Chlorophyll → Mg
Haemoglobin → Fe
Vitamin B12 → Co

Addition Compounds : When 2 or more salts are mixed in a fixed proportion and allowed to crystallise then new type of compound formed is known as Addition compounds.

Double salt

- Those addition compds. which are stable in crystalline form and get 100% ionised in aq. medium c/a double salt.

eg: $KCl + MgCl_2 + 6H_2O \rightarrow KCl.MgCl_2.6H_2O$
Carnallite

$K_2SO_4 + Al_2(SO_4)_3 + 24H_2O \rightarrow K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$
Potash Alum

$FeSO_4 + (NH_4)_2SO_4 + 6H_2O \rightarrow FeSO_4.(NH_4)_2SO_4.6H_2O$
Ferrous ammonium sulphate
Mohr's Salt

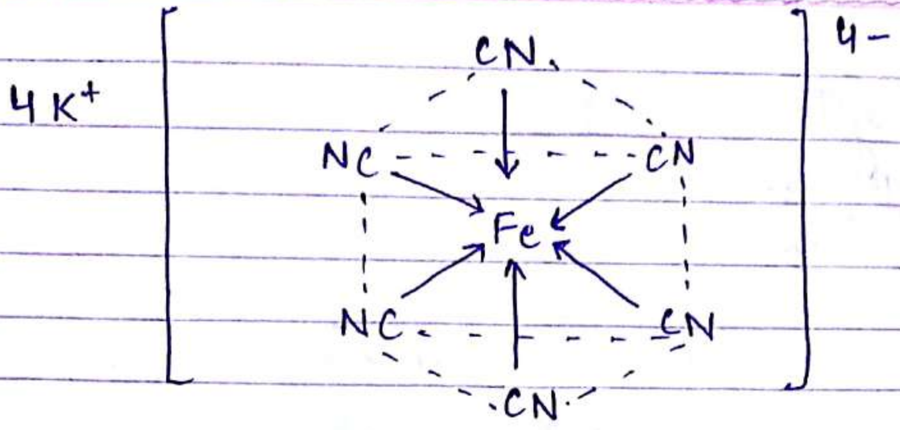
Coordination compounds.

- Those addition compds. which are stable in crystalline form as well as in aq. form or medium and donot get 100% ionised is c/a coordination compds.

Example of Coordination Compds :-

eg $K_4[Fe(CN)_6] \xrightarrow{aq.} 4K^+ + [Fe(CN)_6]^{4-}$

When $K_4[Fe(CN)_6]$ is dissolved in water then its aq. sol^n shows properties of K^+ ions but do not show properties of Fe^{2+} & CN^- ions becoz these are +nt in form of complex ion $[Fe(CN)_6]^{4-}$



Important terminology related to C.C. :-

1. Central metal atom and ion ÷ It is metal atom or ion which have same or nearly same energy vaccant orbital to accept lp donated by ligand

* Central metal atom or ion behave as lewis acid.

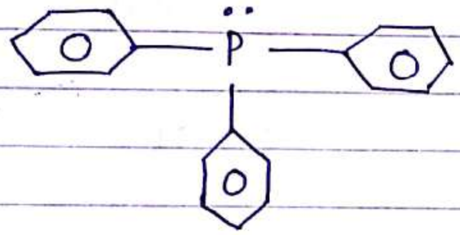
2. Ligand ÷ Any atom, molecule or ion which have lp to donate central metal atom or ion.

* Ligand behave as lewis base.

Types of ligand :-

(a) Monodentate Ligand :- which have one donor atom.

	ligand	Name	Charge
1.	$H_2\ddot{O}$	aqua	0
2.	$\ddot{N}H_3$	ammine	0
3.	CN^-	cyano	-1
4.	X^-	Halido	-1
	(F^-, Cl^-, Br^-, I^-)	(Fluorido, Chlorido, Bromido, Idido)	
5.	H^-	Hydrido	-1
6.	OH^-	Hydroxo	-1
7.	NO_2^-	nitro	-1
8.	NO_3^-	nitrato	-1

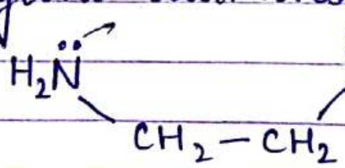
9.	NH_2^-	amido	-1
10.	NH^{2-}	imido	-2
11.	N^{3-}	nitrido	-3
12.	SO_4^{2-}	Sulphato	-2
13.	O^{2-}	oxo	-2
14.	O_2^{2-}	peroxo	-2
15.	S^{2-}	sulphido	-2
16.	CH_3COO^-	acetato	-1
17.	CO	carbonyl	0
18.	NO	nitrolsyl	0
19.		pyridene (py)	0
20.		triphenyl phosphine	0
21.	$\ddot{P}H_3$	phosphine	0

(b) Bidentate ligand : which have 2 donar atom.

eg: ① Oxalato ligand ($C_2O_4^{2-}$)

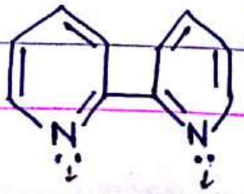
* COO^- →
| 2 donor O-atom
COO^- → Charge = -2

* ② Ethylene diamine (en) or (Ethane-1,2-diamine)



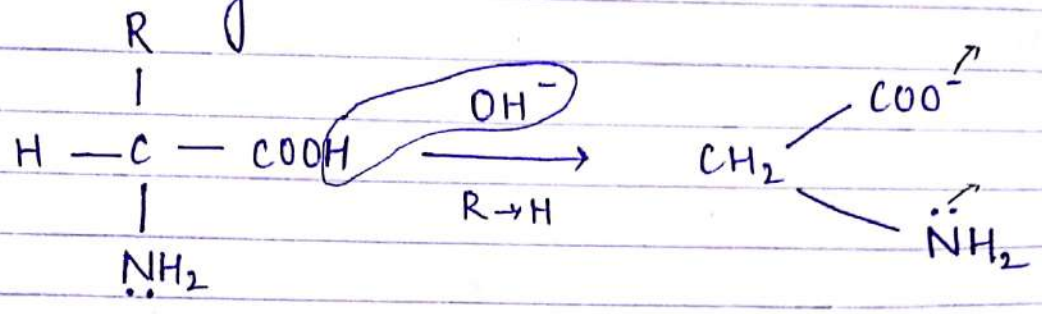
2 donor N-atom
Charge = 0

③ 2, 2' - bipyridine



4. Glycinato ligand :

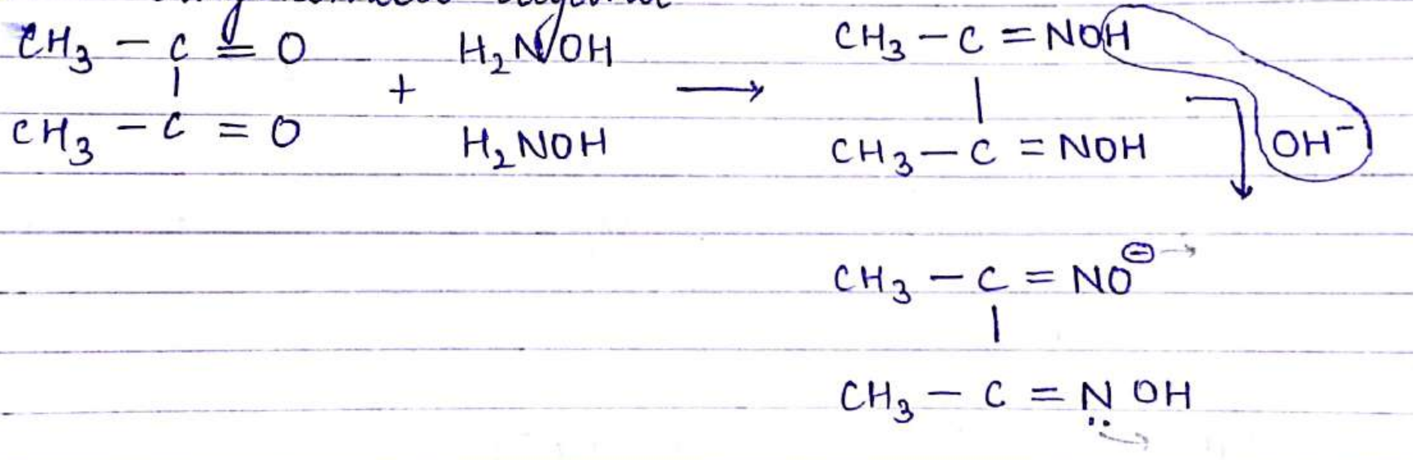
*



$$H-\overset{\displaystyle R}{\underset{\displaystyle \ddot{N}H_2}{C}}-COOH \xrightarrow[R \to H]{OH^-} CH_2\begin{matrix} COO^- \\ \ddot{N}H_2 \end{matrix}$$

1 donor O - atom & 1 donor N - atom
it is an ~~eg~~ example of unsymmetrical bidentate ligand.

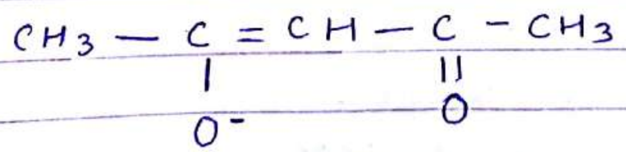
5. Glyoximato ligand



$$\begin{matrix} CH_3-C=O \\ CH_3-C=O \end{matrix} + \begin{matrix} H_2NOH \\ H_2NOH \end{matrix} \longrightarrow \begin{matrix} CH_3-C=NOH \\ CH_3-C=NOH \end{matrix} \xrightarrow{OH^-} \begin{matrix} CH_3-C=NO^{\ominus} \\ CH_3-C=\ddot{N}OH \end{matrix}$$

1 donor O atom & 1 donor N - atom

6. Acetyl acetonato (acac)⁻

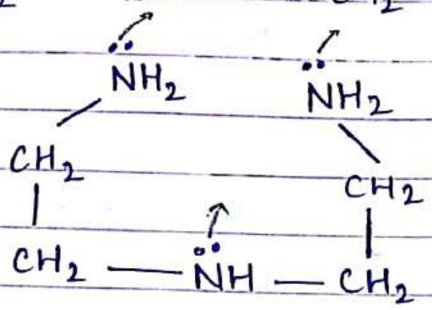


$$CH_3-\underset{\displaystyle O^-}{C}=CH-\underset{\displaystyle O}{\overset{}{C}}-CH_3$$

(c) **Polydentate ligand** : which have more than 2 donar atom

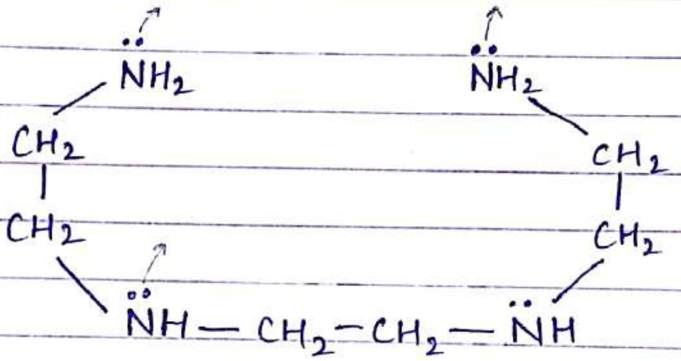
eg : ⓐ diethylene triamine (dien)

$H_2\ddot{N}-CH_2-CH_2-\ddot{N}H-CH_2-CH_2-\ddot{N}H_2$



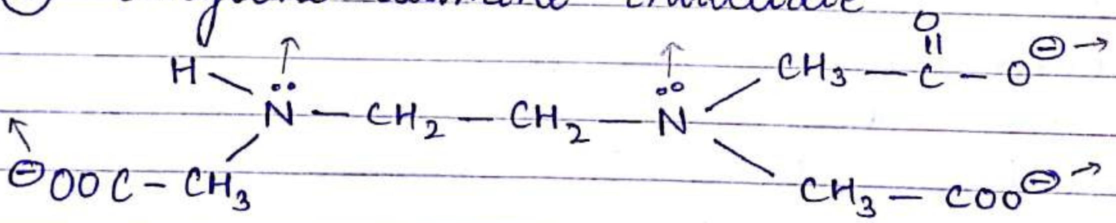
3 donar N- atom
tridentate

ⓑ triethylene tetramine



4 donar N. atoms
tetradentate

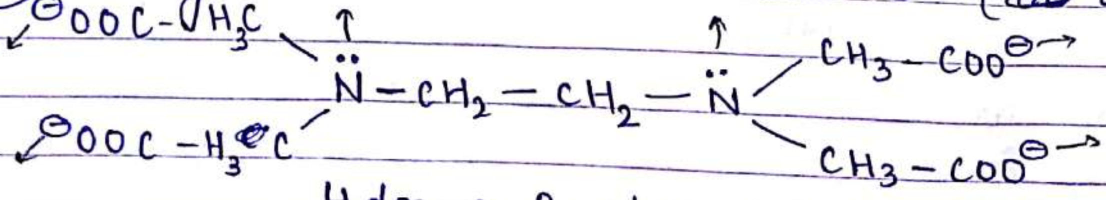
ⓒ ethylene diamine triacetate



3 donor O- atom & 2 donor N-atom

IIT (Unsymmetrical) Pentadentate

ⓓ Ethylene diamine tetracetate (~~ED~~ EDTA)



4 donar O-atom & 2 donor N-atom

(Unsymmetrical) Hexadentate

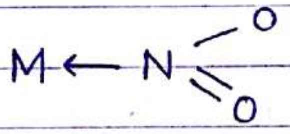
(d) **Ambidentate ligand** :- Those ligand which have 2 donor atom but either of them donate one time.

M ← CN
cyano

M ← NC
isocyano

M ← SCN
thiocyanato

M ← NCS
isothiocyanato



nitro

M ← O – N = O

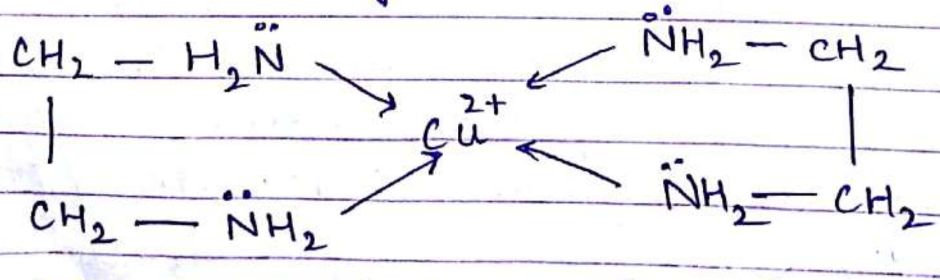
nitrito

Ambidentate ligands are monodentate ligands.

(e) **Chelating Ligand** : When bidentate or polydentate ligand donate simultaneously to central atom. They form ring-like structure c/a chelate ligands.

Chelate → "Ring like structure"

eg Cu^{2+}

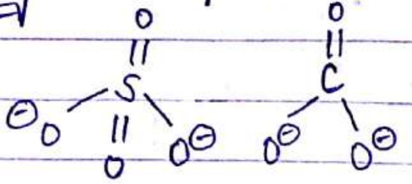


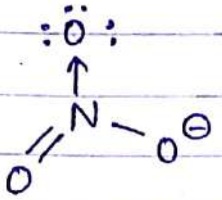
- monodentate can not form ring like structure.
- as no. of donor atoms ↑ in chelating ligand Stability of molecule ↑
- EDTA form more stable str. than ethylene diamine.

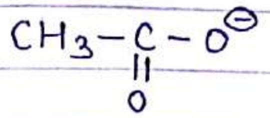
f) **Flexidentate ligand :** which ~~hav~~ can change their denticity.

eg SO_4^{2-} , CO_3^{2-} , NO_3^- , CH_3COO^-

⇒







$[Co(NH_3)_5SO_4]Cl$ SO_4^{2-} → monodentate

26/10/17 $[Co(en)_2SO_4]Cl$ SO_4^{2-} → bidentate

3. Ionisation sphere :- Species outside coordination sphere form ionisation sphere.

4. Coordination sphere : species +nt in square bracket form coordination sphere.

$\boxed{K_4}\underbrace{[Fe(CN)_6]}$

Ionisation sphere ← ; Coordination sphere

$\underbrace{[Co(NH_3)_6]}_{C.S.}\boxed{Cl_3}$ → I.S.

5. Coordination No. :- no. of coordinate covalent bond formed by C.M.A. is c/a C.N.

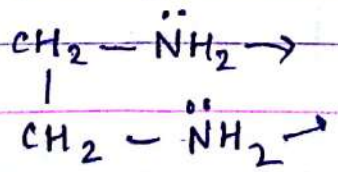
$K_4[Fe(CN)_6]$ C.N. = 6

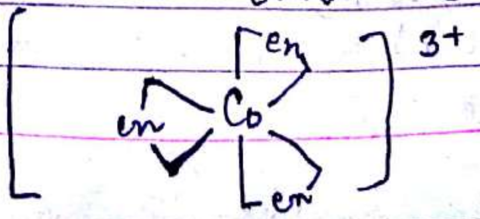
$[Co(NH_3)_4Cl_2]Cl$ C.N. = 6

$[Ag(NH_3)_2]Cl$ C.N. = 2

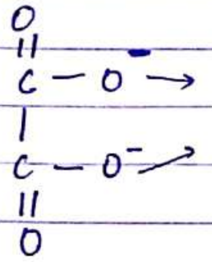
$[Cu(CN)_4]^{2-}$ C.N. = 4

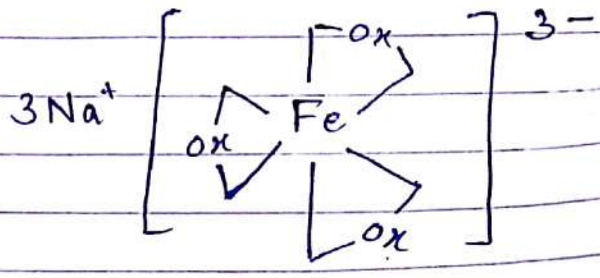
$[Co(en)_3]^{3+}$ C.N. = 3×2 = 6





$Na_3[Fe(C_2O_4)_3]$ C.N. = 3 × 2 = 6





$[Co(NH_3)_5SO_4]Cl$ C.N. = 6

$Na_3[CrOF_4]$ C.N. = 5

$Ni(CO)_4$ C.N. = 4

$Fe(CO)_5$ C.N. = 5

$Cr(CO)_6$ C.N. = 6

$[Cr(EDTA)]^{3+}$ C.N. = 1 × 6 = 6

6. Oxidation Number :-

$K_4[Fe(CN)_6]$

$x + 6(-1) = -4$

$x = -4 + 6 = 2$

$K_3[Fe(CN)_5CO]$

$x + 5(-1) + 0 = -3$

$x = 2$

$[Cr(NH_3)_4Cl_2]Cl$

$x + 4(0) + 2(-1) = +1$

$x =$ [illegible] 3 [illegible]

AIEEE

$K_4[Ni(CN)_4]$

$x + 4(-1) = -4$

$x = 0$

$[Co(NH_3)_6]Cl_3$

$x + 0 = +3$

$x = 3$

$[Co(en)_2F_2]Cl$

$x + 2(-1) = +1$

$x = 1 + 2 = 3$

$Na_3[Fe(C_2O_4)_3]$

$x + 3(-2) = -3$

$x = 3$

$NH_2^{-}NH_3^{\oplus}$ (ium) $NO = \boxed{+1}$ $NO_2^{\oplus}$

$CO = 0$ charge

$[Ag(NH_3)_2]Cl$

$x + 0 = +1$

$x = 1$

II $[Fe(H_2O)_5NO]SO_4 \Rightarrow x + 5(0) + 1 = 2 \Rightarrow x = 1$

~~$x + 0 + 1 = +1$~~

~~$x = 0$~~

$x + 5(0) + 1 - 2 = 0$

$x = +1$

$Na_2[OsF_5N]$

$x + 5(-1) - 3 = -2$

$x = 6$

$[Pt(en)_2Cl_2]Cl_2$

$x + 0 - 2 = +2$

$x = 4$

$Cr(CO)_6$

$x + 0 = 0 \Rightarrow x = 0$

$Ni(CO)_4$

$x + 0 = 0$

$x = 0$

$[Co(NH_3)_5SO_4]Cl$

$x + 0 - 2 = +1$

$x = 3$

$[Co(H_2O)_5SO_4]^+$

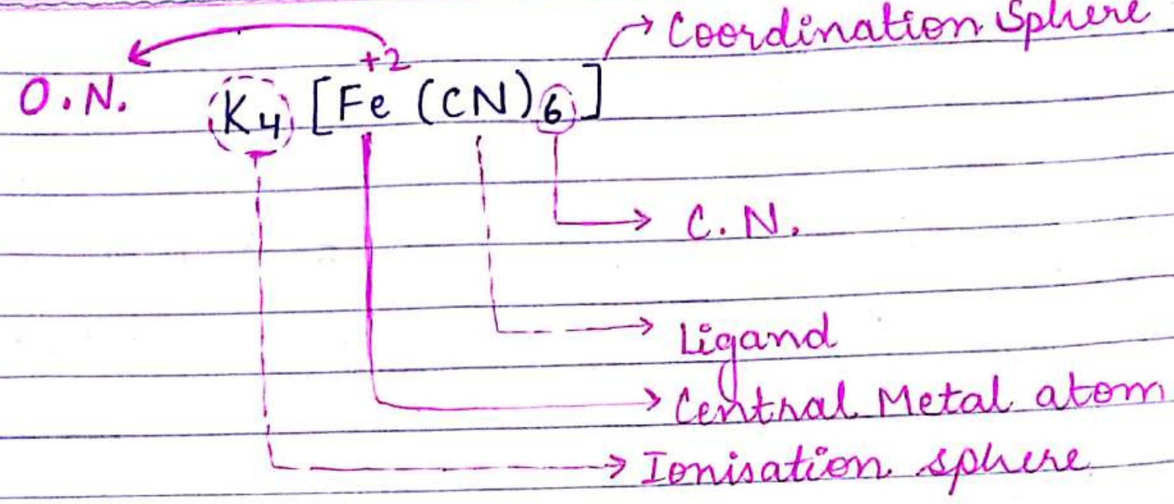
$x + 5(0) - 2 = +1$

$x = 3$

$[Pd(NH_3)_4Cl_2]^{2+}$

$x + 4(0) + 2(-1) = +2$

$x = 4$



Werner's Theory :-

Every C.M.A. has 2 valency in complex fos^{m}.

Primary Valency	Secondary valency
• equal to O.N.	→ equal to C.N.
• due to anions (-ve charge)	• due to ligand (neutral, -ve, +ve)
• ionisable → means changes it O.N.	• non-ionisable → means not changes its C.N.
• non-directional	• directional
• donot play any role in geometry	• decide geometry

Note :- Every C.M.A. tends to satisfy both valencies.

$Cr(CO)_6$
↳ C.N. = 6
O.N. = 0

$[Cr(NH_3)_6]Cl_3$
CN = 6
O.N. = 3

- Secondary valency i.e. C.N is fix.

eg	Cr^{3+}	6	
	Co^{3+}	6	
	Pt^{4+}	6	Pt^{2+} → 4
	Fe^{2+}	6	
	Cu^{2+}	4	
	Ag^{+}	2	

eg $[Pt(NH_3)_6]Cl_4 \rightarrow [Pt(NH_3)_6]^{4+} + 4Cl^{\ominus} \rightarrow 4AgCl$

$4AgNO_3$

Compound	Pri. valency	Sec. valency	No. of Cl^- ions precipitated as AgCl if $AgNO_3$ added	Total no. of ions
1. $[Pt(NH_3)_6]Cl_4$	4	6	4	5 $[Pt(NH_3)_6]^{4+} + 4Cl^-$
2. $[Pt(NH_3)_5Cl]Cl_3$	4	6	3	4 $[Pt(NH_3)_5Cl]^{3+} + 3Cl^-$
3. $[Pt(NH_3)_4Cl_2]Cl_2$	4	6	2	3 $[Pt(NH_3)_4Cl_2]^{2+} + 2Cl^-$
4. $[Pt(NH_3)_3Cl_3]Cl$	4	6	1	2 $[Pt(NH_3)_2Cl_3]^+ + Cl^-$
5. $[Pt(NH_3)_2Cl_4]$	4	6	0	1 $[Pt(NH_3)_2Cl_4]^0$

Question based on table :-

Ques Which of the following has max^m conductivity?
conductivity ∝ no. of ions.
① $[Pt(NH_3)_6]Cl_4$

Ques which of the following will give 3 mol AgCl when mixed with $AgNO_3$.
② $[Pt(NH_3)_5Cl]Cl_3$

Ques which of the following is electrically neutral
⑤ $[Pt(NH_3)_2Cl_4]$

Ques which of the following do not form white ppt. when mixed with $AgNO_3$.
⑤ $[Pt(NH_3)_2Cl_4]$

Ques which of the following will gives white ppt. when mixed with $BaCl_2$

① $[Co(NH_3)_4Cl_2]Cl$
② $[Co(NH_3)_5Cl]SO_4$
③ $[Pt(en)_2Cl_2]Cl_2$
④ $[Pt(NH_3)_5SO_4]Cl_2$

$[Co(NH_3)_5Cl]^{2+} + SO_4^{2-}$
$Ba\,Cl_2$
$\downarrow$
$BaSO_4$

$BaSO_4$ → white ppt.

$Fe(NH_3)_6Cl_3 \rightarrow [Fe(NH_3)_6]Cl_3$
$Fe(NH_3)_5Cl_3 \rightarrow [Fe(NH_3)_5Cl]Cl_2$
$Fe(NH_3)_4Cl_3 \rightarrow [Fe(NH_3)_4Cl_2]Cl$

$Fe(H_2O)_5Cl_3$
$\rightarrow [Fe(H_2O)_5Cl]Cl_2$
$\rightarrow [Fe(H_2O)_4Cl_2]Cl \cdot H_2O$
$\rightarrow [Fe(H_2O)_3Cl_3] \cdot 2H_2O$ X

Effective Atomic Number or Sidgwick Rule :-

A metal atom or ion continue to accept $e^{\ominus}$ till ~~no~~ total no. of $e^{\ominus}$ on metal atom or ion and those accepted from ligand reach to a noble gas configuration.

E.A.N. = Atomic No. − Ox. No. + total $e^{\ominus}$ accepted from ligand
or (2 × C.N.)

$[Co(NH_3)_6]Cl_3$ E.A.N. $= 27 - 3 + 2\times6 = 36$ ← Kr
$K_4[Fe(CN)_6]$ E.A.N. $= 26 - 2 + 2\times6 = 36$
$[Cu(CN)_4]^{3-}$ E.A.N. $= 29 - 1 + 2\times4 = 36$
$[Pd(NH_3)_4Cl_2]Cl_2$ E.A.N. $= 46 - 4 + 2\times6 = 54$ Xe

$[PtCl_4]^{2-}$ E.A.N. = 78 − 2 + 4×2 = 84 ✗

$[PtC_6]^{2-}$ E.A.N. = 78 − 4 + 6×2 = 86 ✓

$K_3[Fe(CN)_6]$ E.A.N. = 26 − 3 + 6×2 = 35 ✗

$Ni(CO)_4$ E.A.N. = 28 − 0 + 4×2 = 36

$Fe(CO)_5$ E.A.N. = 26 − 0 + 5×2 = 36

$Cr(CO)_6$ E.A.N. = 24 − 0 + 6×2 = 36

Applications :-

① To calculate no. of carbon monoxide attached to metal atom in carbonyls.

$Ni(CO)_x$ x = 4 $Fe(CO)_y$ y = 5 $Cr(CO)_z$ z = 6

② $[Mn(CO)_6]^0$ behave as reducing agent

$$\underset{37}{Mn(CO)_6} \longrightarrow \underset{36}{[Mn(CO)_6]^+} + e^{\ominus}$$

③ $[V(CO)_6]$ behave as oxidising agent

$$\underset{23-0+12\,=\,35}{[V(CO)_6]} + e^{\ominus} \longrightarrow [V(CO)_6]^-$$

IUPAC Nomencaluture of C.C :-

Rules :-

① If cation is +nt in C.C then it is written is always 1st.

$K_4[Fe(CN)_6]$ Potassium - - -

② Naming of Coordination Sphere :-

First of all name of ligands is written in alphabetical order then name of C.M.A. is written following its O.N. in Roman number.

If multiple ligand are +nt :-

- Then write them in alphabatical order.
- Use di, tri, tetra - - - for monodentate ligands

if +nt in multiple no.

- For multiple no. of chelate ligand use bis, tris, tetrakis ---

di, tri, tetra are not used in alphabatical order
bis, tris --- ~~at~~ → used ~~at~~ in alphabatical order

Naming of -ve ligand suffix 'o'	neutral name as it	cation suffix 'ium'
Cl^- → chlorido	NH_3 → amine	NO^+ nitrozonium
O^{2-} → oxo	H_2O → aqua	NO_2^+ nitronium
N^{3-} → Nitrido	CO → carbonyl	$NH_2-NH_3^{\oplus}$ hydrazinium
SO_4^{2-} → sulphato		

$[Co(NH_3)_4Cl_2]^{\oplus}$ tetraamine dichlorido cobalt (III) ions

$[Co(en)_2Cl_2]^+$ bis (ethane-1,2-diamine) dichloro cobalt (III) ion

③ If coordination sphere is +nt as anionic part then suffix '~~at~~ ate' is used after name of metal

$K_4[Fe(CN)_6]^{4-}$ Potassium hexacyano ferrate (II)

④ If anion is +nt outside coordination sphere then name of anion is written at last.
$[Co(NH_3)_6]Cl_3$ hexaammine Cobalt (III) Chloride

1. $[\overset{+4}{Pt}(NH_3)_4Cl_2]^{2+}Cl_2$
tetra ammine dichlorido Platinium (IV) Chloride

2. $[Cr(H_2O)_4Cl_2]^{+}Cl$
Tetra aqua dichlorido cromium (III) Chloride

AIEEE 3. $K_4[Ni(CN)_4]^{4-}$
Potassium tetracyano nickelate (0)

4. $K_3[Fe(CN)_5CO]^{3-}$
Potassium carbonyl pentacyano Ferrate (II)
thio cyano

5. $(NH_4)^{+}_2[Pt(SCN)_6]$
hexathiocyanato Platinumate (IV)

6. $Na_2[CrOF_4]^{2-}$
sodium tetrafluorido oxo cromiate (IV)

7. $[Al(H_2O)_5OH]^{2+}$
Penta aqua hydroxo aluminaium (III)

8. $[Co(en)_2Cl_2]^{2+}SO_4$ Dichlorido di (ethane 1,2-diamine) cobalt (IV) Sulphato

iso thio cyano

9. $[Co(NH_3)_5NCS]^{2+}Cl_2$ Penta amine iso thio cyanato cobalt (III) Chloride

Lithium ~~tetra hydrido aluminate (III)~~

10. $(Li^{+}AlH_4)^{-}$

11. $[\{(C_6H_5)_3\ddot{P}\}_3Rh]Cl$ tris (tri phenyl phosphine) Rhodium I Chloride

12. $K_2[PdCl_4]^{2-}$ Potassium tetra chlorido pallidiumate (II)

13. $[Pt(NH_3)_2Cl(NH_2NH_3)]Cl$
Diamine chlorido hydrazinium Platium (I) Chloride

14. $K_3[Cr(C_2O_4)_3]$
Potassium tris-oxalato Chromiate (III)

15. $[Pt(NH_3)_2Cl(NO_2)]$ $x + 0 - 1 + 1 = 0$
$x = 0$
diamine chlorido nitronium Platinum.

16. $Cr(CO)_6$
hexa carbonyl cromium

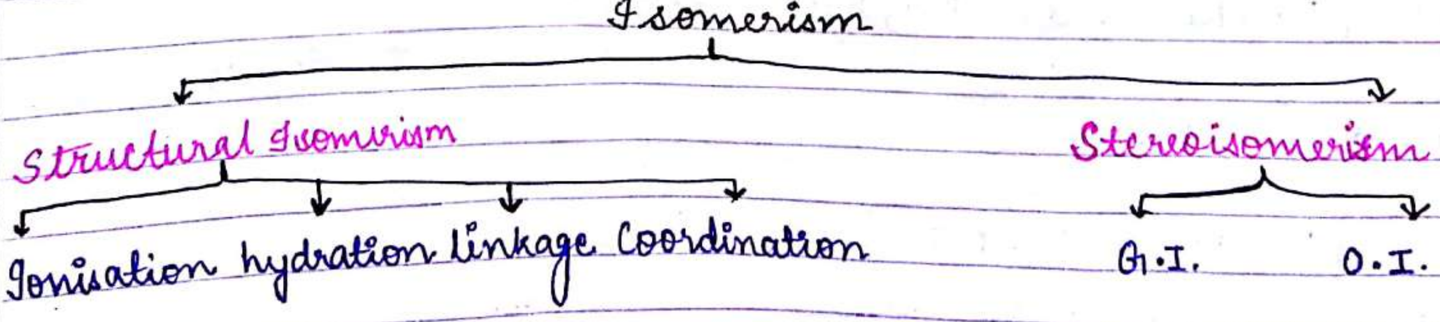
17. $[Cr(NH_3)_6]^{3+}$ $[Co(CN)_6]^{3-}$
hexa amine Chromium (III) hexacyano cobaltate (III)

Ques: Write formula of following :-

1. tetra carbonyl Nickel (0)
$Ni(CO)_4$
2. tetra amine aqua chlorido cobalt (III) chloride
$[Co(NH_3)_4(H_2O)Cl]Cl_2$
3. bis (ethane-1,2-diamine) dibromido chromium (II)
$(Cr(en)_2Br_2)$
5. Ammine bromido chlorido nitro-N-Platinate (II)
Pt
4. 5. Iron (III) hexacyano ferrate (II)
Fe^{3+} $[Fe(CN)_6]^{4-}$ $Fe_4[Fe(CN)_6]_3$
6. Potassium tetracyano nickelate (II)
$K_2[Ni(CN)_4]$
7. Potassium tris oxalato aluminate (III)
$K_3[Al(C_2O_4)_3]$

IQ NEET/AIIMS

Isomerism :- Compds which have same molecular formula but different structural formula are ~~c/a~~ k/n as isomers & phenomena is k/n as isomerism.



1. **Ionisation isomerism :** In these type of isomerism, interchange of ligands takes place b/w coordination & ionisation ~~isomerism~~ sphere

eg $[Co(NH_3)_5Br]SO_4$ or $[Co(NH_3)_5SO_4]Br$

Pentamine amine bromido Cobalt (III) Sulphate — Pentamine sulphato Cobalt (III) bromide.

$[Pt(NH_3)_4Cl_2]Br_2$ — $[Pt(NH_3)_4Br_2]Cl_2$

$[Co(NH_3)_5 . NO_2]SO_4$ — $[Co(NH_3)_4 SO_4]NO_2$

$[Pt(NH_3)_4SO_4]Cl_2$ — $[Pt(NH_3)_4Cl_2]SO_4$

Hydration isomerism : water molecule are +nt in coordination as well as ionisation sphere

$Cr(H_2O)_6 . Cl_3$	Solvation
$[Cr(H_2O)_6]Cl_3$	$[Cr(NH_3)_6]Cl_3$
$[Cr(H_2O)_5Cl]Cl_2 . H_2O$	$[Cr(NH_3)_5Cl]Cl_2 . NH_3$
$[Cr(H_2O)_4Cl_2]Cl . 2H_2O$	$[Cr(NH_3)_4Cl_2]Cl . 2NH_3$
$[Cr(H_2O)_3Cl_3] . 3H_2O$ X	$[Cr(NH_3)_3Cl_3] . 3NH_3$ X

Hydration isomerism is a special case of ionisation isomerism

Linkage Isomerism :- Shown by those coordination compd which have ambidentate ligand.

- This type of Isomerism takes place due to change of donor atom due to ambidentate ligand.

eg $[Cr(NH_3)_5NO_2]Cl_2$. & $[Cr(NH_3)_5(ONO)]Cl_2$

Penta ammine nitro chromium (III) Chloride — Penta ammine nitrito chromium (III)

Pentaammine nitro-N-chromium (III) Chloride — Pentaamine nitro-O-chromium (III) chloride

$[Co(NH_3)_5(NCS)]Br_2$ — $[Co(NH_3)_5(SCN)]Br_2$

Coordination isomerism :- This type of isomerism takes place in those compd in which cation & anion both are +nt as complex.

- ~~This~~ It takes place due to interchange of ligand b/w 2 complex.

eg : $[Cr(NH_3)_6]^{3+}[Co(CN)_6]^{3-}$ & $[Co(NH_3)_6][Cr(CN)_6]$

hexa amine chromium (III)
hexacyano cobaltate (III)

$[PtCl_4]^{2+}[CuCl_4]^{2-}$ $[CuCl_4]^{2+}[PtCl_4]^{2-}$

tetra chlorido Platinum (VI) tetra chlorido copper
tetra chlorido cuprate (VI)

· $[PtCl_4][Cu(CN)_4]$ $[CuCl_4][Pt(CN)_4]$

Stereo isomerism :- which have same M.F. or chemical formula but special arrangement.

Geometrical isomerism — Cis
Trans

Cis :- If same ligand occupy similiar posⁿ w.r.t. each other c/a cis isomer.

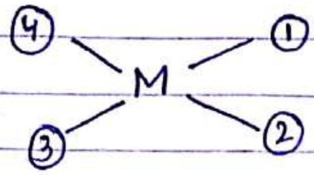
trans: If same ligand occupy opposite posⁿ w.r.t each other, c/a trans isomer.

$\boxed{C.N. = 4}$

tetrahedral sp^3
G.I. X
$[CuCl_4]^{2-}$, $Ni(CO)_4$

Square Planar
$[Pt(NH_3)_2Cl_2]$

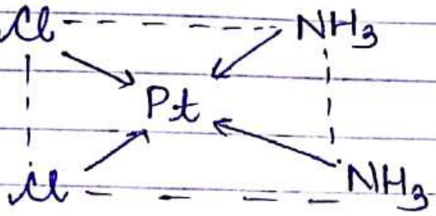
Type-I Ma_2b_2

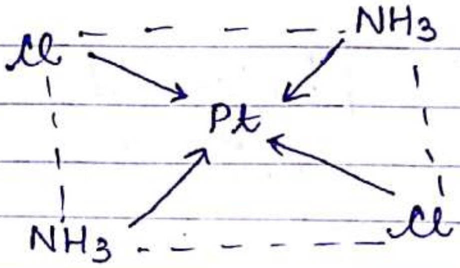


M → C.M.A.
a → Monodentate
b → Monodentate

cis 1-2, 2-3, 3-4, 4-1
trans 1-3, 2-4

$[Pt(NH_3)_2Cl_2]$



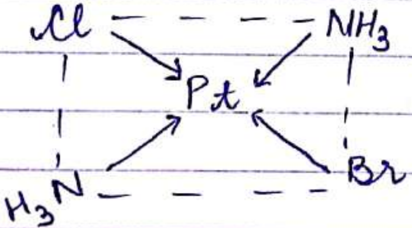


cis platin
anti cancerous used in chemotherapy

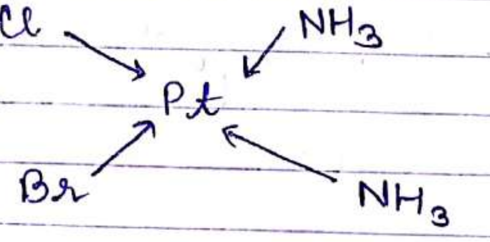
trans-platin

Type-II Ma_2bc

M → CMA
a, b, c → monodentate ligand

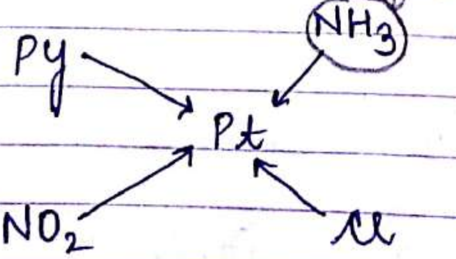


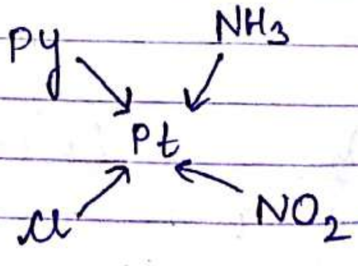
trans

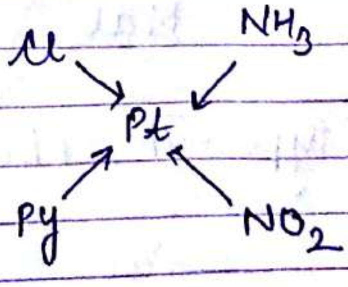


cis

Type-III Mabcd fix G.I. = 3







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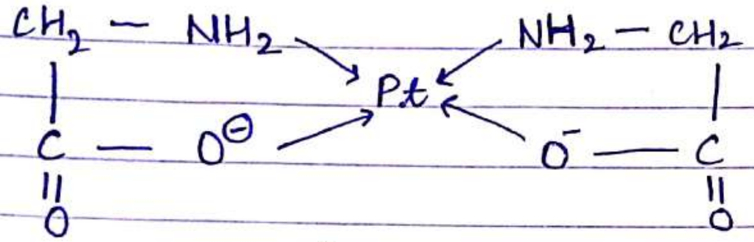
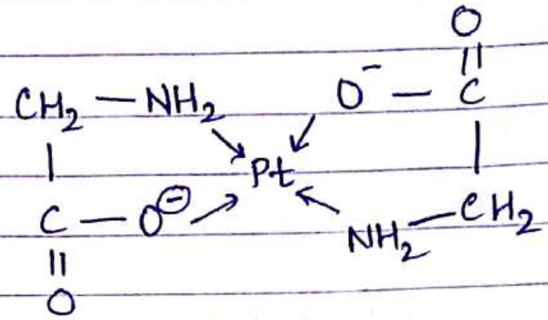
Type-IV $[M(ab)_2]$
↳ unsymm. bidentate

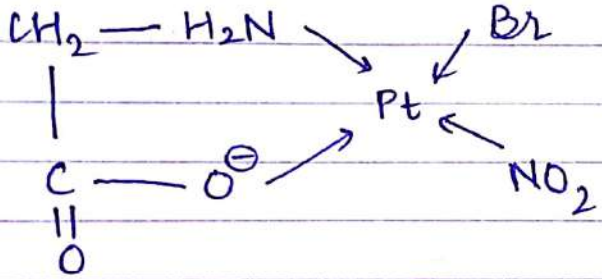
$Pt(gly)_2$ G.I. = 2

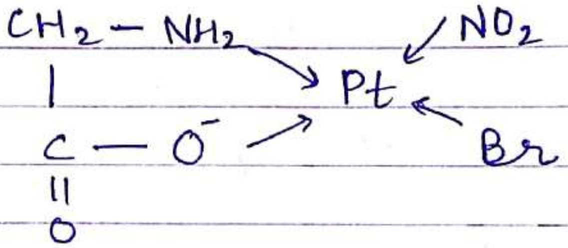

cis


trans

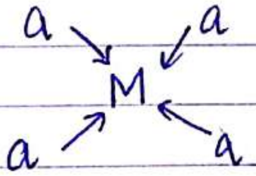
Type V $[M(ab)cd]$
↓ unsy. bi ↓ mono

G.I. = 2



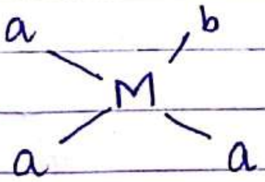


Type VI Ma_4



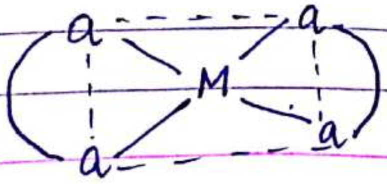
G.I. = 0

Type VII Ma_3b
or
Mab_3



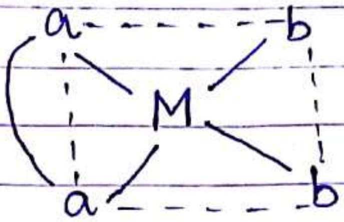
G.I = 0

Type VIII $M(aa)_2$ $Pt(en)_2$



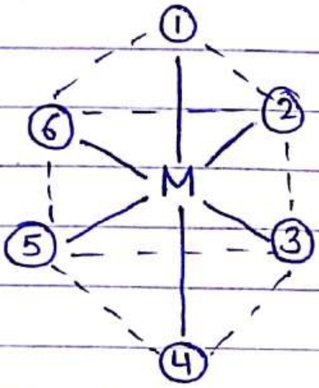
G.I. = 0

Type $M(aa)b_2$



G.I. = 0

$\boxed{C.N. = 6}$ d^2sp^3 / sp^3d^2 Octahedral



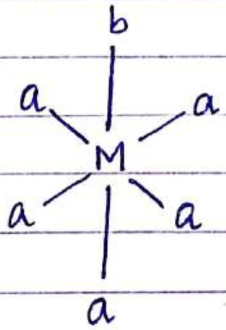
cis → (1,2) (1,3) (1,5) (1,6) (4,3)
(4,2) (4,6) (4,5)
(2,6) (2,3)
(5,6) (5,3)

trans → (1,4) (2,5) (3,6)

① Ma_6

G.I. = 0

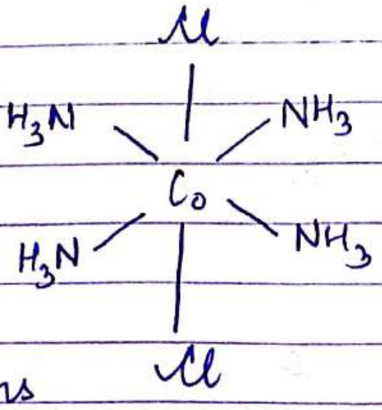
② Ma_5b



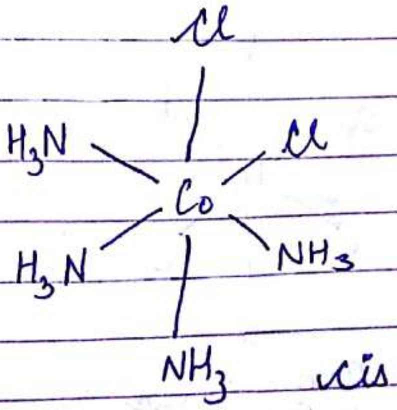
G.I. = 0

③ Ma_4b_2

G.I. = 2

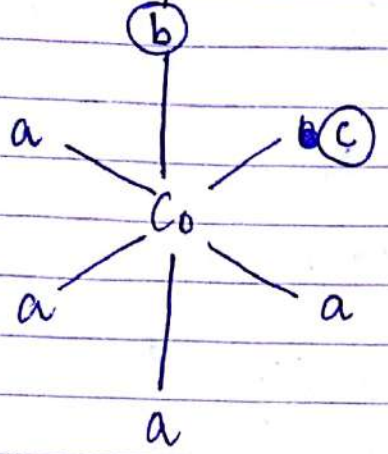


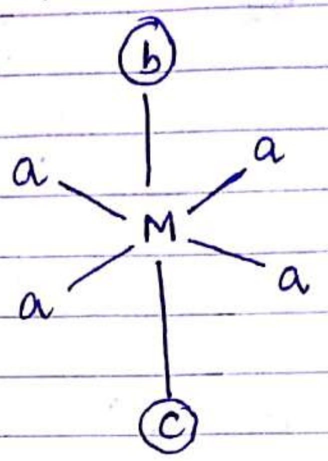
trans



cis

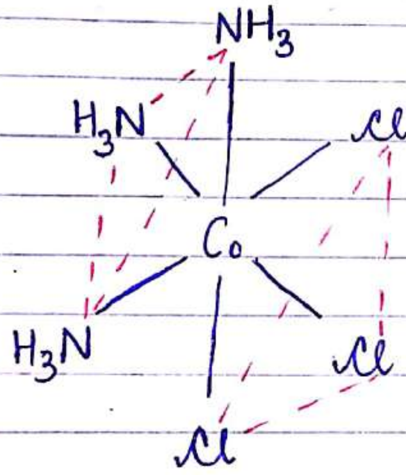
④ Ma_4bc G.I. = 2



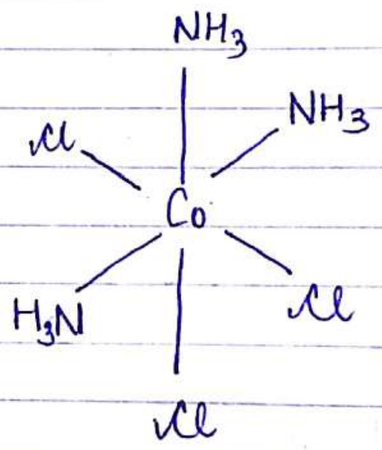


trans

⑤ Ma_3b_3 G.I. = 2

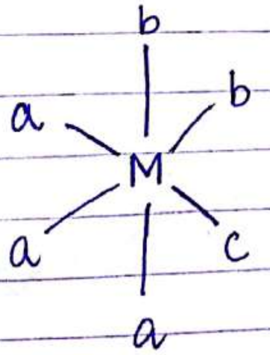


Facial or fac isomer



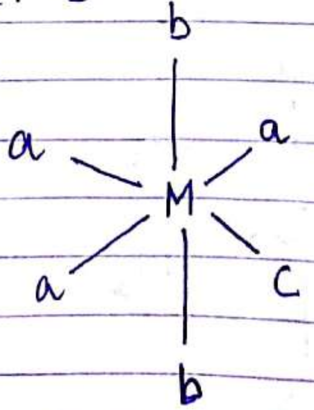
Meridonal or mer isomer

⑥ Ma_3b_2c G.I. = 3



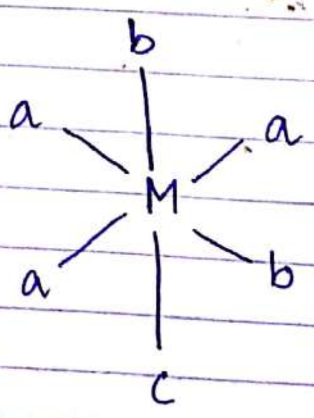
a–b] trans
a–c

b–b
a–b] cis
a–c



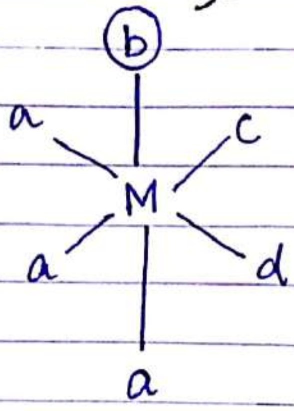
a–a
a–c] trans
b–b

a–a, ac, bc, ab → cis

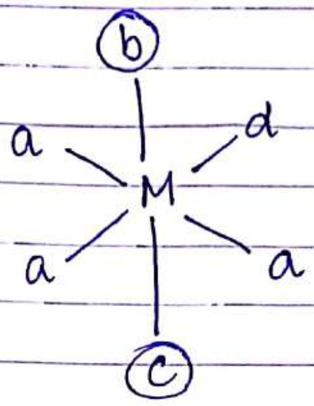


ab, aa, bc → trans
aa, ab, ca, cb, ba, bb → cis

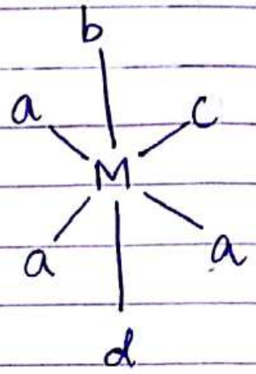
⑦ Ma_3bcd G.I. = 4



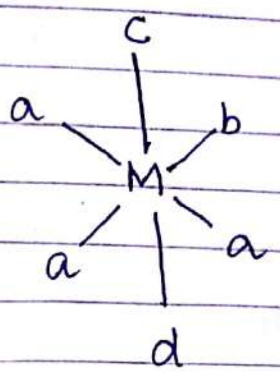
a & b trans



b & c trans

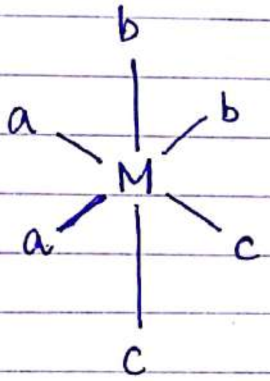


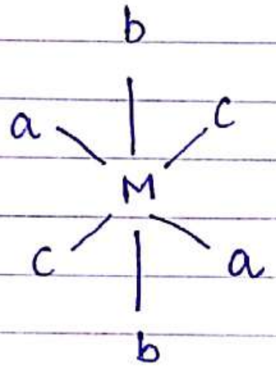
b&d trans

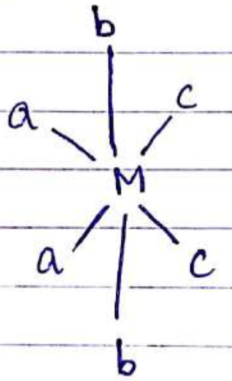


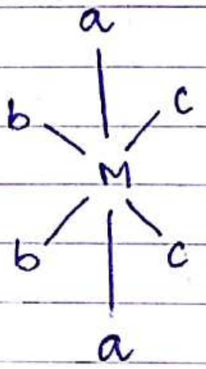
c&d trans

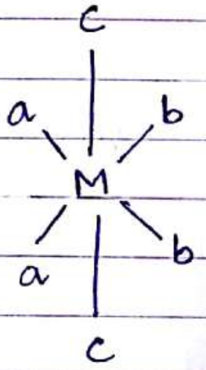
⑧ $Ma_2b_2c_2$ G.I. = 5





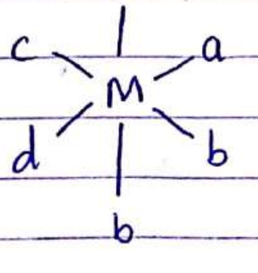


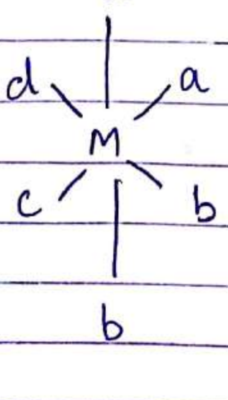


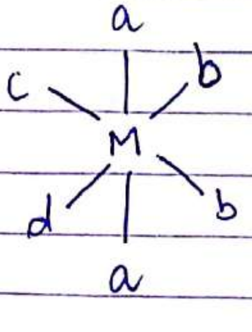


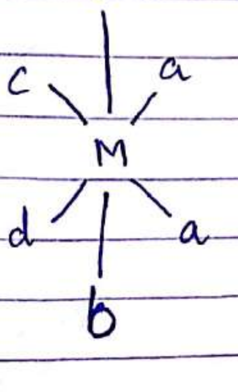
a → b/c/d → 3
a, b → c, d → 2
a, b, c → d → 1
6

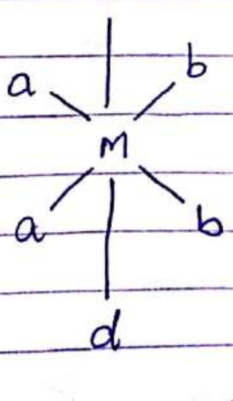
⑨ Ma_2b_2cd

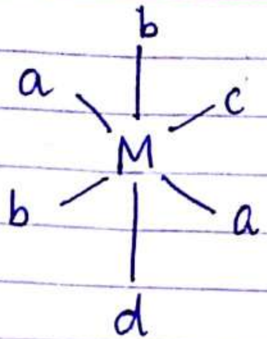












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⑩ Ma_2bcde

a-a cis

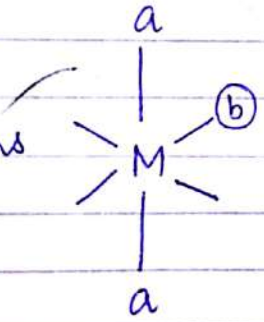
fix

ⓑ - c, d, e → 3

(b, c) - d, e → 2

(b, c, d) → e → 1

⑥

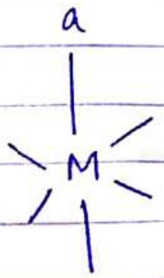


a-a trans

ⓑ → c, d, e → 3

total = 6 + 3 = 9

⑪ Mabcdef



ⓐ → bcdef → 5

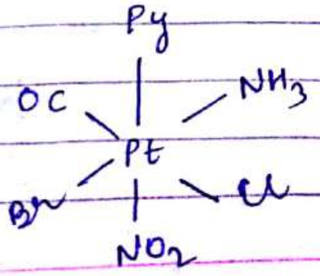
a,b → cdef → 4

a,b,c → d,e,f → 3

a,b,c,d → e,f → 2

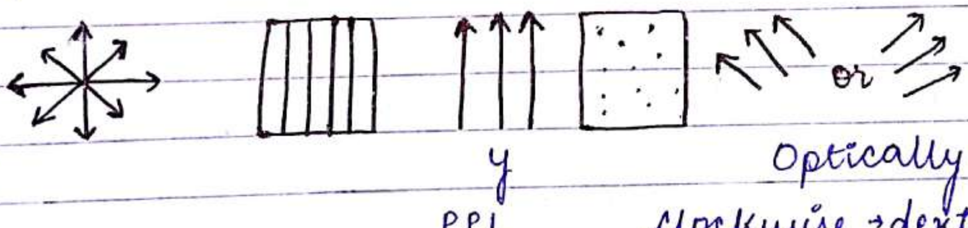
abcde → f → 1

15

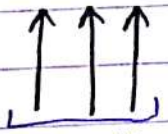


	G.I.	O.I.
$Mabcdef$	15	Imp 30
Ma_2bcde	9	12
Ma_2b_2cd	6	
$Ma_2b_2c_2$	5	
Ma_3bcd	4	
Ma_3b_2c	3	
Ma_3b_3	2	
Ma_4bc	2	
Imp Ma_4b_2	2	
Ma_5b	0	
Ma_6	0	

Imp Optical Isomerism :- which form non-super imposable mirror images of each other c/a optical isomers and phenomena c/a optical isomerism



Optically Active
clockwise → dextro rotatory → d (+)
anticlockwise → laevorotatory → l (-)

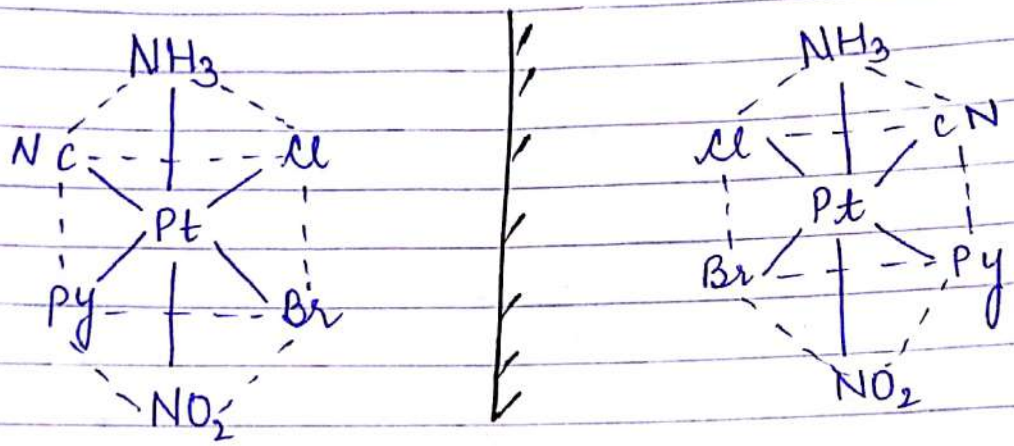


Optically inactive

Note: Unsymmetrical compds shows optical isomerism i.e. posn, centre and axis of symmetry is absent in optically Active compds.

Note : cis give O. Active

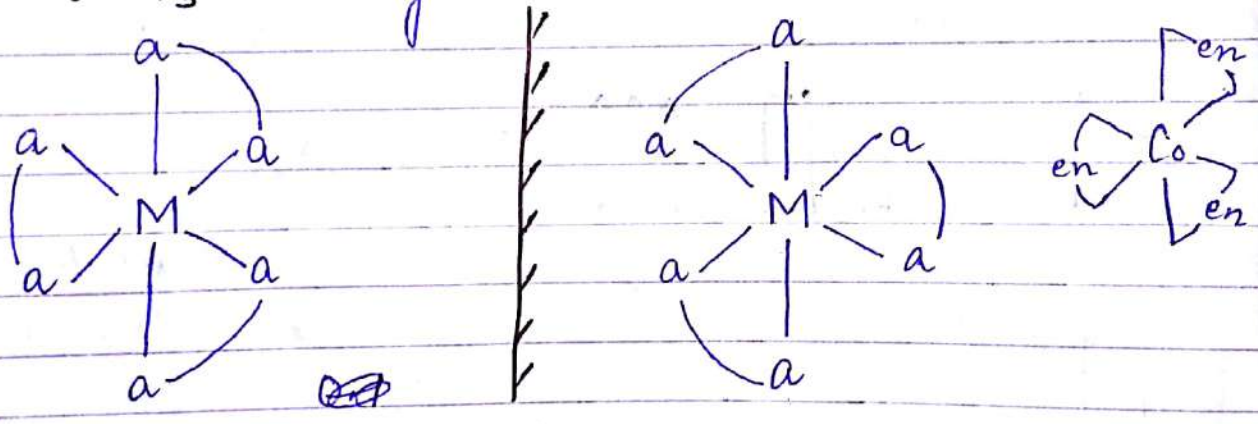
Mabcdef



G. I. = 15

O. I. = 30

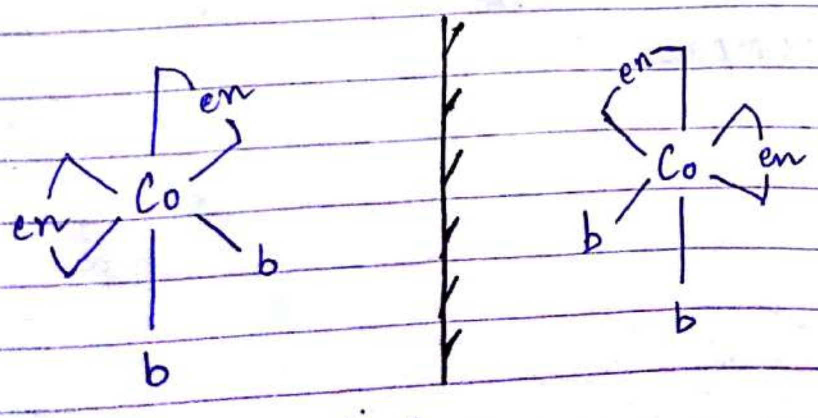
M(aa)$_3$ eg $[Co(en)_3]^{3+}$



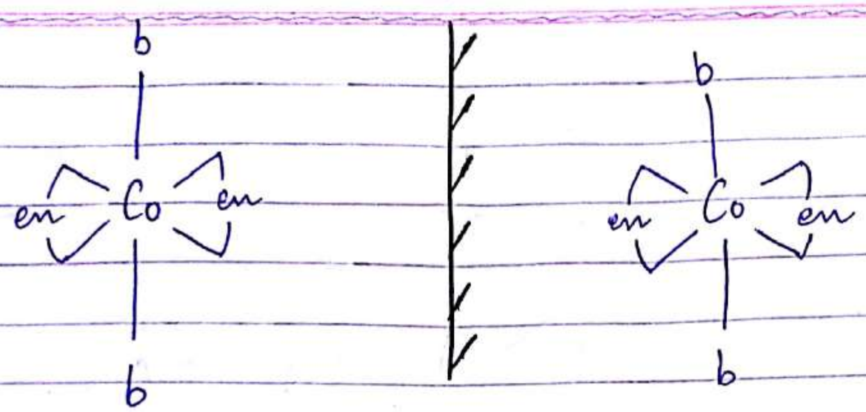
O. A.

v. Imp

M(aa)$_2$b$_2$

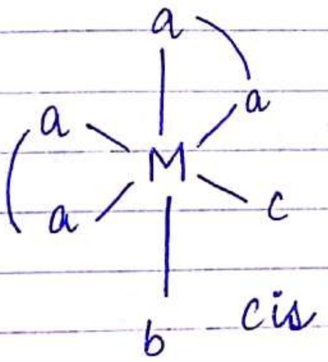


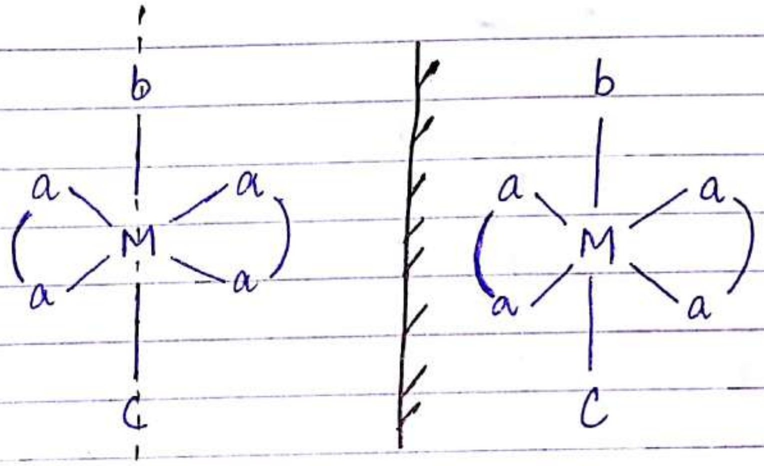
cis O. A.



trans O.A. X

M $(aa)_2bc$

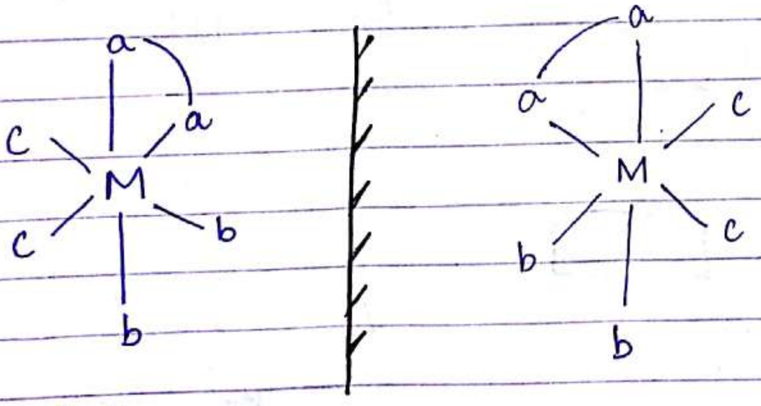




O.A.

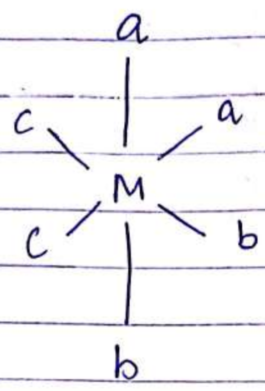
Optically Inactive

M $(aa)b_2c_2$

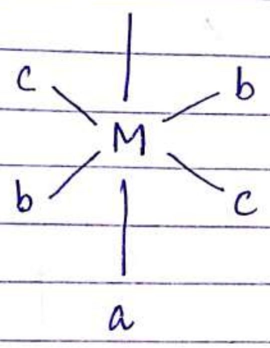


O.A.

$Ma_2b_2c_2$

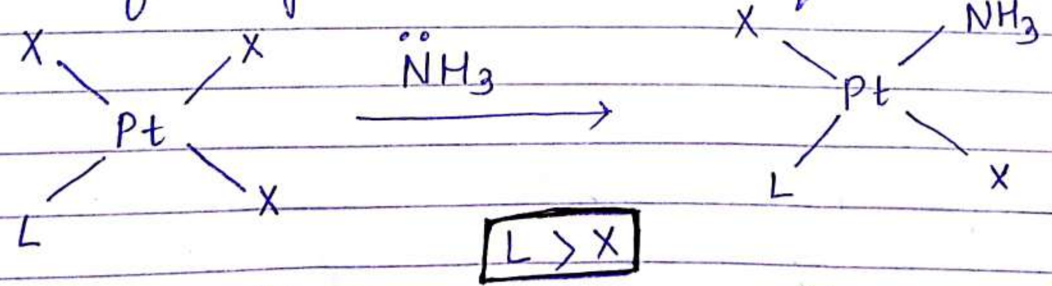


cis O.A.

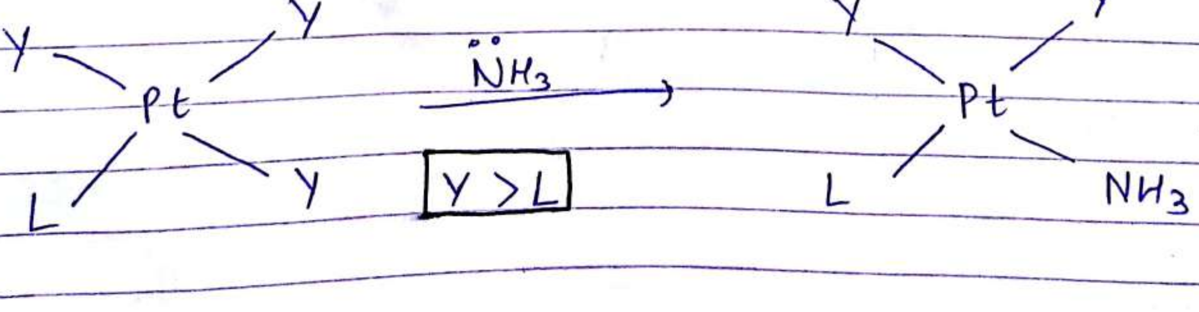


trans O. inactive

Trans - Effect : It is kinetic phenomena which means that ~~fo~~ it promotes faster substitution rate for ligands trans to itself than cis to itself.



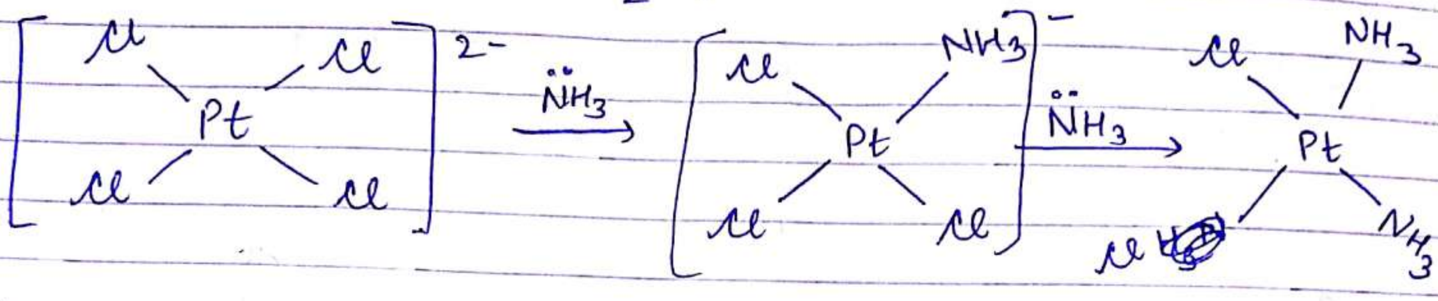
$\boxed{L > X}$

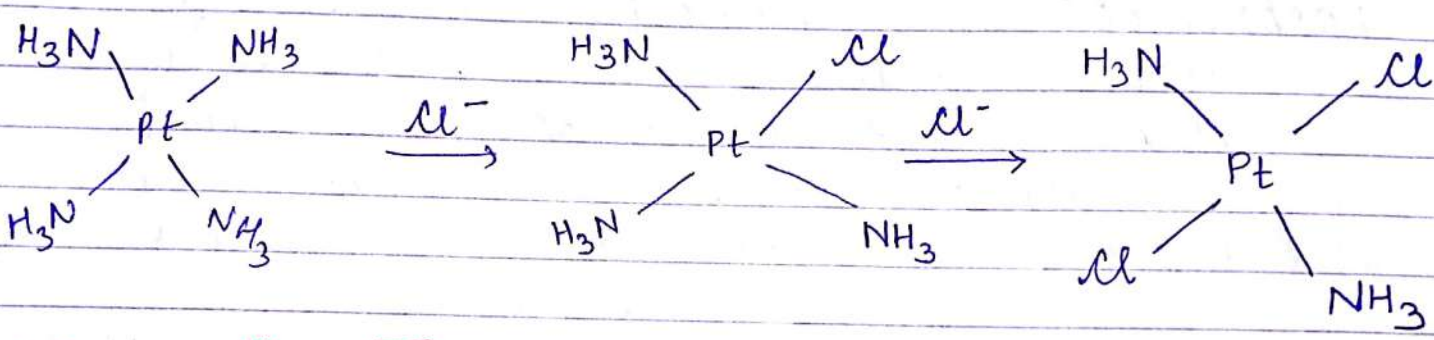


$\boxed{Y > L}$

Strength of trans director

$H_2O < OH^- < NH_3 < Py < Cl^- < Br^- < SCN^- < I^- < NO_2^- < Ph^-$
$< CH_3^- < H^- < PR_3 < C_2H_4 < CN^- < CO$



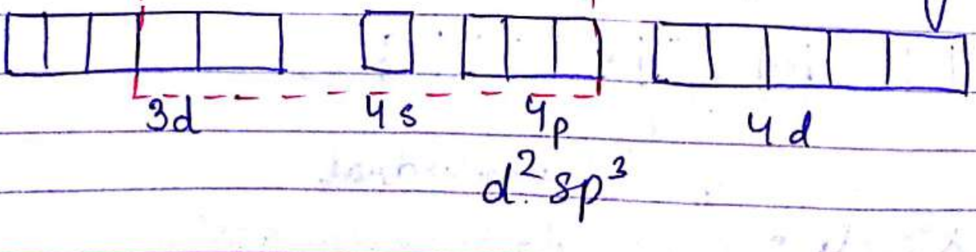


Valence Bond THEORY :- given by Pauling.

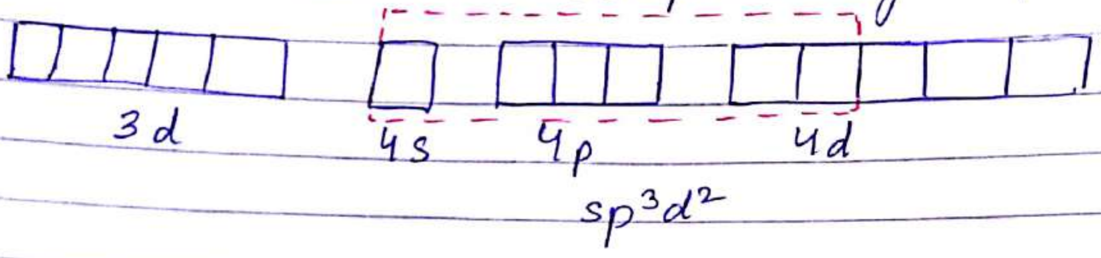
Postulate 1 : C.M.A or ion must have vacant orbitals to accept lp donated by ligands.

Postulate 2 : Vaccant orbitals of same ~~en~~ or nearly same energy undergoes ~~hyd~~ hybridisation & forms new set of —

Postulate 3: If inner Δ (n-1)d take part in hybridisation complex formed is k/n as. Inner orbital complex eg d^2sp^3



Postulate-4 : If outer 'nd' orbitals take part in hybridisation then complex formed is k/n as outer orbital complex eg: sp^3d^2



Postulate5:- Outer ~~com~~ orbital complex is formed in +nce of weak ligand while inner orbitals complex is formed in +nce of strong ligand. Ligands are arranged in a series acc^r to their strength known as spectrochemical series

$I^- < Br^- < S^{-2} < SCN^- < Cl^- < F^- < OH^- < C_2O_4^{2-} < H_2O$

← weak →

$< py < NH_3 < NO_2^- < en < CN^- < CO$

← STRONG →

Halogen atom < O-donor < N-donor < C-donor

Postulate-6

Generally complex are diamagnetic in +nce of strong ligand ∵ SL cause pairing $e^\ominus$.

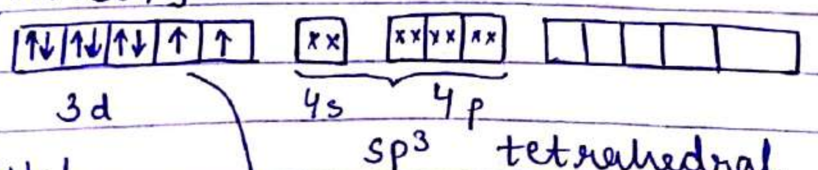
→ Inner orbital complex / low spin complex

and in +nce of weak ligand complex are paramagnetic ∵ WL donot cause pairing of $e^\ominus$.

→ Outer orbital Complex / high spin complex.

eg ① $[NiCl_4]^{2-}$

Ni^{2+}



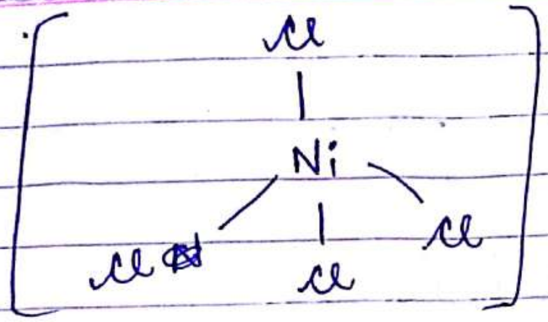
sp^3 tetrahedral

$Cl^- \rightarrow W.L$

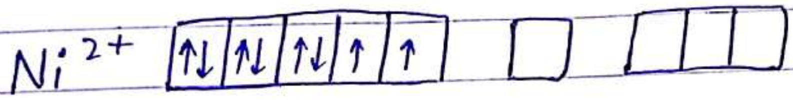
pairing X

→ 2 unpaired, Paramagnetic

②

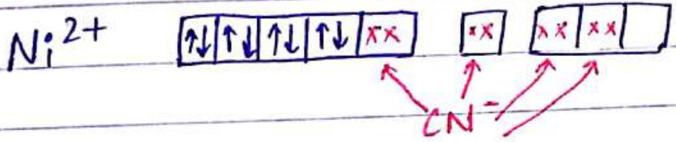


② $[Ni(CN)_4]^{2-}$



3d

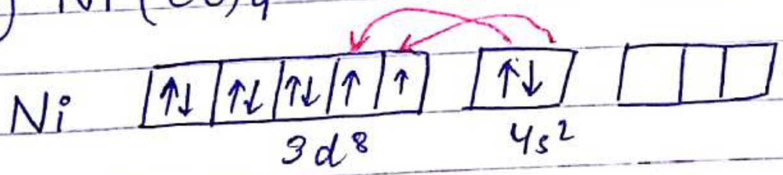
CN^- S.L. Pairing ✓



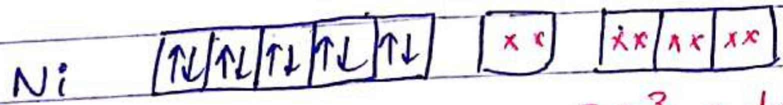
dsp^2, Square Planar

diamagnetic

③ $Ni(CO)_4$

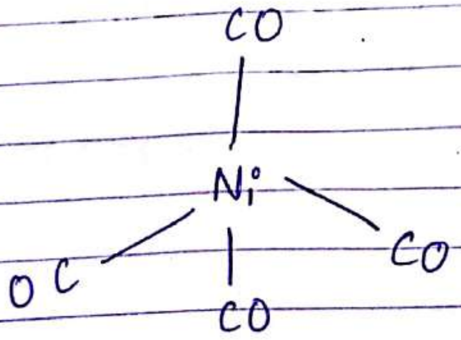


CO → SL, pairing ✓

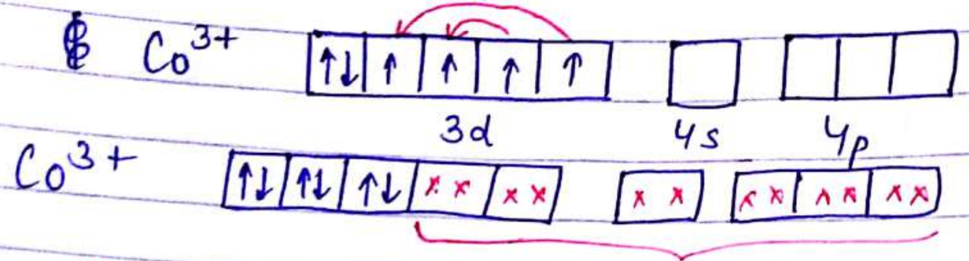


sp^3, tetrahedral

dia



④ $[\overset{+3}{Co}(NH_3)_6]^{3+}$



NH_3 → S.L.

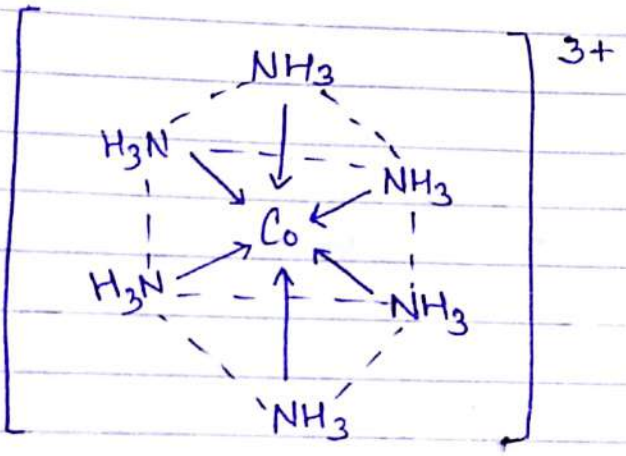
Pairing

d^2sp^3, Octahedral

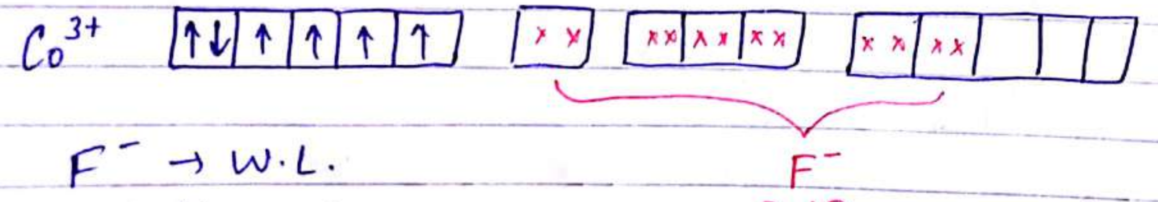
dia. IOC / LSC

IOC ↓ Inner orbital Complex

LSC → Low spin ~~comp~~ complex



⑤ $[CoF_6]^{3-}$



F^- → W.L.

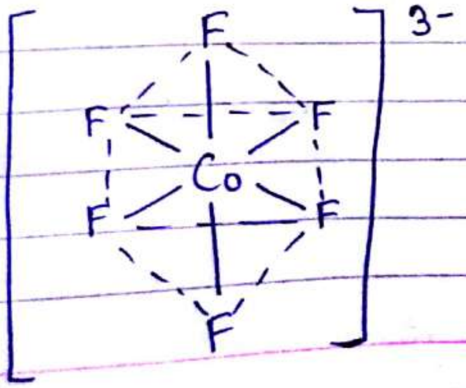
pairing ✗

sp^3d^2, Octahedral

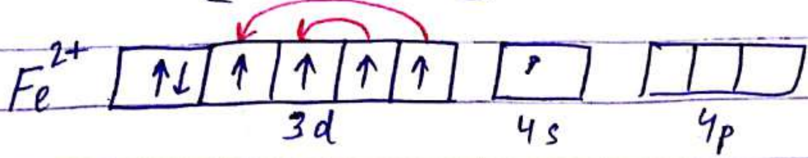
$n = 4$, Paramagnetic

Outer orbital Complex ← OOC / HSC

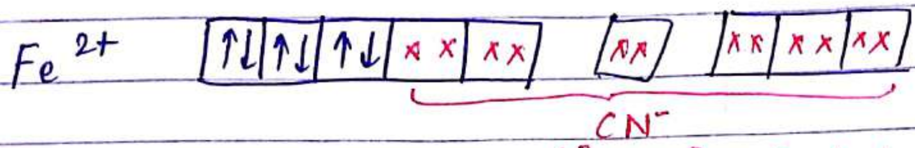
HSC ↳ High spin complex



6. $[Fe(CN)_6]^{4-}$



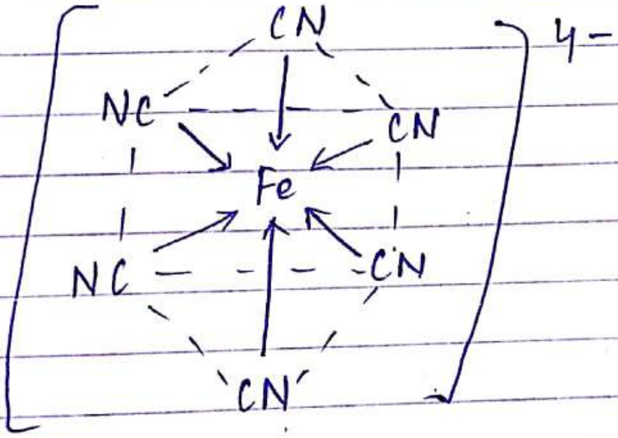
$CN^- \rightarrow$ S.L.



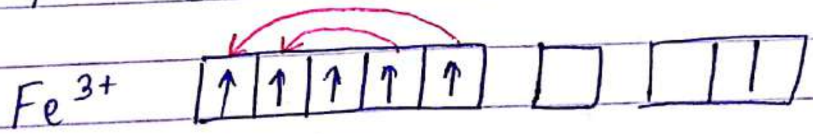
d^2sp^3, Octahedral

$n = 0$ dia

IOC / L.S.C.



7. $[Fe(CN)_6]^{3-}$



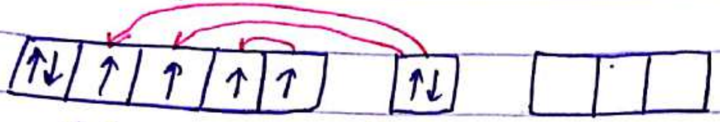
$CN^- \rightarrow$ S.L. $\rightarrow$ pairing ✓

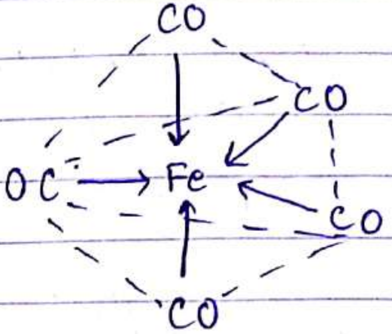
d^2sp^3, Octahedral

$\boxed{n = 1}$ Paramagnetic

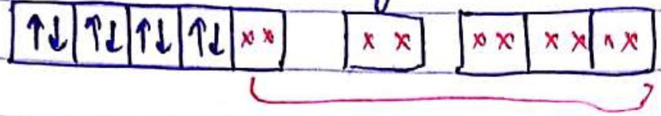
IOC / L.S.C.

8. $Fe(CO)_5$

Fe 



$CO \rightarrow S.L. \rightarrow$ Pairing

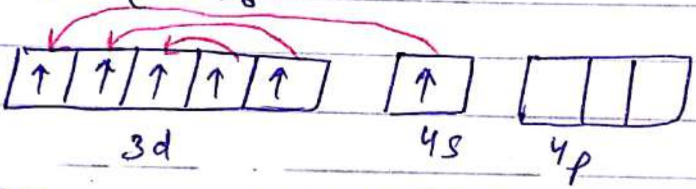
$Fe(CO)_5$ 

dsp^3, Trigonal Bipyramidal

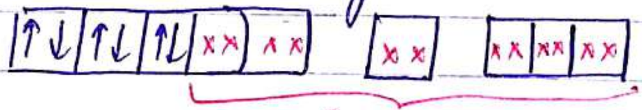
$n = 0$ dia

IOC / LSC

9. $Cr(CO)_6$

Cr 

$CO \rightarrow S.L \rightarrow$ pairing

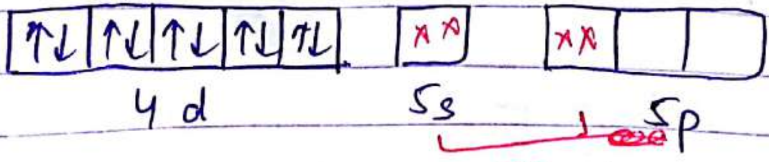
$Cr(CO)_6$ 

d^2sp^3, Octahedral

$n=0$, dia

IOC / L.S.C.

10. $[Ag(NH_3)_2]^+$

Ag^+ 

sp, linear

$[NH_3 \rightarrow Ag \leftarrow NH_3]^+$ $n=0$, dia

$[Cu(H_2O)_4]^{2+} \rightarrow$ S.L

$[Ni(H_2O)_6]^{3+} \rightarrow$ W.L

Note :- 1. NH_3 & ~~e~~ H_2O works as strong ligand in case of Cu^{2+} & Co^{3+}.

AIEEE ① $[Ni(NH_3)_6]^{2+}$

Ni^{2+} $\underset{3d}{\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}}$ $\underset{4s}{\boxed{}}$ $\underset{4p}{\boxed{}\boxed{}\boxed{}}$

$\boxed{NH_3 \rightarrow \text{S.L., pairing}}$ × → ~~Co~~ Cu^{2+} & Co^{3+}

$NH_3 \rightarrow$ W.L., Pairing ×

Ni^{2+} $\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}$ $\underbrace{\boxed{\times\times}\ \boxed{\times\times}\boxed{\times\times}\boxed{\times\times}\ \boxed{\times\times}\boxed{\times\times}}_{sp^3d^2,\ \text{Octahedral}}\boxed{}\boxed{}\boxed{}$

** $n = 2$, Paramagnetic

OOC / HSC

② $[Fe(NH_3)_6]^{2+}$

Fe^{2+} $\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}$ $\boxed{}$ $\boxed{}\boxed{}\boxed{}$ $\boxed{}\boxed{}\boxed{}\boxed{}\boxed{}$

($NH_3 \rightarrow$ SL, pairing) × Cu^{2+} & Co^{3+}

$NH_3 \rightarrow$ WL, Pairing ×

Fe $\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}$ $\boxed{\times\times}$ $\boxed{\times\times}\boxed{\times\times}\boxed{\times\times}$ $\boxed{\times\times}\boxed{\times\times}\boxed{}\boxed{}\boxed{}$

sp^3d^2, Octahedral

OOC / HSC

$n=4$, Para

③ $[Cu(NH_3)_4]^{2+}$

Cu^{2+} $\underset{3d}{\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow}}$ $\underset{4s}{\boxed{}}$ $\underset{4p}{\boxed{}\boxed{}\boxed{}}$

$NH_3 \rightarrow$ SL, excitation

$\underset{3d}{\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}}\underbrace{\boxed{\times\times}\ \underset{4s}{\boxed{\times\times}}\ \underset{4p}{\boxed{\times\times}\boxed{\times\times}}}\boxed{\uparrow}$

IOC / HSC dsp^2, Square Planar

$n = 1$ Paramagnetic

$Pd \rightarrow [Kr]\ 4d^{10}\ 5s^0$

Note : W.L. works as S.L. in +nce of 4d & 5d metals

$[NiCl_4]^{2-}$ $Cl^- \rightarrow$ W.L. Para

$[PdCl_4]^{2-}$] $Cl^- \rightarrow$ S.L. dia

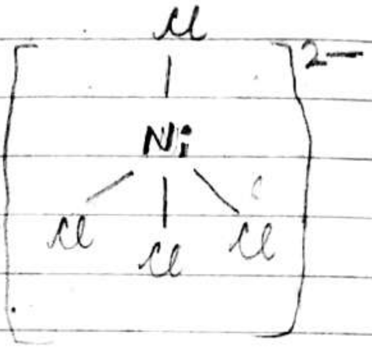
$[PtCl_4]^{2-}$]

$[NiCl_4]^{2-}$

Ni^{+2} [↑↓|↑↓|↑↓|↑|↑] [ ] [| |]

$Cl^- \rightarrow$ W.L.

Ni^{2+} [↑↓|↑↓|↑↓|↑|↑] [××] [××|××|××] [| | | |]



sp^3 tetrahedral

$n = 2$ Para.

$[PdCl_4]^{2-}$

Pd^{2+} [↑↓|↑↓|↑↓|↑|↑] [ ] [| |] [| | | |]

($Cl^- \rightarrow$ W.L. Pairing ✗) ✗

$Cl^- \rightarrow$ S.L. Pairing ✓

Pd^{2+} [↑↓|↑↓|↑↓|↑↓|××] [××] [××|××|]

4d 5s 5p

dsp^2 Square Planar

diamagnetic

$[PtCl_4]^{2-}$

Pt^{2+} [↑↓|↑↓|↑↓|↑|↑] [ ] [| |]

($Cl^- \rightarrow$ W.L. Pairing ✗) ✗

$Cl^- \rightarrow$ S.L. Pairing ✓

Pt^{2+} [↑↓|↑↓|↑↓|↑↓|××] [××] [××|××|]

5d 6s 6p

dsp^2 Square Planar

$n = 0$ diamagnetic

NCERT
NEET-2018

$[Co(C_2O_4)_3]^{3-}$ → dia

oxalato → $C_2O_4^{2-}$ in +nce of Co^{3+} works as S.L.

Co^{3+} $\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\;\boxed{}\;\boxed{}\boxed{}\boxed{}$

Co^{3+} $\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\times}\boxed{\times}\;\boxed{\times}\;\boxed{}\boxed{}\boxed{}$

d^2s

$\boxed{C_2O_4^{2-} \rightarrow \text{W.L. Pairing}}$ X

$C_2O_4^{2-}$ → Pairing, S.L.

dia~~s~~magnetic

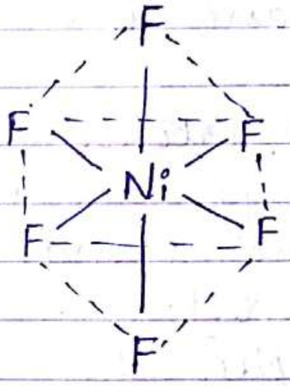
AIIMS

F^- works as S.L. in +nce Ni^{4+}

$[NiF_6]^{2-}$ → dia

→ d^2sp^3

Ni^{4+} $\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\;\boxed{}$



$\boxed{F^- \rightarrow \text{W.L. Pairing} \times}$ X

F^- → S.L, Pairing

Ni^{4+} $\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\times}\boxed{\times}\;\boxed{\times}\;\boxed{\times}\boxed{\times}\boxed{\times}$

d^2sp^3, Octahedral
diamagnetic.

LIMITATIONS OF V.B.T. :-

1. It ~~couldnot~~ involues a no. of assumptions.
2. It doesnot give quan~~tative~~-titatiue interpretion of magnetic data.
3. It does not explain color exhibit by V.B.T. compd.

4. It doesnot explain stability of coordination compd.

5. It ~~do~~ couldnot distinguish W.L. and S.L.

6. It couldnot explain tetrahedral and square planar structures of compd.

~~St~~ Spectro chemical Series :-

$I^- < Br^- < SCN^- < Cl^- < S^{-2} < F^- < OH^- < C_2O_4^{2-} < H_2O < NCS < EDTA < py < NH_3 < en < CN^- < CO$

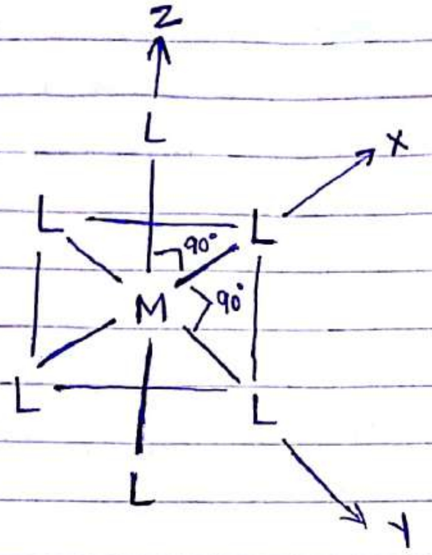
C.F.T. :-

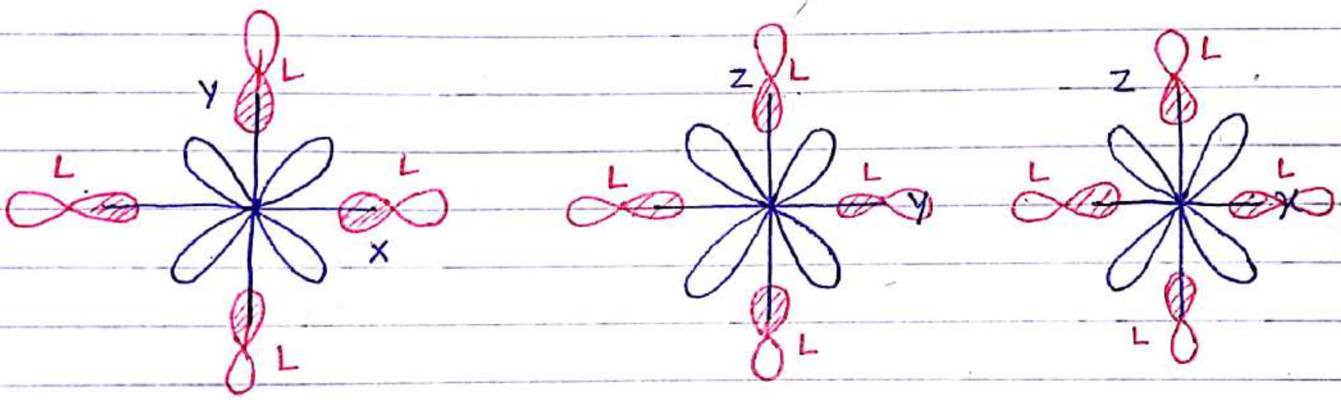
1. Ligands are considered as point charges. 2. There is only electrostatic force of attraction b/w metal orbital & ligand orbital i.e. bond b/w metal & ligand is purely ionic.

3. 5d orbital are degenerate orbital i.e. have same energy.
When ligands approaches these degenerate orbitals they destroy degeneracy of these 5 d orbitals and splits them into 2 new set of orbitals c/a t_{2g} orbitals & e_g orbitals.
This splitting of orbitals ~~into~~ is c/a crystal Field splitting and amt. of energy released is c/a Crystal Field Stabilisation Energy (CFSE)

The amt. of energy (CFSE) released in +nce of strong ligand is more than the amt. of energy released in +nce of weak ligand. So strong field ligand form more stable complex than weak field ligand.

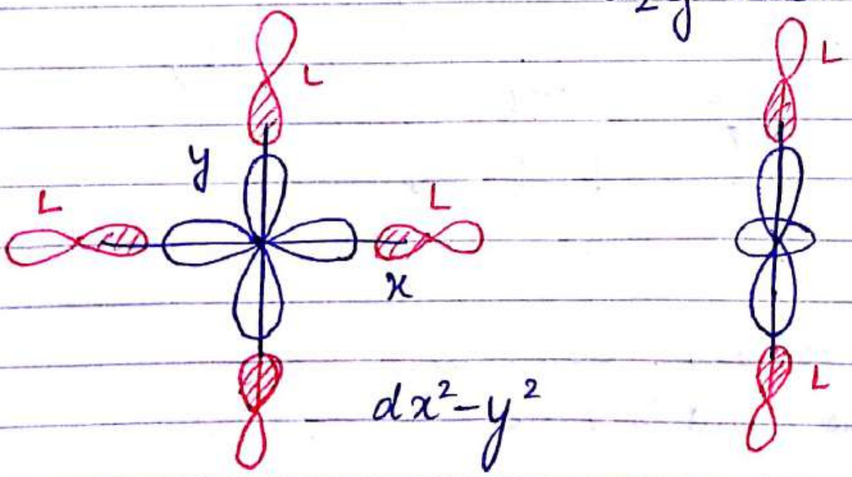
CFS in Octahedral Complex :-





d_{xy} d_{yz} d_{zx}

t_{2g} orbitals



dx^2-y^2

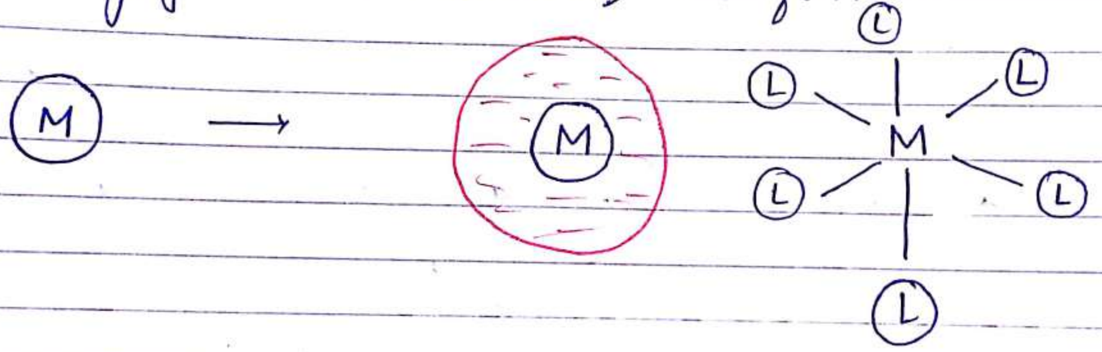
dz^2

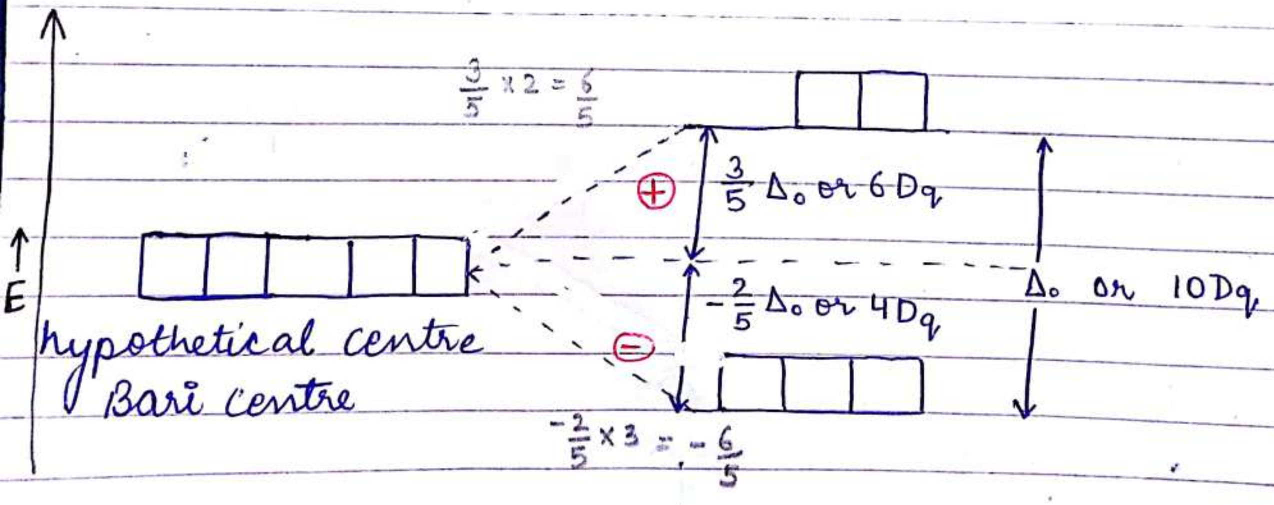
eg orbitals

→ Acc^n. to CFT, ligands always approach along the axes.

dxy, dyz & dxz orbitals does not come directly in path of approaching ligand so ~~that~~ there is less repulsion b/w metal orbital & ligand orbital hence lower energy t_{2g} orbital (tripally generate orbitals) are formed.

dx^2-y^2 & dz^2 orbitals comes direct in path of approaching ligands so there is more ~~to~~ repulsion b/w metal orbital & ligand orbital ~~have~~ hence higher energy eg orbitals (doubly genertate orbitals) are formed.





Δ_o → CFSE for Octahedral Complex

$e^{\ominus}$ are filled acc^n to Hund's Rule

(e^- are filled in t_{2g} / lower energy orbitals acc^n to Hund's Rule)

Conf.	Weak ligand $\Delta_o < P$	n	μ	Strong ligand $\Delta_o > P$	n	μ
d^1	$t_{2g}^1 e_g^0$	1	1.73	$t_{2g}^1 e_g^0$	1	1.73
d^2	$t_{2g}^2 e_g^0$	2	2.84	$t_{2g}^2 e_g^0$	2	2.84
d^3	$t_{2g}^3 e_g^0$	3	3.90	$t_{2g}^3 e_g^0$	3	3.90
d^4	$t_{2g}^3 e_g^1$	4	4.92	$t_{2g}^4 e_g^0$	2	2.84
d^5	$t_{2g}^3 e_g^2$	5	5.	$t_{2g}^5 e_g^0$	1	1.73
d^6	$t_{2g}^4 e_g^2$	4	4.	$t_{2g}^6 e_g^0$	0	0
d^7	$t_{2g}^5 e_g^2$	3	3.90	$t_{2g}^6 e_g^1$	1	1.73
d^8	$t_{2g}^6 e_g^2$	2	2.84	$t_{2g}^6 e_g^2$	2	2.84
d^9	$t_{2g}^6 e_g^3$	1	1.73	$t_{2g}^6 e_g^3$	1	1.73
d^{10}	$t_{2g}^6 e_g^4$	0	0	$t_{2g}^6 e_g^4$	0	0.

P → Pairing energy required for pairing of $e^\ominus$ in an orbital.

in case of $d^1, d^2, d^3, d^8, d^9, d^{10}$ conf. does not depend upon strength of ligand.

but in case of d^4, d^5, d^6, d^7 conf. depend upon strength of ligand.

Ques Which of the following configuration will show magnetic moment equal to 2.84 BM?

① d^3

② d^5 (in case of weak ligand)

[✓ ③ d^4 (in case of strong ligand)]

④ d^4 (in case of weak ligand)

AIEEE

Ques which of the following have least value of magnetic moment?

① $[Fe(CN)_6]^{3-}$ [✓ ② $[Co(CN)_6]^{3-}$] ③ $[Cr(CN)_6]^{3-}$ ④ $[Mn(CN)_6]^{3-}$

$3d^5$ $n = 1$

$3d^6$ $n = 0$

$CN^- \rightarrow$ S.L.

CFSE for Octahedral complex = $\left[-0.4 \times n_{t_{2g}} + 0.6\, n_{eg}\right]\Delta_o + P$

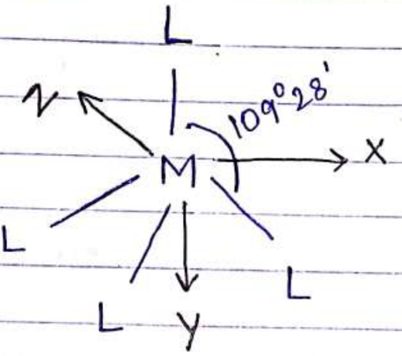
$P \rightarrow$ Pairing energy

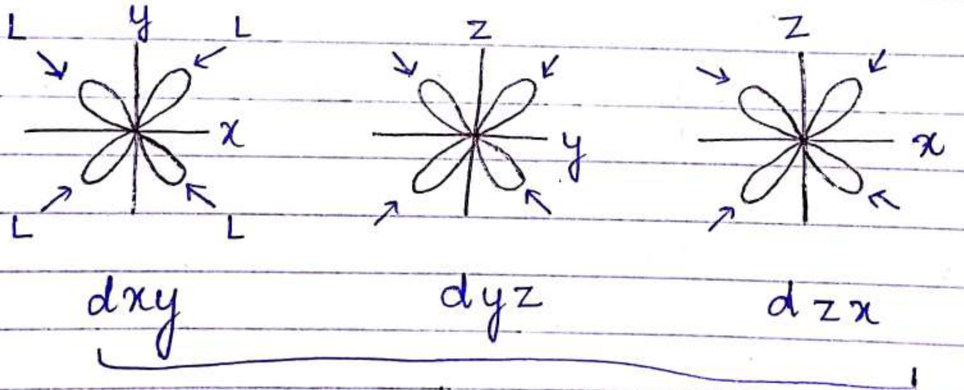
$\Delta_o \rightarrow$ CFSE for Octahedral complex

$n_{t_{2g}} \rightarrow$ no. of $e^{\ominus}$ in t_{2g} orbitals

$n_{eg} \rightarrow$ no. of $e^{\ominus}$ in eg orbitals.

CFS in Tetrahedral complex :-



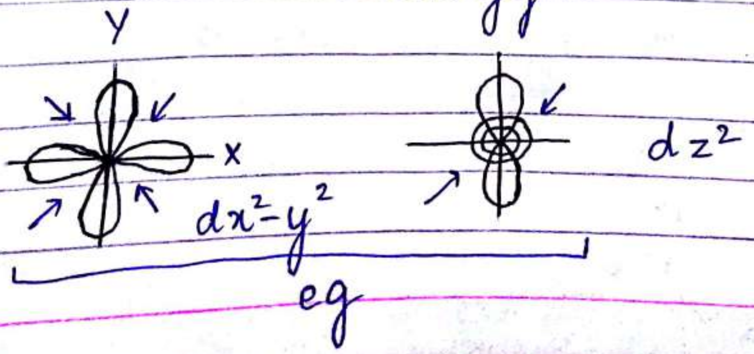


t_{2g}

t_{2g} orbitals point directly to ligand

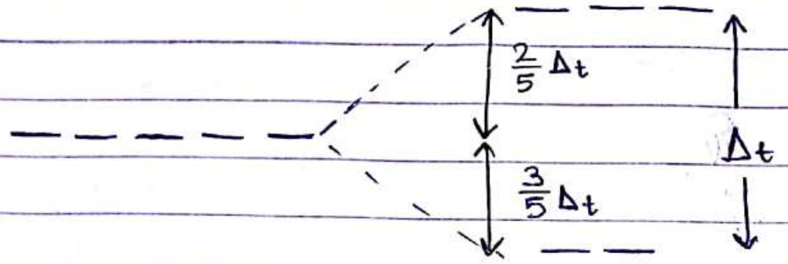
repulsion ↑

energy ↑



eg

eg orbitals does not point directly to ligand
repulsion ↓
energy ↓



Δt → CFSE for Tetrahedral complex

$$\boxed{CFSE = (+0.4\,\Delta t)\, n_{t_2g} + (-0.6\,\Delta t)\, n_{eg} + P}$$

Note : Tetrahedral complex are formed in +nce of W.L.

Conf.	Weak ligand $\Delta_t < P$	n	μ
d^1	$t_{2g}^0 e_g^1$	1	1.73
d^2	$t_{2g}^0 e_g^2$	2	2.84
d^3	$t_{2g}^1 e_g^2$	3	3.87
d^4	$t_{2g}^2 e_g^2$	4	4.90
d^5	$t_{2g}^3 e_g^2$	5	5.92
d^6	$t_{2g}^3 e_g^3$	4	4.90
d^7	$t_{2g}^3 e_g^4$	3	3.87
d^8	$t_{2g}^4 e_g^4$	2	2.84
d^9	$t_{2g}^5 e_g^4$	1	1.73
d^{10}	$t_{2g}^6 e_g^4$	0	0

Ques Arrange following in ↑ order of magnetic moment

$[Fe(CN)_6]^{3-}$

$Fe^{3+} \hookrightarrow$ S.L.

d^5

$t_{2}g^5\ eg^0$

$\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow}\quad\boxed{}\boxed{}$

$n = 1$

$[MnCl_4]^{2-}$

Mn^{2+}

$3d^5$

$t_{2}g^3\ eg^2$

$\boxed{\uparrow}\boxed{\uparrow}\quad\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}$

$n = 5$

$[CoCl_4]^{2-}$

Co^{2+} W.L.

$3d^7$

$n = 3.$

$eg^4\ t_{2}g^3$

$\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\quad\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}$

$n = 3$

Factor affecting CFSE :-

1. Nature of metal

Energy $3d < 4d < 5d$

2. O.S. on C.M.A. CFSE $\propto$ O.S. of C.M.A.

$$\underset{+3}{[Fe}(CN)_6]^{3-} > \underset{+2}{[Fe}(CN)_6]^{4-}$$

3. Nature of ligand : S.L. > W.L.

$$\underbrace{Fe(CO)_5 > [Fe(CN)_6]^{3-}}_{CO > CN^-} \underbrace{> [Fe(CN)_6]^{4-}}_{O.S.}$$

4. Nature of complex Octahedral > tetrahedral

$$\boxed{\Delta_t = \frac{4}{9}\Delta_o = 0.45\,\Delta_o = 45\%\,\Delta_o}$$

Ni^{+3} Co^{2+} Cu^{2+} Zn^{3+}

JOHN TELLER EFFECT :-

Acc^n to John Teller Effect, distoration in regular octahedral geometry occurs when unsymmetric configuration in ~~of~~ easy orbitals of C.M.A.

In ~~of~~ Octahedral field if all d $e^{\ominus}$ are symm. arranged then they will repel six ~~long~~ ligands equally. Thus the structure will be a complete regular Octahedral.

$[Cr(CN)_6]^{3-}$ $[Cr(NH_3)_6]^{3+}$

	t_{2g}	e_g	
d^0	[ ][ ][ ]	[ ][ ]	S.L. or W.L. $[TiCl_6]^{2-}$
d^3	[↑][↑][↑]	[ ][ ]	S.L. or W.L [illegible]
d^5	[↑][↑][↑]	[↑][↑]	W.L $[Fe(H_2O)_6]^{3+}$
d^6	[↑↓][↑↓][↑↓]	[ ][ ]	S.L $[Fe(CN)_6]^{4-}$
d^8	[↑↓][↑↓][↑↓]	[↑][↑]	SL or W.L $[Ni(NH_3)_6]^{2+}$ $[Ni(CN)_6]^{4-}$
d^{10}	[↑↓][↑↓][↑↓]	[↑↓][↑↓]	S.L. or W.L $[Zn(NH_3)_6]^{2+}$, $[Zn(H_2O)_6]^{2+}$

In Octahedral field if d e^- are unsymm. arranged then some of ligands will repel more than other hence geometry will be distorated octahedral

	t_{2g}	e_g		
d^4	[↑][↑][↑]	[↑][ ]	WL → HSC	Cr(II)
d^7	[↑↓][↑↓][↑↓]	[↑][ ]	SL	Co(II) Ni(III)
d^9	[↑↓][↑↓][↑↓]	[↑↓][↑]	S.L. or WL	Cu(II)

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Ques Which does not undergo John Teller distortion?

① d^4 ② d^7 ③ d^8 ④ d^9

If eg orbitals point directly at ligands so unsymm. filling of $e^{\ominus}$ in eg orbitals cause distortion in Octahedral geometry.

t_{2g} orbital lies b/w ligand approaching dir^n so in unsymm. filling of $e^\ominus$ in t_{2g} orbital cause less distortion which is negligible.

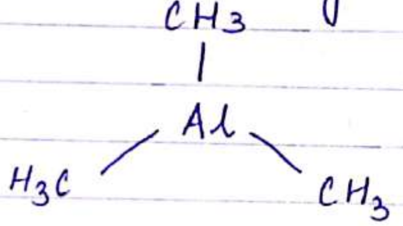
Organo Metallic Compound :-

Those compd in which metal atom is attached to carbon atom of some organic group are c/a O.M.C.

1. Sigma bonded O.M.C

$$\text{Metal} \xrightarrow[\sigma \text{ bond}]{} \text{Carbon}$$

eg : $Al(CH_3)_3$ → Trimethyl aluminium



$R-Mg-X$ Grignard Reagent

$(CH_3)_2 Zn$ Frankland Reagent

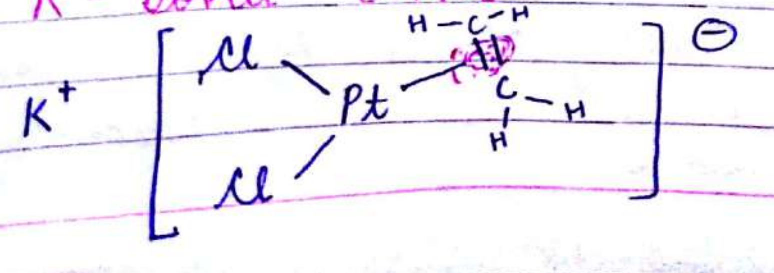
$(C_2H_5)_4 Pb$ → tetra ethyl lead

(TEL) → used as antiknocking agent in petrol.

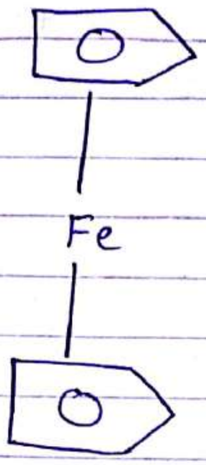
$(C_2H_5)_2 Zn$ Frankland Reagent

phenyl lithium

2. π - bond O.M.C.



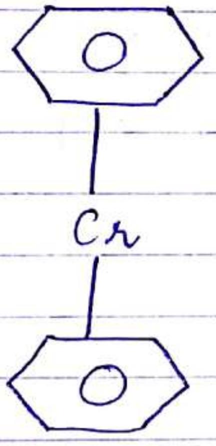
Zeise's Salt $K^+ PtCl_3 \eta^2 (C_2H_4)]^{\ominus} x H_2O$



$\eta^5 (C_6H_5^-)_2 Fe (II)$

Ferrocene
bicyclo Pentadienyl Iron (II)

~~bi~~ dibenzene Chromium (0)



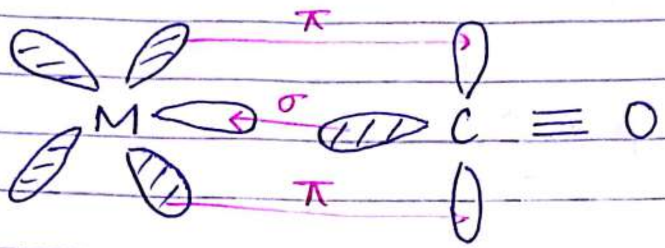
$\eta^6 (C_6H_2)_2 Cr (0)$

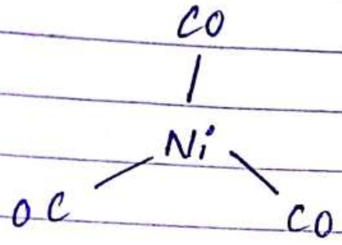
σ and π bond

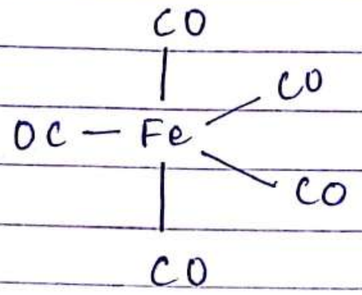
→ include metal carbonyls like $Ni(CO)_4$, $Fe(CO)_5$

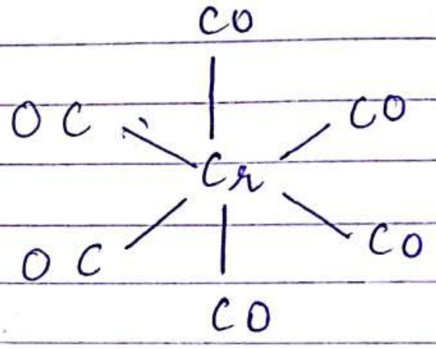
→ In this compd, σ bond formed b/w vaccant hybrid orbital of metal & lp of carbon atom in CO.

→ While a π bond is formed b/w antibonding orbital (π*) of ~~co~~ CO & filled orbital of Metal atom. This bonding is also k/n as cinergic bonding.



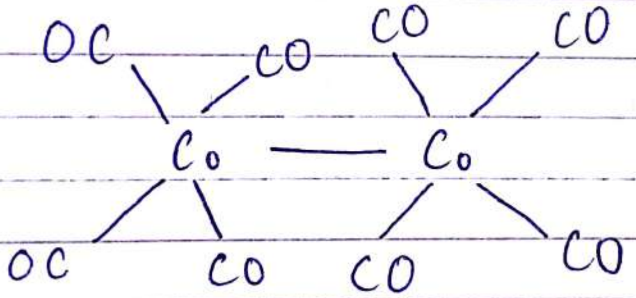


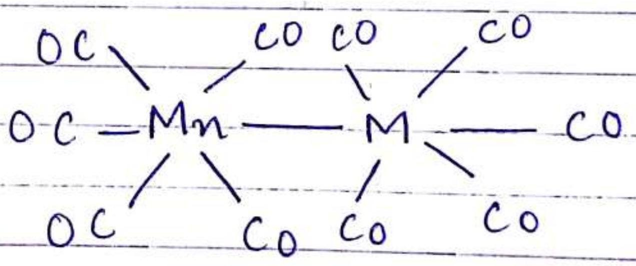




C–O B.L. order $[Fe(CO)_5]^- > [Cr(CO)_6]^0 > [V(CO)_6]^+$

$Co_2(CO)_8$ $Mn_2(CO)_{10}$





Appⁿ of O.M.C.

1. Ziegler Nata Catalyst :-

$(C_2H_5)_3Al + TiCl_3$

Triethyl aluminium Titarium chloride

→ used in polymerisation of alkene

$$n\,CH_2 = CH_2 \xrightarrow{(C_2H_5)_3Al + TiCl_3} -(CH_2 - CH_2)_n$$

ethene Polythene

2. Wilikinson's catalyst $[\{(C_6H_5)_3\ddot{P}\}_3Rh]Cl$
used in hydrogenation of alkene

$CH_2 = CH_2 + H_2 \xrightarrow[\text{Catalyst}]{\text{Wilikinson}} CH_3 - CH_3$

3. C_2H_5HgCl (ethyl Mercury Chloride)
used as fungicide in agriculture (Toxic)

Application of Coordination Compd :-

In Qualitative Analysis

1. To separate group I radical like Ag^+ & Hg^{2+} complexation formation with NH_4OH is done

$AgCl + NH_4OH \longrightarrow [Ag(NH_3)_2]Cl$
(Soluble

$HgCl_2 + NH_4OH \longrightarrow \underline{Hg(NH_2)Cl + Hg}$
black insoluble ppt.

2. To detect Cu^{2+} ion
complex ~~for~~ for^m with ammonia is done

** $CuSO_4 + 2NH_3 \longrightarrow [Cu(NH_3)_4]SO_4$
dark blue

$Cu^{2+} + K_4[Fe(CN)_6] \longrightarrow Cu_2[Fe(CN)_6]$
Chocolate brown

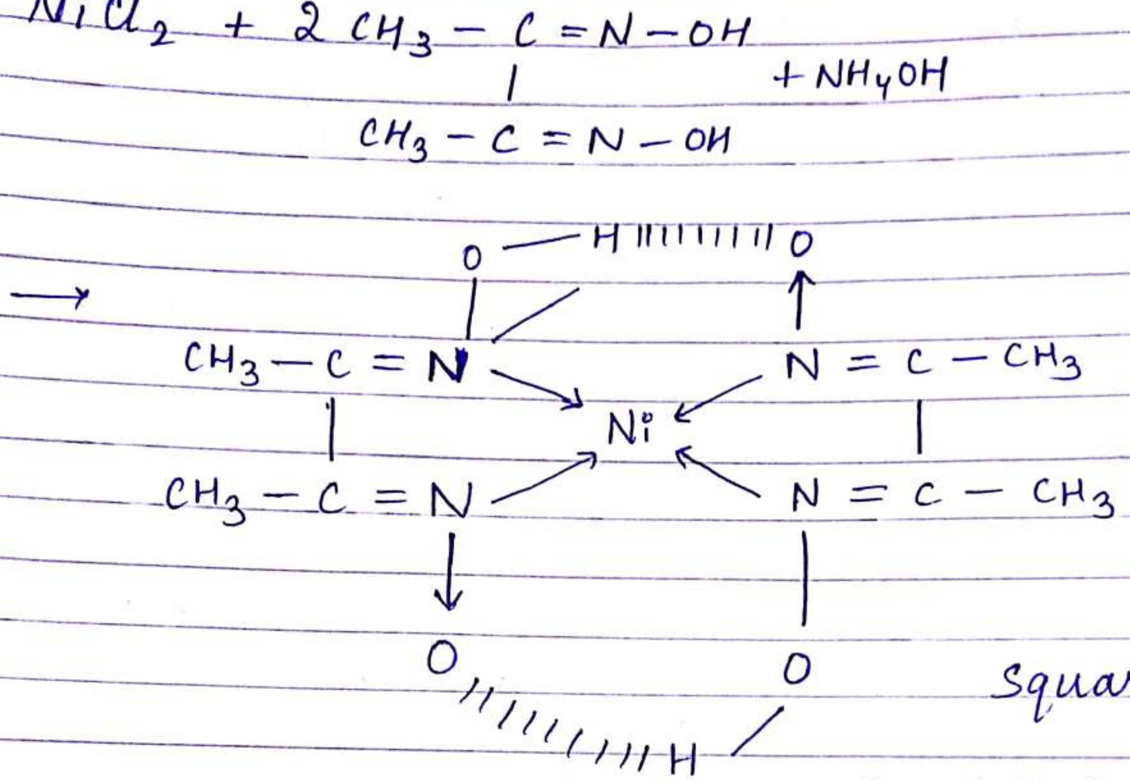
3. To ~~dect~~ detect Fe^{3+} ~~color~~ ion

$Fe^{3+} + KSCN \longrightarrow [Fe(SCN)]^{2+} + K^{\oplus}$
~~block~~ blood red color

4. To detect sulphide ~~ion~~ (S^{2-}) ion

$Na_2S + Na_2[Fe(CN)_5NO] \rightarrow Na_4[Fe(CN)_5NOS]$
Sodium Nitro Prusside — Violet color

5. To ~~deb~~ detect Ni^{2+} ion



$$NiCl_2 + 2\,\begin{matrix} CH_3-C=N-OH \\ | \\ CH_3-C=N-OH \end{matrix} + NH_4OH \rightarrow$$

Square Planar

Scarlet Red Color

$NO_3^{\ominus}$ test

$$\underset{\text{light blue}}{[Cu(H_2O)_4]SO_4} \xrightarrow{4NH_3} \underset{\text{dark blue}}{[Cu(NH_3)_4]SO_4}$$

$$\underset{O.A.}{NO_3^{\ominus}} + \underset{R.A.}{Fe^{2+}} + 4H^+ \longrightarrow Fe^{3+} + NO + H_2O$$

$$[Fe(H_2O)_6]SO_4 + N\dot{O} \longrightarrow [Fe(H_2O)_5(\overset{+}{N}O^{+})]SO_4$$

Brown Ring complex

$\boxed{Fe^{+1}}$

In Medical field :-

① Cis-platin is used in anti-cancer drug.

② Ca - EDTA is used for treatment of patients suffering from lead poisoning.
Ca EDTA dissociates lead ~~into~~ inside the body & more stable Pb - EDTA complex is formed which is excreted through urine by body. while harmless Ca^{2+} ions remains inside the body.

Vitamin B12 : cyanocabalamine is a cobalt vitamin in which Co^{2+} is central metal ion. It is anti-pernicious anemia factor.

Chlorophyll (Mg^{2+})

AIIMS-13 Haemoglobin (Fe^{2+})

Myoglobin (Fe^{3+})

Insulin (Zn)

Carboxypeptide (Zn)

In Metallurgy :-

In extraction of metals like silver & gold, complex form with sodium cyanide (NaCN) solⁿ is done.

$$* \; Ag_2S + 2NaCN \rightleftharpoons 2Na[\underset{\hookrightarrow sp}{Ag}(CN)_2] + Na_2S$$

Soluble complex

$$4Na_2S + 5H_2O + 2O_2 \longrightarrow 2Na_2SO_4 + 4NaOH + 2S$$

$2Na[Ag(CN)_2] + Zn \rightarrow Na_2[Zn(CN)_4] + 2Ag\downarrow$

In Electroplating :-

In electroplating of noble metals like silver & gold, their complex forming tendency is used.

For eg :-

In electroplating of silver complex potassium dicyano argento (I) - $K[Ag(CN)_2]$ is formed due to which Ag^+ ions are not available for displacement & layer over silver remain stable for a longer time.

In a masking agent :-

To detect a particular ion in +nce of other ions. A specific ligand is added which form stable complex with all the other ions. Except the ion to be detected, this is k/n as masking Method.

for eg : Cd^{2+} ions are detected in +nce of the Cu^{2+} ions by this method -

$Cu^{2+} + 4CN^- \longrightarrow [Cu(CN)_4]^{2-}$ stable complex

$Cd^{2+} + 4CN^- \longrightarrow [Cd(CN)_4]^{2-}$ Unstable

$Cd^{2+} + H_2S \longrightarrow CdS\downarrow$ Yellow

In photography :-

Sodium Thiosulphate is used in photography becoz of its complex forming tendency as it removes undecomposed AgBr by forming complex with it.

$Na_2S_2O_3 + AgBr \longrightarrow Na_3[Ag(S_2O_3)_2] + NaBr.$