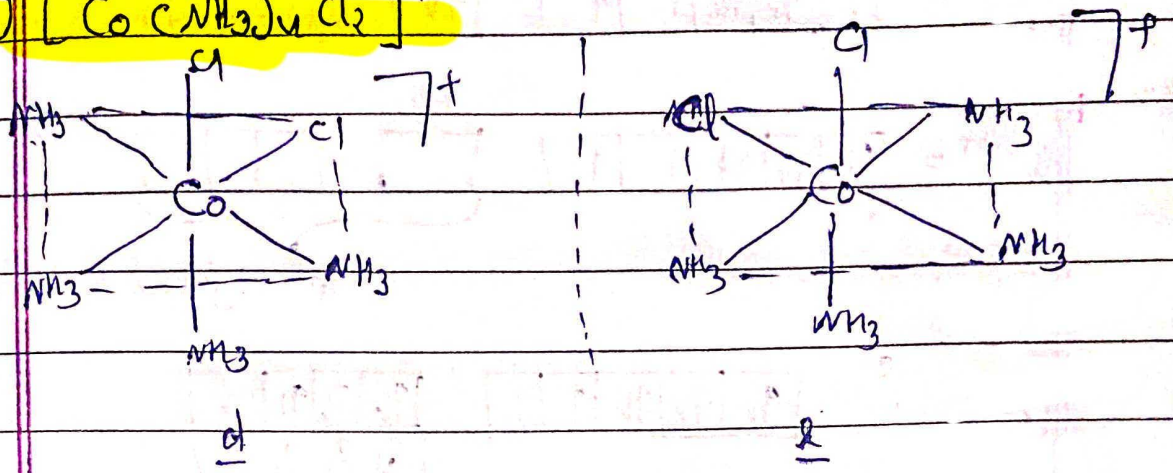
C.N = 4

(1) $[Co(en)_2Cl_2]^+$



CN = 6

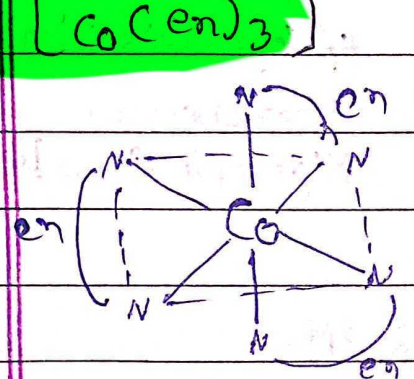
① $[Co(NH_3)_4Cl_2]^+$



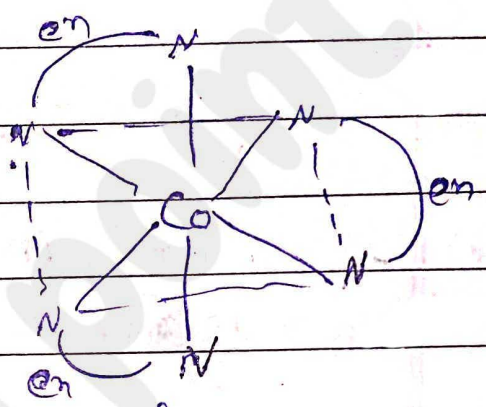
d

ℓ

② $[Co(en)_3]$



d



ℓ

Valence bond theory (VBT) & Crystal Bond Theory (CFT)

CN = 4

Tetrahedral
sp^3

Square planar
dsp^2

① $[NiCl_4]^{2-}$

(i) Primary Valency = +2

(ii) Secondary Valency = 4

(iii) VBT (CN = 4)

sp^3 tetrahedral

dsp^2 square planar

Ni° = 3d | 4s | 4p

Ni^{2+} = 3d | 4s | 4p

Sp^3 hybrid orbital

$[NiCl_4]^{2-}$ = 3d | 4s | 4p

Cl^- Cl^- Cl^- Cl^-

Sp^3 hybridisation

tetrahedral

High Spin Complex

(iv) $\mu = \sqrt{n(n+2)}$ BM

$\mu = \sqrt{2(2+2)} = \sqrt{8} = 2.8$ BM

Paramagnetic

(v) CFT :- CN = 4

t_2

$e^4 t_2^4$

e

(2) $[Fe(CN)_4]^{2-}$

(i) Primary Valency = +2

(ii) Secondary Valency = 4

(iii) VBT

Fe = 3d | 4s | 4p

Fe^{2+} = 3d | 4s | 4p

dsp^2 hybrid orbital

$[Fe(CN)_4]^{2-}$ = 3d | 4p

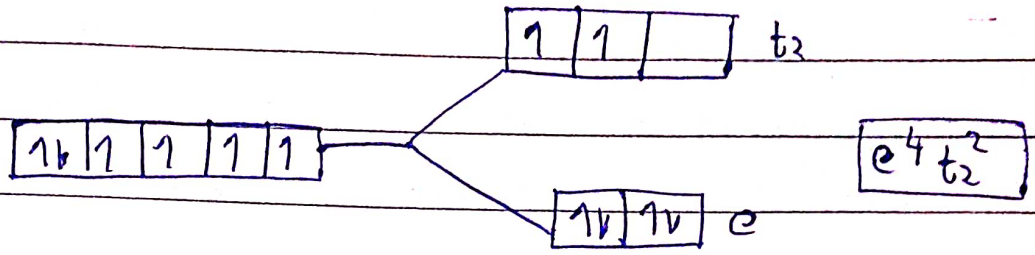
CN^- CN^- CN^- CN^-

dsp^2 hybridisation

(iv) $\mu = 0$ B.M

Diamagnetic.

(v) CFT



$CN_{Co} = 6$ (octahedral)

(1) $[FeCl_6]^{3-}$

(i) Primary Valency = +3

(ii) Secondary Valency = 6

(iii) VBT (CN = 6)

d^2sp^3 — Inner orbital complex

sp^3d^2 — outer orbital Complex

$Fe = 3d^6 4s^2$

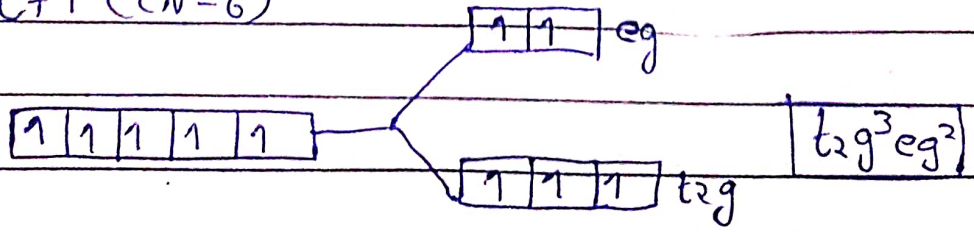
Fe^{3+} = 3d | 4s | 4p | 4d

sp^3d^2 hybrid orbital

$[Fe(Cl)_6]^{3-}$ = sp^3d^2 hybridisation

(iv) $\mu = \sqrt{S(S+2)} = \sqrt{35} = 5.9$ BM — paramagnetic, HSC.

(v) CFT (CN = 6)



Note :- if $\Delta_o > P$ = L.S.E

$\Delta_o < P$ = H.S.C

⇒ **Spectrochemical Series** :- The arrangement of ligand in order of increasing there CfSE Value is known as spectrochemical Series.

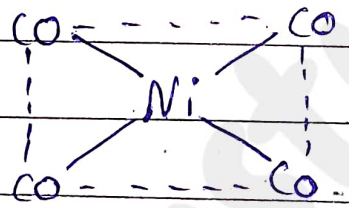
$I^- < Br^- < SCN^- < Cl^- < F^- < OH^- < C_2O_4^{2-} < H_2O < NH_3 < en < NO_2^- < CN^- < CO$

⇒ **Metal Carbonyle** :- (M ← CO)

Metal Carbonyle is organo metallic Compound in which Carbon monooxide act as a ligand which coordinate with transition element.

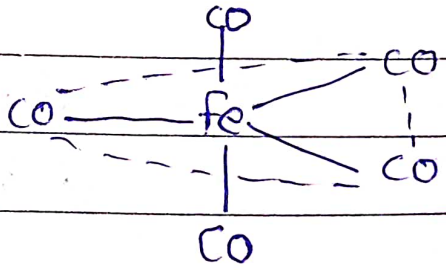
Example -

① $Ni(CO_4$



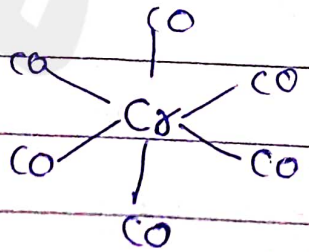
Square planer

② $Fe(CO)_5$

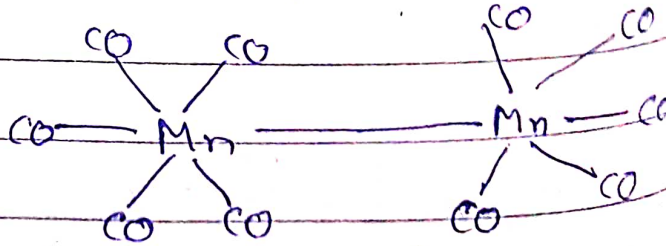


Trigonal bipyramidal

③ $[Cr(CO)_6]$



④ $Mn_2(CO)_{10}$



octahedral

⑤ $[Co_2(CO)_8]$