

Coordination Compounds —

Coordination compounds are those compound that are formed by two or more stable salt which retain their property/identity in solid as well as in aqueous form.

OR

Coordination compounds are chemical compounds that consist of an array of anion or neutral molecule that are bound to a central atom via coordinate covalent bond.

↓
Coordinate bond

when an atom have lone pair of e- available then it donates its lone pair of e- to the metal ; hence the bond formed is coordination bond.

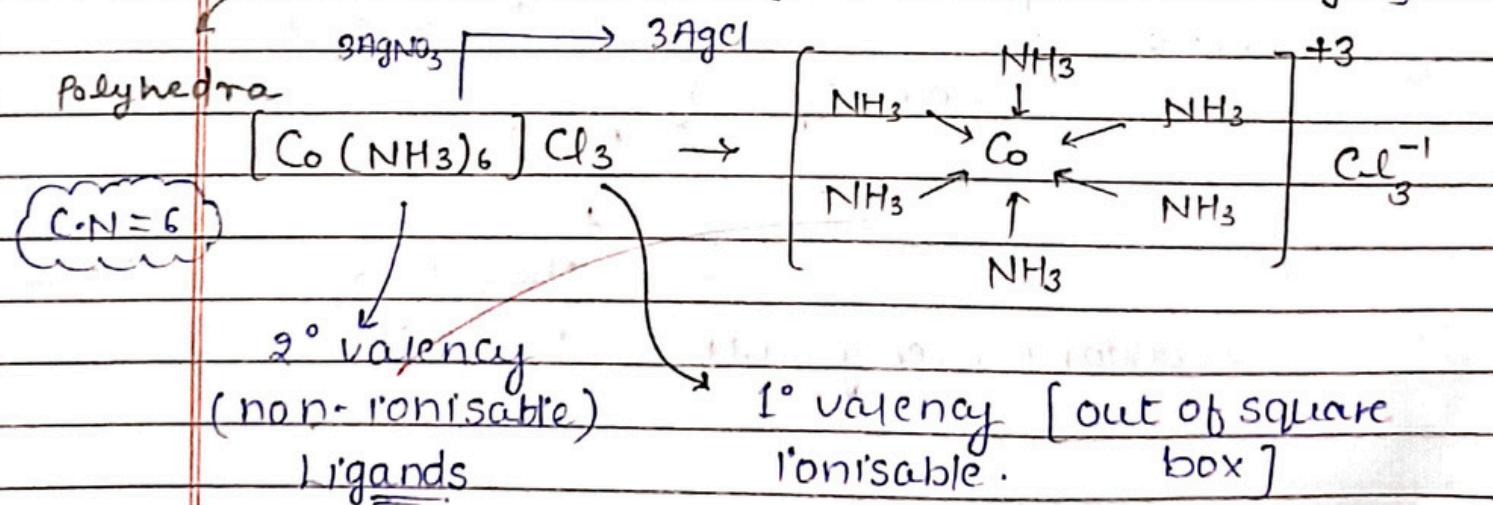
Werner Theory of Coordination Compounds -

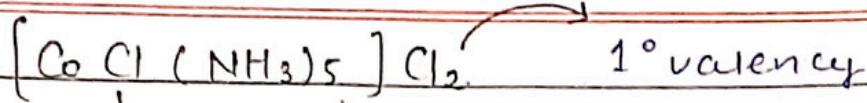
Alfred Werner ; CoCl_3 with NH_3 and found.

- ① $\text{CoCl}_3 \cdot 6\text{NH}_3$ Yellow + $3\text{AgNO}_3 \rightarrow 3\text{AgCl}$
- ② $\text{CoCl}_3 \cdot 5\text{NH}_3$ Purple + $2\text{AgNO}_3 \rightarrow 2\text{AgCl}$
- ③ $\text{CoCl}_3 \cdot 4\text{NH}_3$ Green + $1\text{AgNO}_3 \rightarrow 1\text{AgCl}$
- ④ $\text{CoCl}_3 \cdot 2\text{NH}_3$ violet + $\text{AgNO}_3 \rightarrow 01\text{AgCl}$

Postulates:

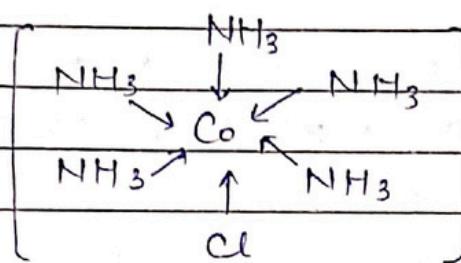
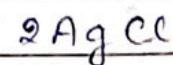
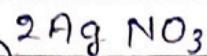
- ① Coordination compound contains two types of valencies.
 i.e. PRIMARY valency
SECONDARY valency.
- ② 1° valencies are ionizable and can be satisfied by anions and dependent on oxidation no. of metal.
- ③ 2° valencies are non-ionizable and are satisfied by ions or neutral molecules, and depends upon size and charge of central atom.
- ④ 2° valency shows coordination Number of central metal atom.
- ⑤ 1° valency is non-directional while 2° valency is directional.
 [because of 2° valencies the salt / compound occupies a geometry, shape and angle].





1° valency

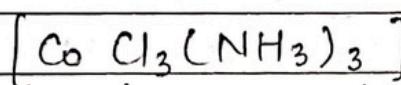
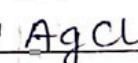
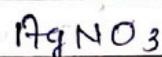
2° valency



1° valency

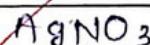
CN = 6

2° valency



1° valency is zero.

2° valency



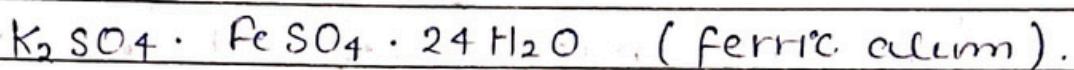
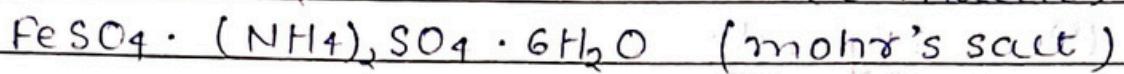
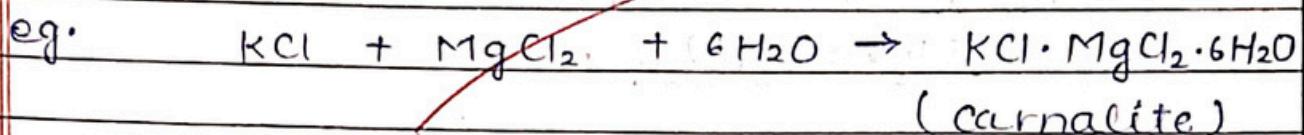
No chlorine is available
for reaction.

secondary valency = CN.

Some Important Terms :-

① Addition Compounds / salts :-

when more than one simple salt combine with each other in a stoichiometric ratio then the salt formed is called addition salt.

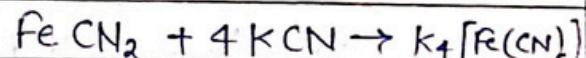
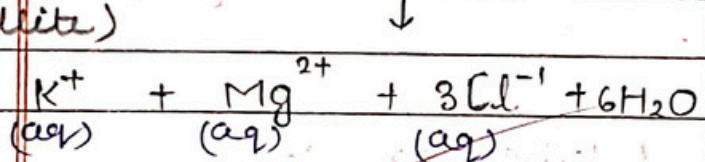
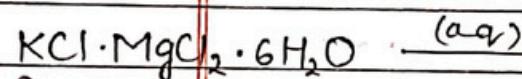


Addition compound are of two types :-

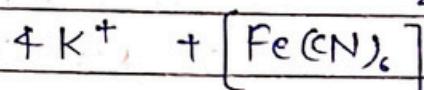
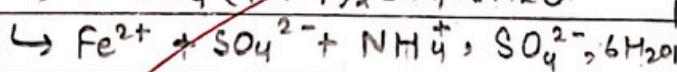
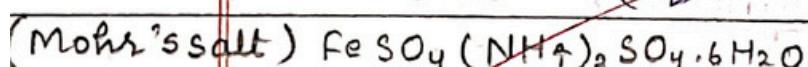
i) Double salt ii) Coordination salt

- loses its identity in aqueous form.
- solid state is stable.

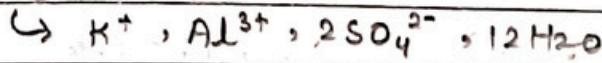
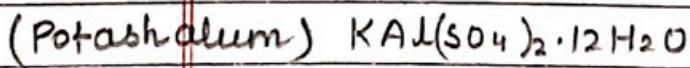
- retain their identity.



$\downarrow aq$



- double salt exist in solid.



② Central metal atom / ion :-

The atom / ion of metal which is present at the centre of compound and accepts lone pair of e^- from ligand and form co-ordination bond with them.

- * Central metal atom accept the lone pair electron, hence act as a LEWIS ACID.

③ Ligands :-

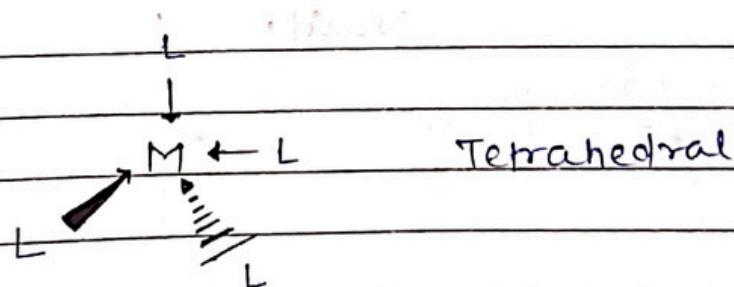
are atoms or group of atoms or ions that donates their lone pair of e^- to the central metal atom to form coordination bond with it.

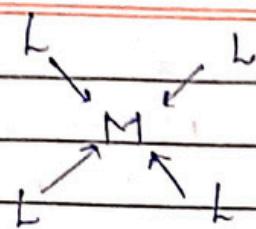
- * Ligands are lone pair donor and hence are LEWIS BASE.

- * Ligand surround the metal in a specific form and the compounds gains a specific shape.

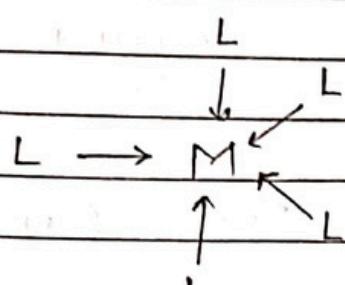
④ Coordination Polyhedron :-

when ligands surrounds CMA they obtains a particular shape called as coordination polyhedron.

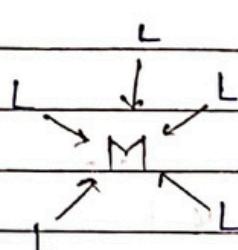




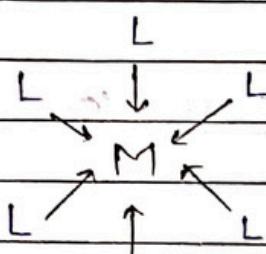
square planar.



Trigonal bipyramidal.



square pyramidal.

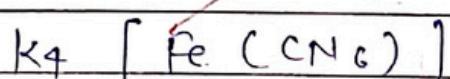


Octahedral

⑤

Coordination Entity :-

Coordination Entity comprises the CMI ligand and are represented under a square bracket. It is also known as COORDINATION SPHERE.

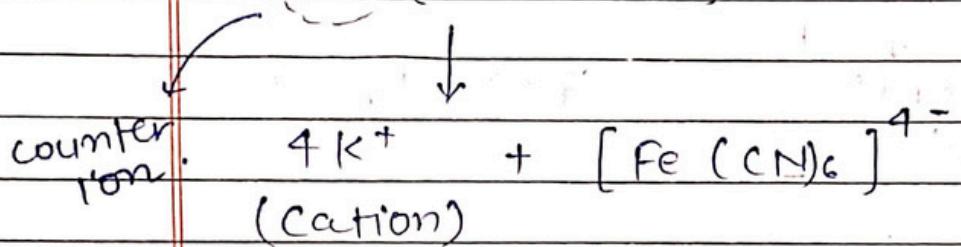
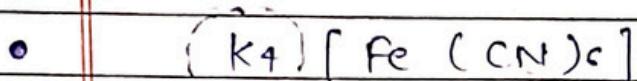
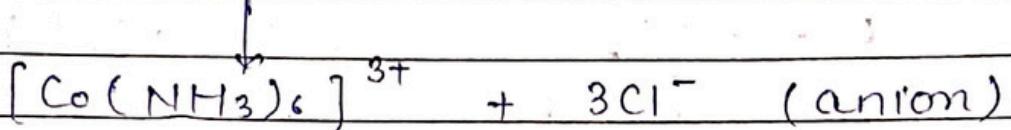
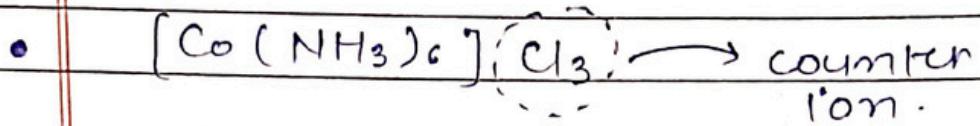


↳ Coordination sphere.

(Non-ionisable).

(6) Counter ion :

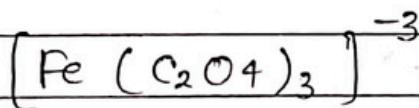
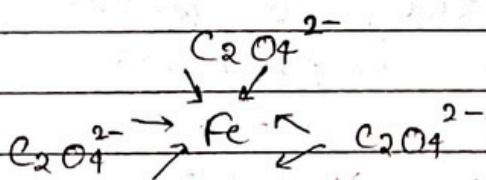
It is placed outside the coordination sphere and are ionisable.



Note: Counter ion can be anion or cation.

(7) Coordination Number :

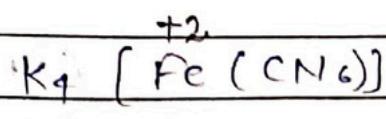
It is the number of bonds that are formed between ligand and central metal atoms.



$$\therefore \boxed{\text{CN} = 6}$$

⑧ Oxidation number:

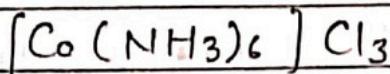
It is the charge present on the CMA when all the attached ligands and counter ions are removed.



$$4(+1) + x + 6(-1) = 0$$

$$4 + n - 6 = 0$$

$$n = 2$$

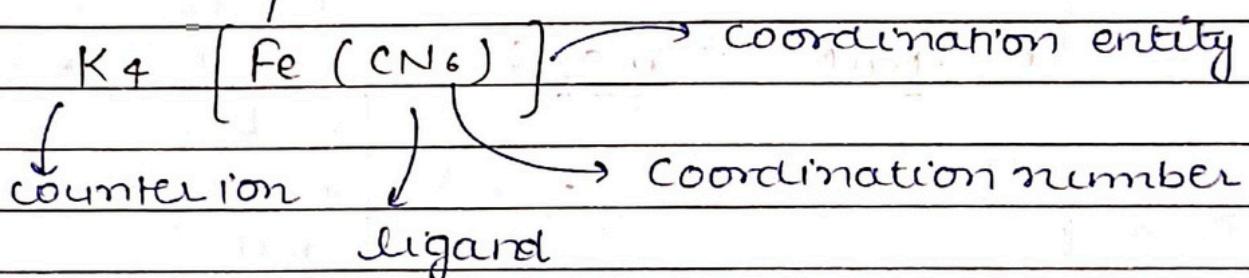


$$x + 6(0) + 3(-1) = 0$$

$$n + (-3) = 0$$

$$x = +3$$

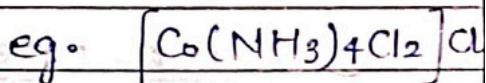
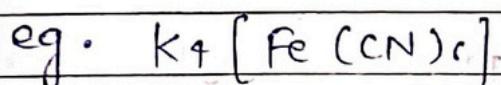
central metal atom.



⑨ Homoleptic and Heteroleptic complex:

same type of ligands.

different type of ligand.



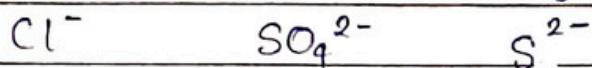
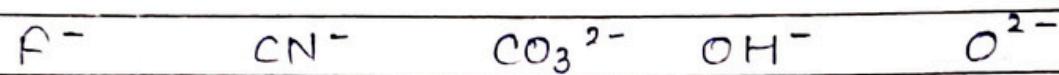
→ Lone pair donor (donating to CMF) Date: _____

Type of Ligands :-

i) On the basis of charge present on ligand.

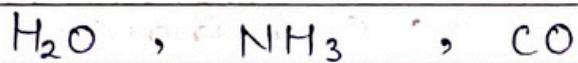
- (a) Neutral
- (b) Positively charged ligands (cationic)
- (c) Negatively charged ligands. (Anionic).

Anionic ligands :

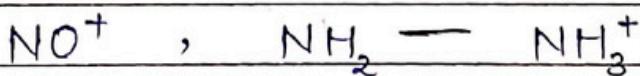


chelate ligand: when
didentate or polydentate
ligand coordinate to metal
ion by more than one donor
site atom, then ring like
structure is obtained
chelate ring.

Neutral ligands :



Cationic ligands :



→ no. of coordination

ii) On the basis of benticity : bond that can
be formed by
a ligand.

(a) Monodenticity :

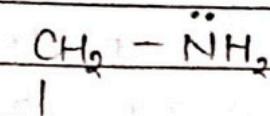
Ligands that form single coordination
bond (single donor atom of lone pair).

e.g. $F^-, Cl^-, OH^-, S^{2-}, O^{2-}$
 H_2O, NH_3

6

Bidentate ligands :

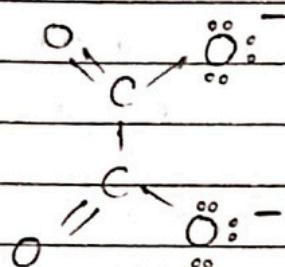
↳ Legend have two donor atom and may form two coordination bond at a time.



(en)



ethane - 1,2-diamine

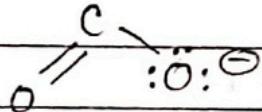


(ox)

600-



(guy)



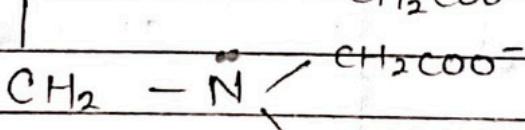
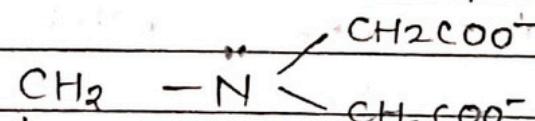
glycinate



C00-

Polydentate ligands :-

↳ many lone pairs - donor atom which are present in ligand.



(EDTA)

hexadentricity

eg. Cd^{2+} Chelate complexes : When a di- or polydentate ligand uses its two or more donor atom simultaneously to bind to a single metal ion, it is ...

Date: _____
Page: _____

(A) Flexidentate :-

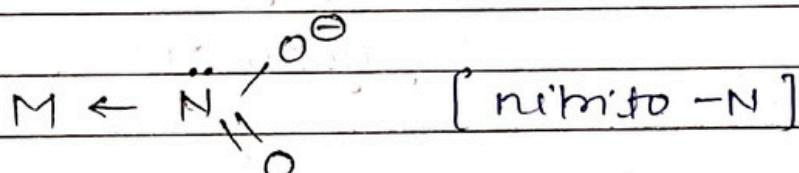
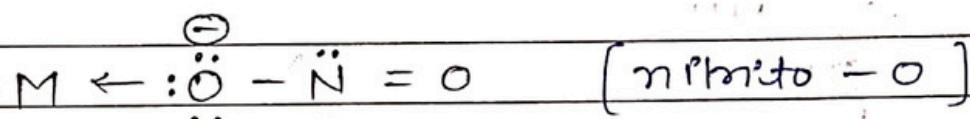
↳ flexible dentistry i.e. lone pair e⁻ donated will depend upon accepting metal.

eg. EDTA [may give 4 lone pair and also or may give 6 lone pair].

(B) Ambidentate Ligands :-

↳ ligands that have 2 donor atoms but they donate lone pair one at a time.

eg. NO_2^- , SCN^- and NCS^- , CN^- and NC^-



monodentate Neutral ligands :

H_2O	Aqua	$\text{C}_5\text{H}_5\text{N}$	Pyridine
----------------------	------	--------------------------------	----------

NH_3	Ammine	N_2	Dihydrogen
---------------	--------	--------------	------------

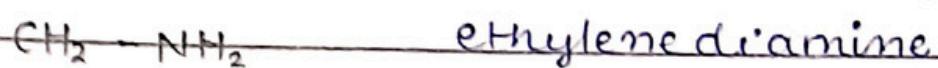
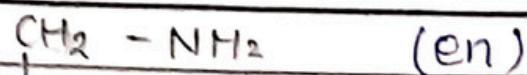
NO	Nitrosyl	O_2	Dioxygen
-------------	----------	--------------	----------

CO	Carbonyl	NH_2CONH_2	Urea
-------------	----------	----------------------------	------

CS	Thiocarbonyl	PH_3	phosphine
-------------	--------------	---------------	-----------

NS	Thionitrosoyl	Ph_3P	Triphenylphosphine
-------------	---------------	-----------------------	--------------------

Bidentate Neutral:



Monodentate Cationic ligands:

Ligand	Charge	
NO^+	+ 1	Nitrosonium
NO_2^+	+ 1	Nitronium
$\text{NH}_3 - \text{NH}_3^+$	+ 1	Hydrazinium

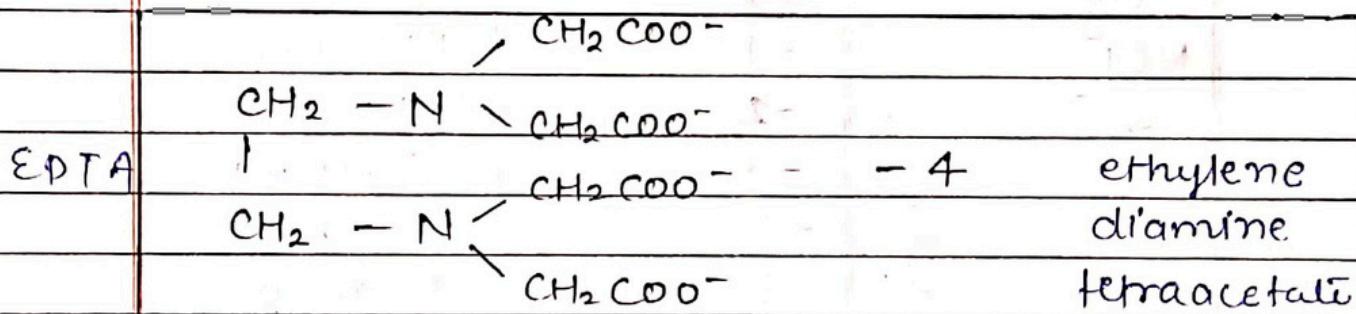
Monodentate anionic ligands:

Ligand	charge	
H^-	- 1	hydrido
O^{2-}	- 2	oxo
OH^-	- 1	hydroxo
CN^-	- 1	Cyano
NC^-	- 1	Isocyano
O_2^{2-}	- 2	peroxo
F^-	- 1	Fluoro
Cl^-	- 1	Chloro
Br^-	- 1	Bromo
I^-	- 1	Iodo
CH_3COO^-	- 1	aceta
SO_3^{2-}	- 2	Sulphito
S^{2-}	- 2	Sulphido
NH_2^-	- 1	Amido
N_3^-	- 1	Azido
SCN^-	- 1	Thiocyanato
NCS^-	- 1	Isothiocyanato

Bidentate Amionic Ligand.

SO_4^{2-}	-2	sulphato
$\begin{array}{c} \ddot{\text{N}}\text{H}_2 \\ \\ \text{CH}_2 \\ \\ -\text{O}-\text{C}=\text{O} \end{array}$	-1	glycamato
$\begin{array}{c} \text{O} \quad \text{O}^\ominus \\ \backslash \quad / \\ \text{C} \\ \\ \text{C} \quad \text{O}^\ominus \\ / \quad \backslash \\ \text{O} \quad \text{O} \end{array}$	-2	oxalato
CO_3^{2-}	-2	carbonato

Polydentate (Hexadentate) amionic ligand.



IUPAC Nomenclature of coordination compounds :-

Rules for IUPAC Nomenclature :-

- (i) Positive part is named first followed by anionic part.

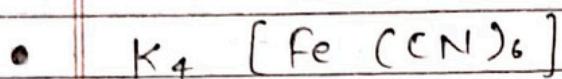
→ alphabetical
order

- (ii) While naming the coordination entity the ligands are named first followed by naming the central metal atom.
- (iii) After the name of CMA we must mention the oxidation number of CMA in Roman Number in bracket.
- (iv) In case of more than one ligand of same type i.e. present then prefixes like di-, tri-, tetra-, penta-, hexa-, are used before the name of ligands. (not include in alphabetical rule).
- (v) In case of complex ligand like (en), (EDTA), (in such ligands prefixes di, tri, tetra, etc. are already mentioned so could not use them while naming) in such ligand prefixes like:
 - bi's → for two
 - tri's → for three
 - tetrakis → for four is used.
 followed by naming the ligand in bracket
- (vi) For anionic ligand, their name should be end with 'O', but IUPAC says - 'ido' must be used.
 - Chbro → chlorido
 - Cyno → cyano
 Cationic ligand end with 'ium' and neutral ligand they are named as such.

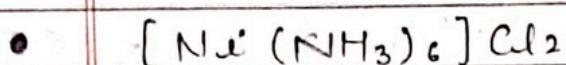
(vii) For anionic coordination entities the name of CMA end with '-ate'.

For cationic coordination entities the CMA are named as such.

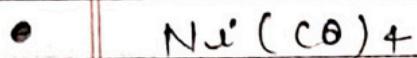
* Counter ions are named normally
(we do not mention their number while naming.)



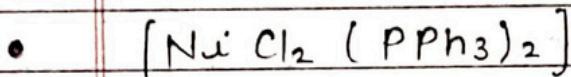
Potassium hexacyanoferrate (II)



Hexaammine nickel (II) chloride.

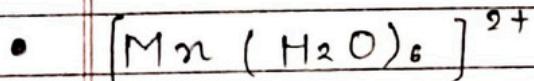


Tetra carbonyl nickel (0).

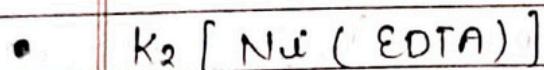


Dichlorido bis (triphenyl phosphine) nickel (II)

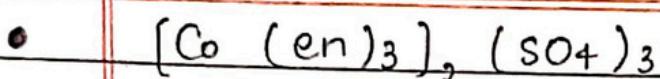
* In case of ionic coordination compounds the name ends after writing 'ion.'



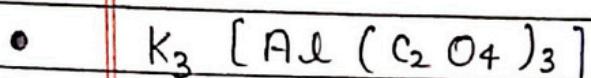
Hexaaquamanganese(II) ion.



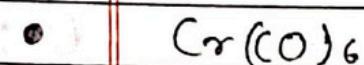
Potassium ethylenediamine tetraacetato nickelate(II)



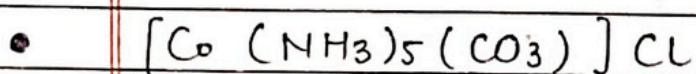
Tri's (ethylene diamine) cobalt (III) sulphate



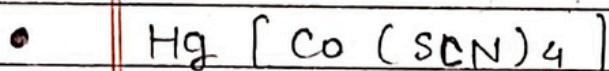
Potassium trioxalatoaluminate (III)



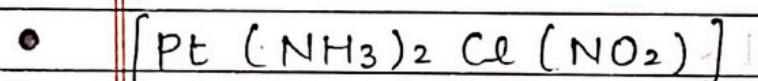
Hexacarbonyl chromium (0)



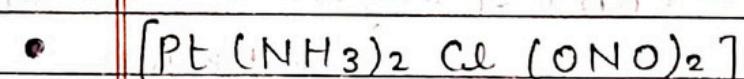
Pentaamine carbonato cobalt (III) chloride



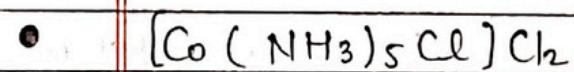
Mercury tetrathiocyanato cobaltate (III)



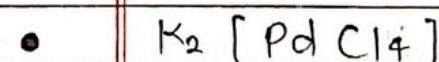
Diammine chlorido nitrito - N platinum(II)



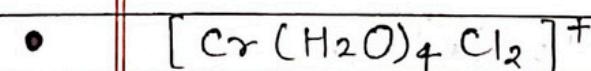
Diammine chlorido nitrito - O platinum(II)



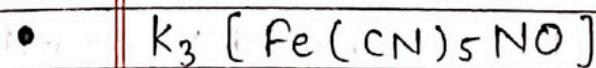
Pentaammine chlorido cobalt (III) chloride



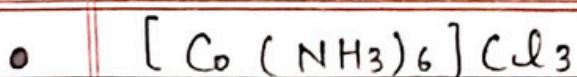
Potassium tetrachloridopalladate(II)



Tetraqua di'chlorido chromium(II) ion.



Potassium pentacyanidonitrosyl ferrate(II).

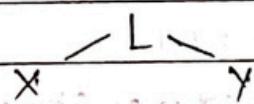
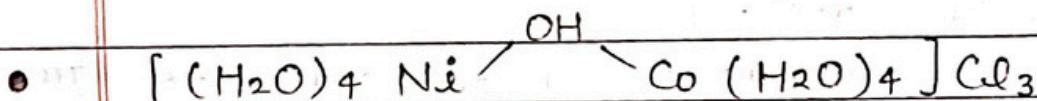
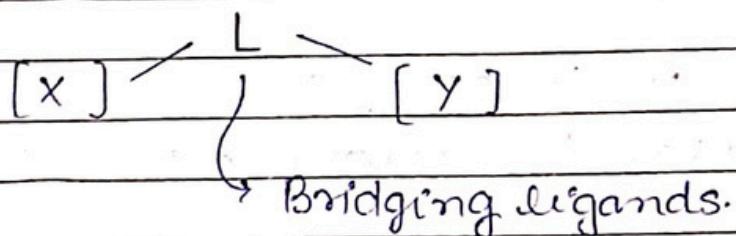


Hexaammine cobalt(III) chloride



Hexaammine platinum(IV) chloride

IUPAC Nomenclature of Bridging ligands :-

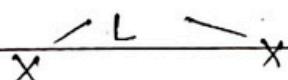
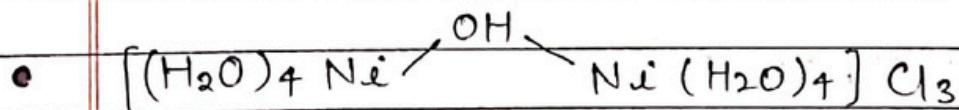


Rule: name of X - μ - name of ligand - name of Y - counter ion

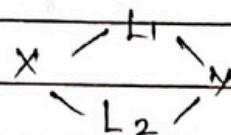
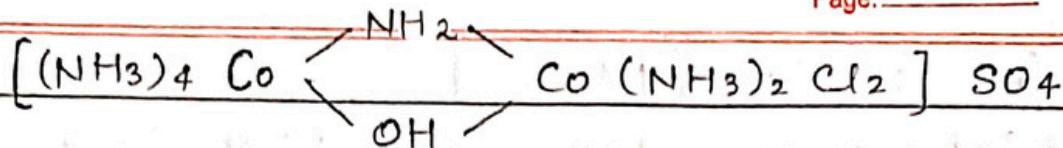
* $\mu \rightarrow$ signifies that ligand is bridging.

Tetraaquanickel(II)- μ -hydroxo-tetraaqua cobalt(II) chloride

* Average oxidation number (II):

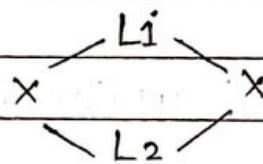
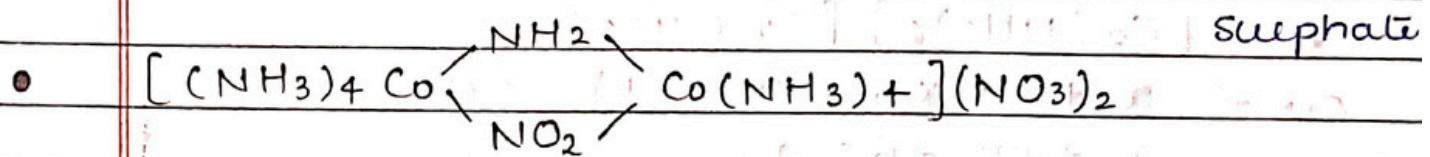


Rule: μ - name of ligand - bi's - name of X - counter ion
 μ - hydroxido - bi's - tetraqua nickel(II) chloride

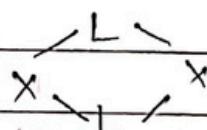
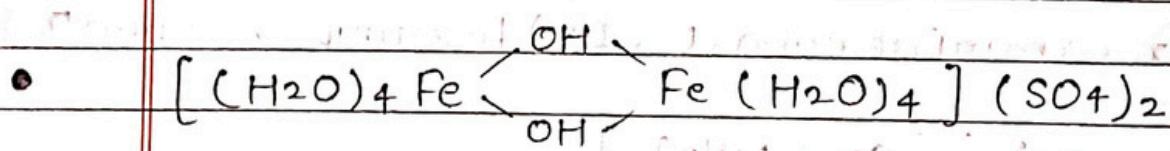


Rule: Name of X - μ - name of L₁ - μ - name of L₂ - name of Y - counterion.
opt the ligand alphabetically

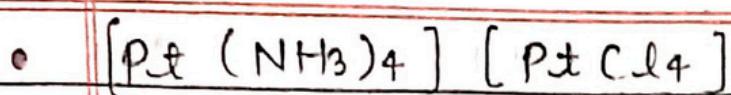
Tetraammine cobalt (III) - μ -amido - μ -hydroxo
di'ammine di'chlorido cobalt(III)



μ -name of ligand, - μ -name of L₂ - bis - name of X - counterion.
 μ -amido - μ -nitrito - bis - tetraammine cobalt (II) nitrate



di - μ -name of ligands - bis - name of X - counter
di - μ - hydroxo - bis - tetraaqua iron III sulphate

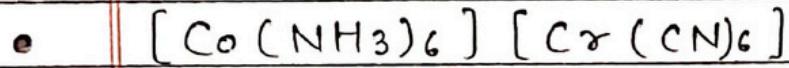
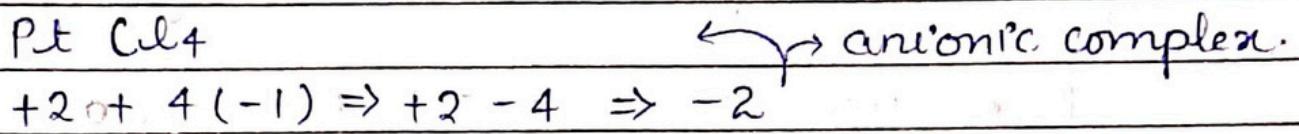
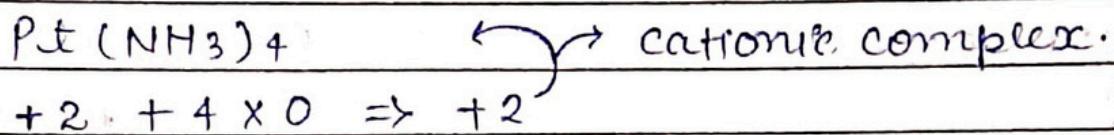


Tetraammine platinum(II) tetrachloroplatinate (II).

$$\text{O.N} \rightarrow 2L + 4 \times 0 + x + 4(-1) = 0$$

$$2n - 4 = 0$$

$$n = +2$$

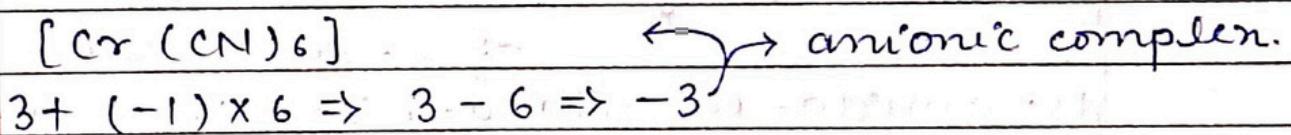
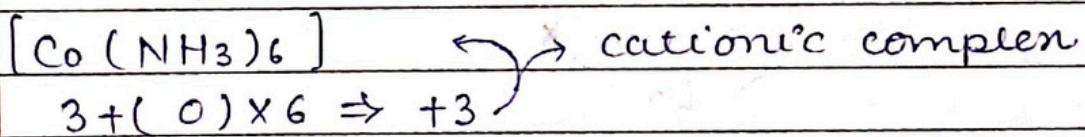


$$\text{O.N} \rightarrow x + (0) \times 6 + x + (-1) \times 6 = 0$$

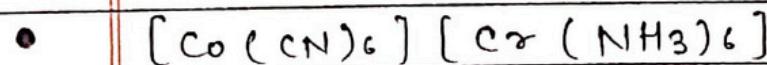
$$x + x - 6 = 0$$

$$2n = 6$$

$$x = +3$$



Hexaammine cobalt (III) hexacyano chromate(III)



$$\text{O.N} \rightarrow x + (-1) \times 6 + x (0) \times 6 = 0$$

$$2n - 6 = 0$$

$$n = +3$$

↑ cationic part
 $[\text{Cr}(\text{NH}_3)_6] \Rightarrow 3 + (0) \times 6 \Rightarrow +3$

$[\text{Co}(\text{CN})_6] \rightarrow$ anionic complex.

$$+3 + (-1) \times 6 \Rightarrow 3 - 6 \Rightarrow -3$$

Hexaammine chromium(III) hexacyano cobaltate(III)

Isomerism :-

Those compounds in which molecular formula is same but have different arrangement of atoms and therefore have difference in properties.

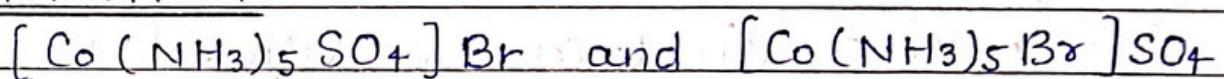
This phenomenon is called ISOMERISM and compound which show isomerism is called ISOMERS.

Types -

- i) Structural Isomerism
- ii) Stereo-Isomerism

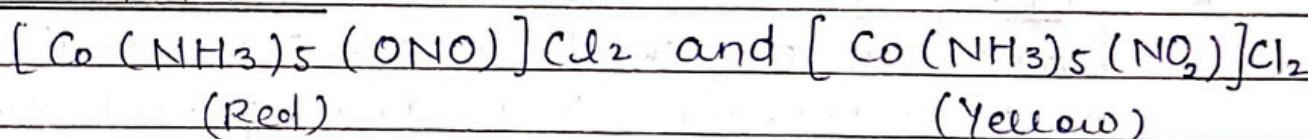
1. STRUCTURAL : Compound have same molecular formula but they have different structural arrangement.

(a) IONIZATION -



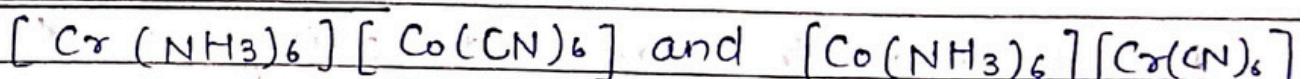
* different counter ion (1° valency).

(b) LINKAGE -



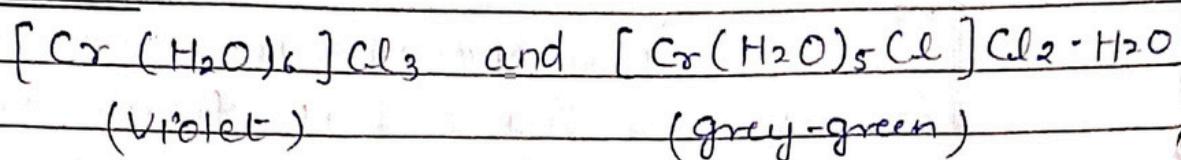
* Ambidentate ligands.

(c) Co-ordination -



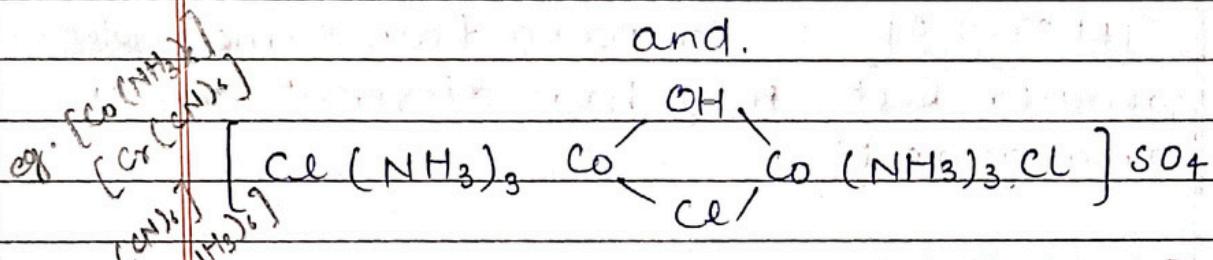
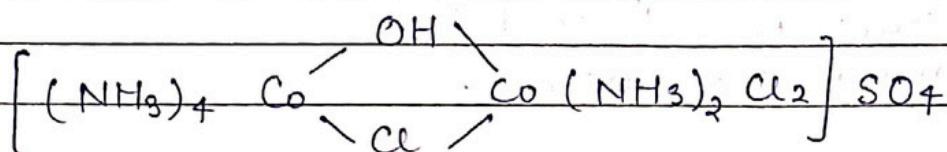
* different in terms of ligands in co-ordination complex.

(a) SOLVATE :



- * differs in terms of different H_2O molecule as ligands.

(b) Co-ordination position Isomers -



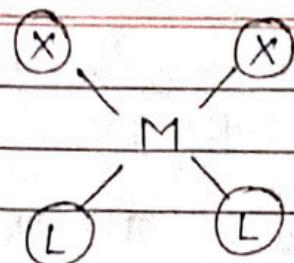
- * Observed in bridging ligands in such complexes ligands differ in terms of their position.

2. Stereoisomerism :-

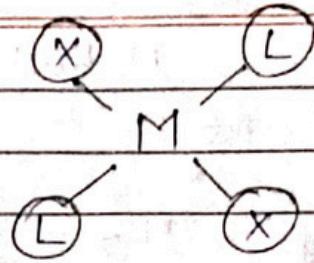
Compound which have same molecular formula but different 3-D arrangement of atoms in space.

(a) Geometrical -

- * common in compound having CN = 4 or 6.
- * square planar compound formula $[\text{MX}_2\text{L}_2]$
 CMA  unidentate

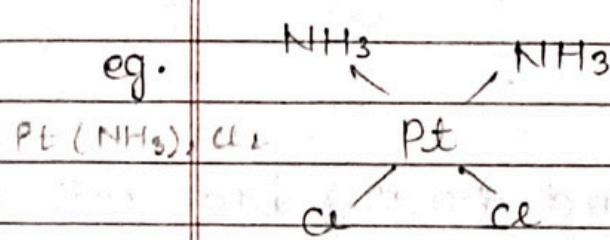


cis
same ligands
on same plane

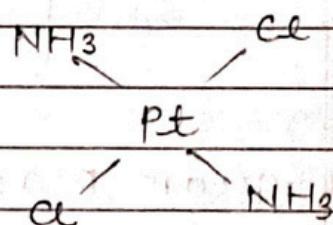


trans
same ligand are on
different plane.

e.g.

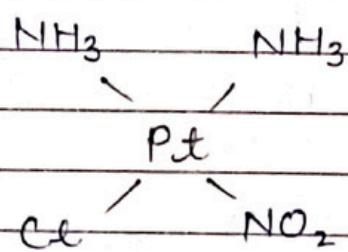
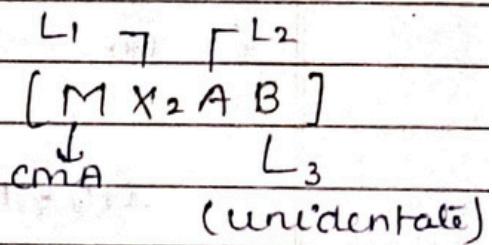


cis - platinum
(anti-cancerous drug)

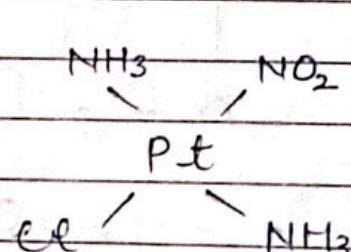


trans - platinum
(no effect on cancer)

* Square planar compound $[M X_2 A B]$



cis



trans.

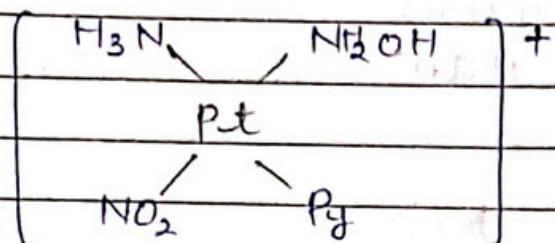
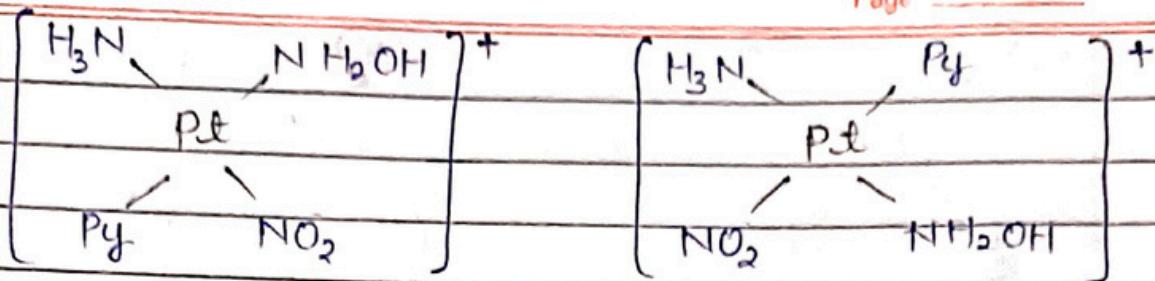
* Square planar compound $[M A B C D]$

→ unidentate

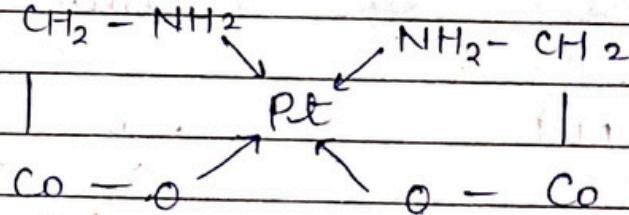
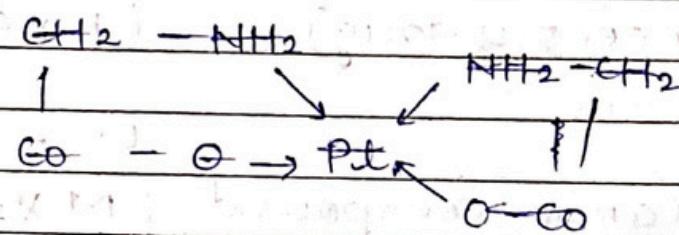
→ 3 isomers are possible.

Py \rightarrow Pyridine

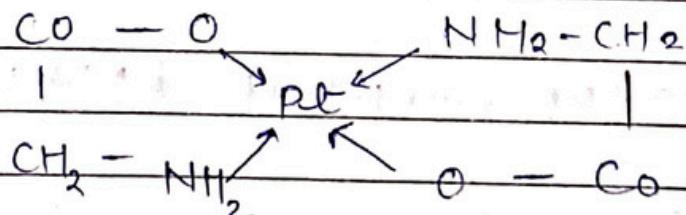
Date: _____
Page: _____



* Square planar compound having bidentate ligands -

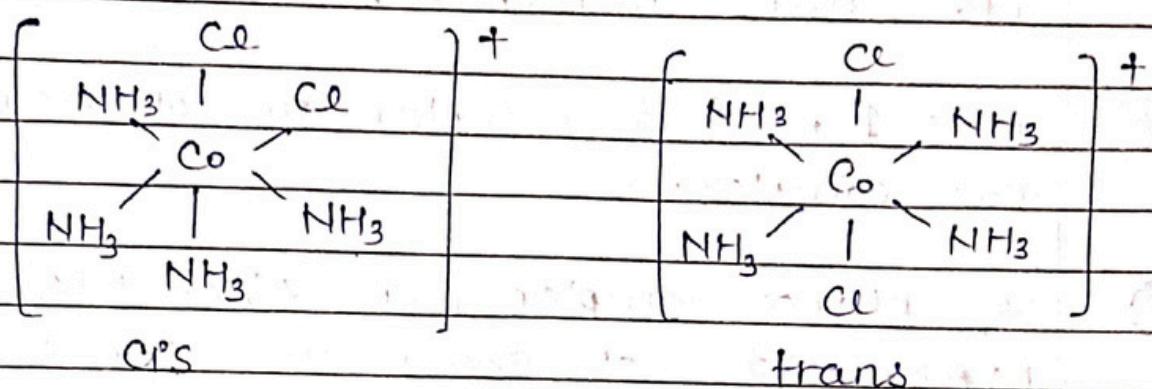


CIS.

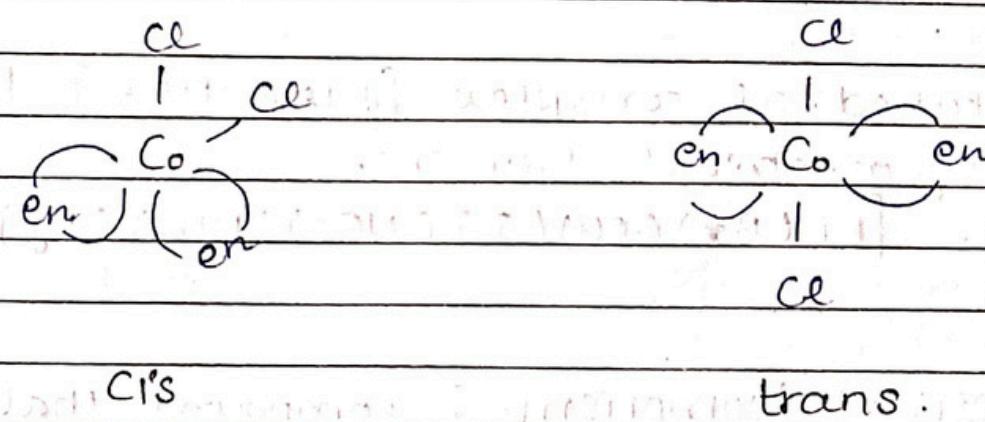


trans

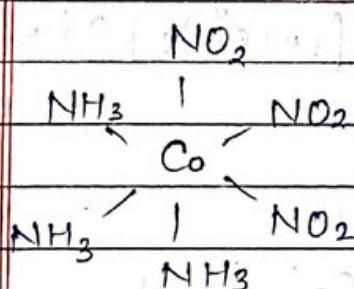
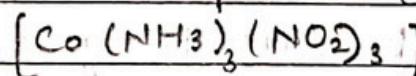
Octahedral complex ($CN = 6$) :
 $(MA_2 L_4)$



Octahedral complex bidentate ligands:

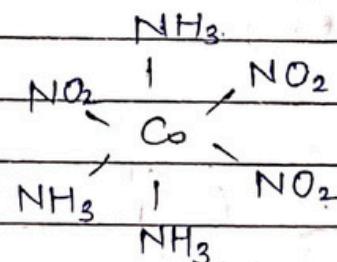


Octahedral complex $[MA_3B_3]$



facial

fac isomer.

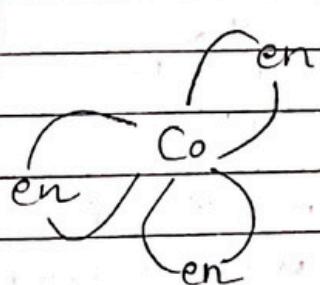


meridional

mer isomer.

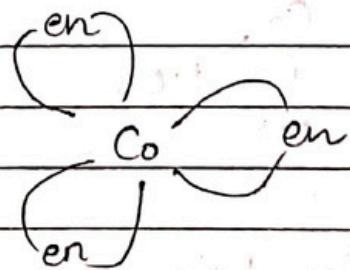
Imp points :-

- ① Tetrahedral complex ($CN = 4$) do not show cis - trans isomerism.
- ② $CN = 1, 2 \& 3$ complex do not show geometrical complex.
- ③ Sq. planar complex ($CN = 4$) of MA_4 , MA_3B , MAB_3 do not show cis - trans isomers.
- ④ Octahedral complex ($CN = 6$) of type MA_6 and $MAsB$ do not show geometrical isomerisms.
- ⑤ * Octahedral complex $[MABCDEF]$ have 15 geometrical isomers.
 e.g. $[Pt\{Br\}(Cl)(I)(NO_2)(NH_3)(Py)]$
- ⑥ Optical Isomerism : Compound that have same formula but different optical activities. These are also called as Enantiomers (because they are non-superimposable mirror images of each other).
 e.g. $[Co(en)_3]Cl_3$



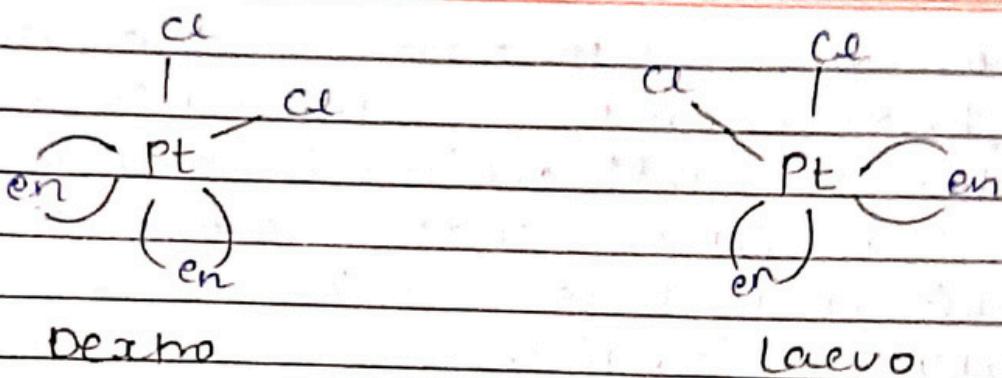
dextro

deviates plane polarise light clockwise



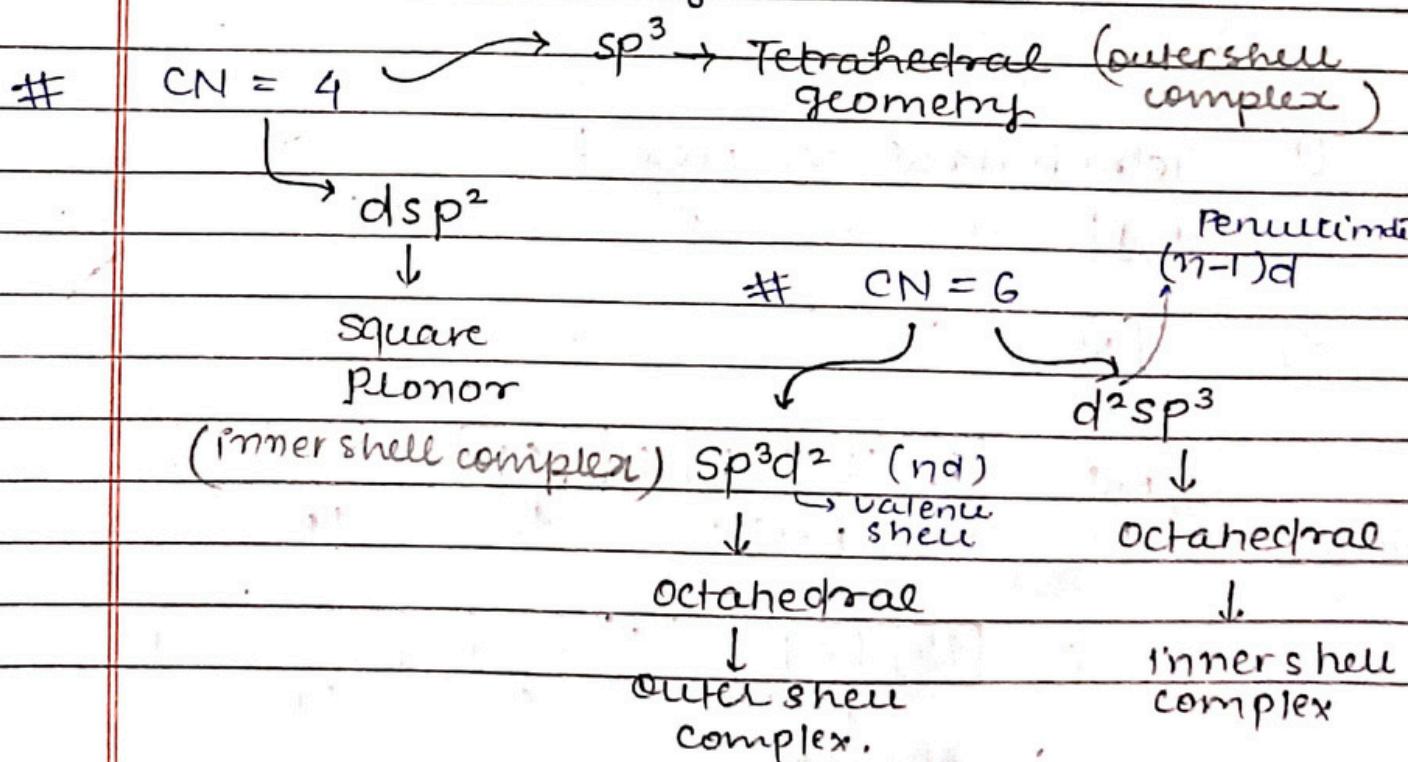
laevo

deviates the plane polarise light anti-clockwise



Valence Bond Theory (VBT) :-

- ↳ Pauling's gave VBT.
- ↳ The orbitals of central metal atom i.e. $(n-1)d$, ns , np and nd may participate in hybridisation.
- ↳ The newly formed hybrid orbital of CMA will now overlap with orbital of ligands.
- ↳ Based on the hybridisation of central metal atom its geometry is decided.



* Those compound that have $(n-1)d$ orbital in hybridisation is called Inner shell complex. whereas (nd) orbital in hybridisation or those complex that do not have $(n-1)d$ orbitals in hybridisation are called as outer shell complex.

VBT in compound having CN = 4:-

~~Strength of ligands
are classified by
spectrochemical
series.~~ Strong

Ligands

I. Octahedral

→ square planar

NH₃

F-1

co

Cl^-

Py

Br

en

I -

$$\text{CN}^-$$

H-2

last

- 2 -

NOT

3

① Tetrahedral complex :

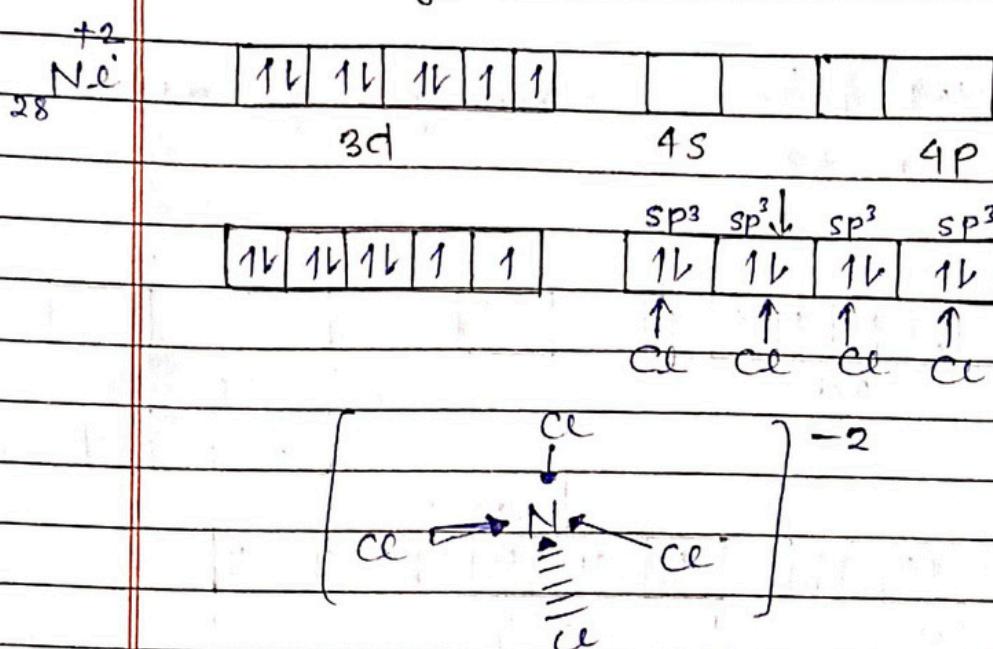
↳ hybridisation sp^3 CN=4

$$\text{eg. } \left[\text{Ni}(\text{Cl})_4 \right]^{+2}$$

^{28}Ni	1s	1s	1s	1	1	1s		
	$(n-1)d$					4s	4p	

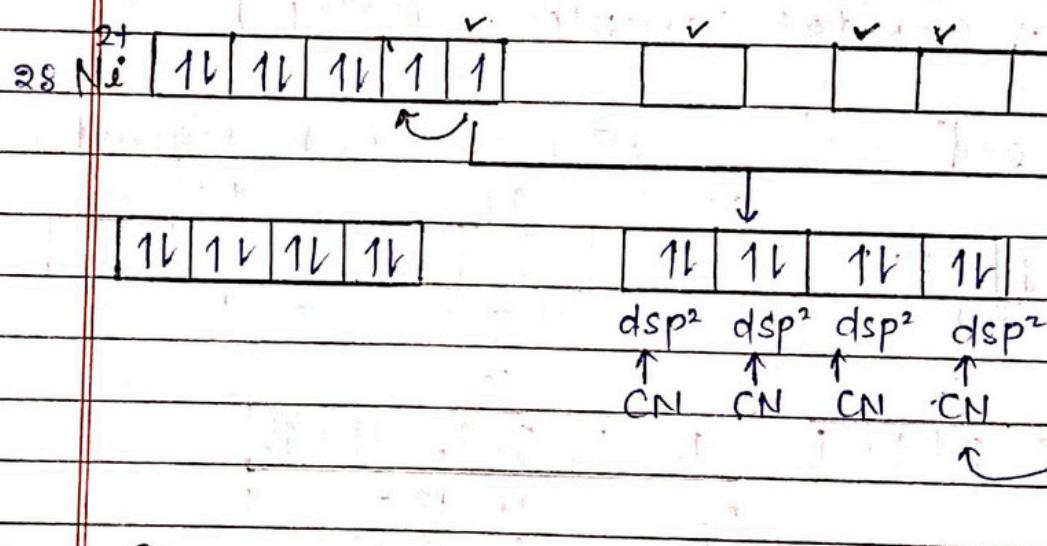
$^{+2}_{28} \text{Ni}$	1	1	1	1	1			
			$(n-1)d$			4s		4p
			or	3d				

as the ligands are weak in nature :



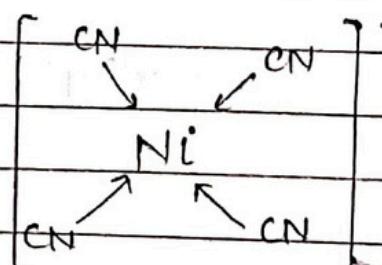
Note *: Because of unpaired electron this complex is PARAMAGNETIC and COLOURED.
High spin complex, outer orbital complex.

Ex. $[Ni^+(CN)_4]^{+2}$; as ligand are strong CN = 4



* Square planar

* Diamagnetic. * Inner orbital complex.



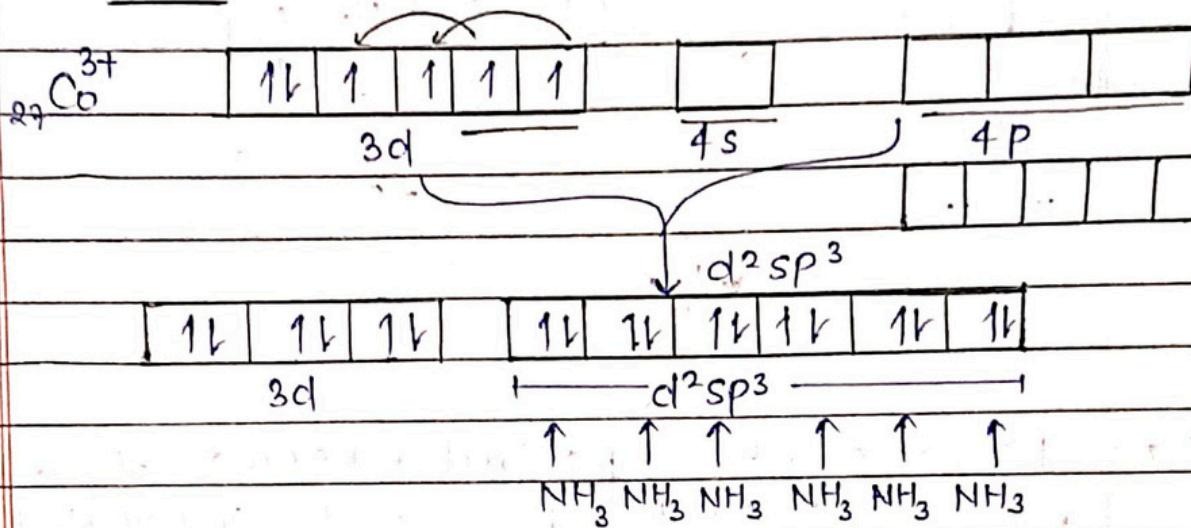
* Low spin complex
(unavailability of free e⁻).
* dsp^2

(2) complexes with CN = 6

e.g. $[\overset{+3}{\text{Co}}(\text{NH}_3)_6]^{3+}$ strong ligands

$$\alpha + 6(0) = +3$$

$$n = +3$$



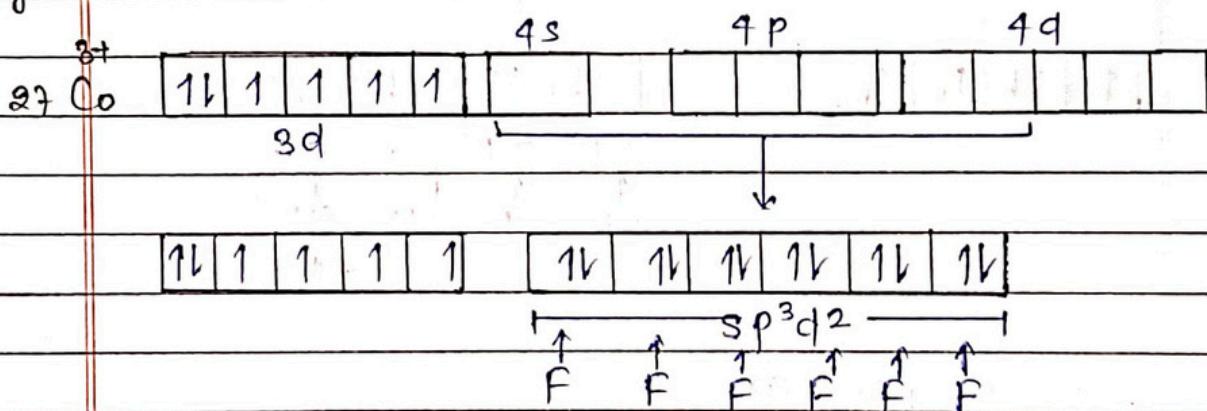
→ Octahedral

→ Low spin complex

→ Diamagnetic in nature

→ Inner orbital complex (d^2sp^3)

e.g. $[\overset{+3}{\text{Co}}\text{F}_6]^{-3}$ F^- is a weak ligand.



→ Octahedral

→ Higher spin complex

→ Outer Orbital complex (sp^3d^2)

→ Paramagnetic.

II

Magnetic Properties:

Those complex in which CMA have atleast 1 unpaired are PARAMAGNETIC while those that have ^{do not} any any unpaired e⁻ are DIAMAGNETIC.

Magnetic moment (μ):

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

if $\mu = 0$; $n = 0$; Diamagnetic

if $\mu \neq 0$; $n \neq 0$ ($n > 0$); Paramagnetic

* ₂₂Ti³⁺, ₂₃V⁺³, ₂₄Cr⁺³, we can directly observed the number of unpaired e⁻ because of availability of two d-orbital $(n-1)d$ for hybridisation.

* Metals after Mn do not have available $(n-1)d$ -orbital for hybridisation because of availability of two d-orbitals for $(n-1)d$ hybridisation.
they have e⁻ in it.

Limitations:

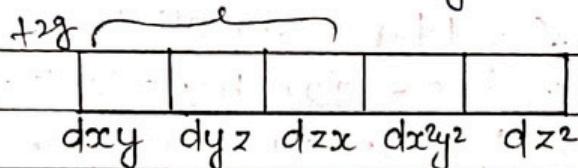
- ① VBT do not tell anything about colour.
- ② Quantitative data of magnetic properties is not given by VBT.
- ③ Do not differentiate between strong and weak ligand.
- ④ We can't predict the hybridisation of complex having CN = 4 i.e. square planar or tetrahedral.

CRYSTAL FIELD THEORY (CFT) :-

↳ Based on electrostatic model which involves :-

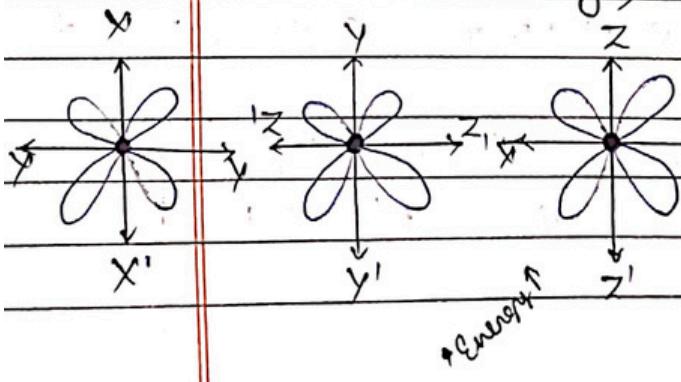
- i). Anionic ligands are negatively charged and neutral ligands are considered as point dipoles where the negative part is oriented towards cma.
- ii). The interaction between cma and ligands are completely electrostatic (ionic) and there is no intermixing of orbitals, & no insertion of e- in metal orbitals.
- iii). Degenerated d-orbitals :

Normal atom in its gaseous form.

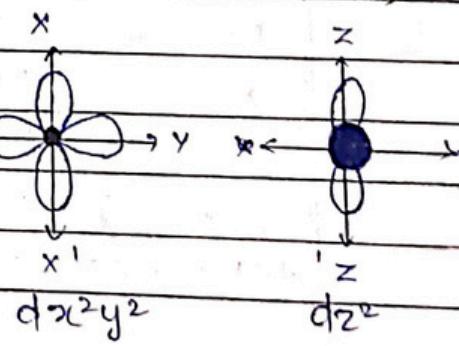


all of them have equal energy and hence are considered as degenerated orbitals.

Non-Axial Orbitals
or triply Degenerated
orbitals (t_{2g}).



Axial Orbitals or
Evenly degenerated
orbital (e_g)



* When the ligand approaches these degenerate orbitals they observed different in the energy of d-orbitals i.e. t_{2g} and e_g have different energy and hence loss of degeneracy is observed & hence it is called Crystal Field splitting.

Note: →

If ligand surround CMA symmetrically then CFS do not take place therefore no loss of degeneracy is observed.

Crystal Field Splitting in Octahedral Entities :-



because ligands are attacking on $(x-x')$, $(y-y')$ & $(z-z')$ axis t_{2g} orbital of CMA are not on the x, y, z axis ∵ feel least repulsion from incoming ligands. (\downarrow their energy for compensation)

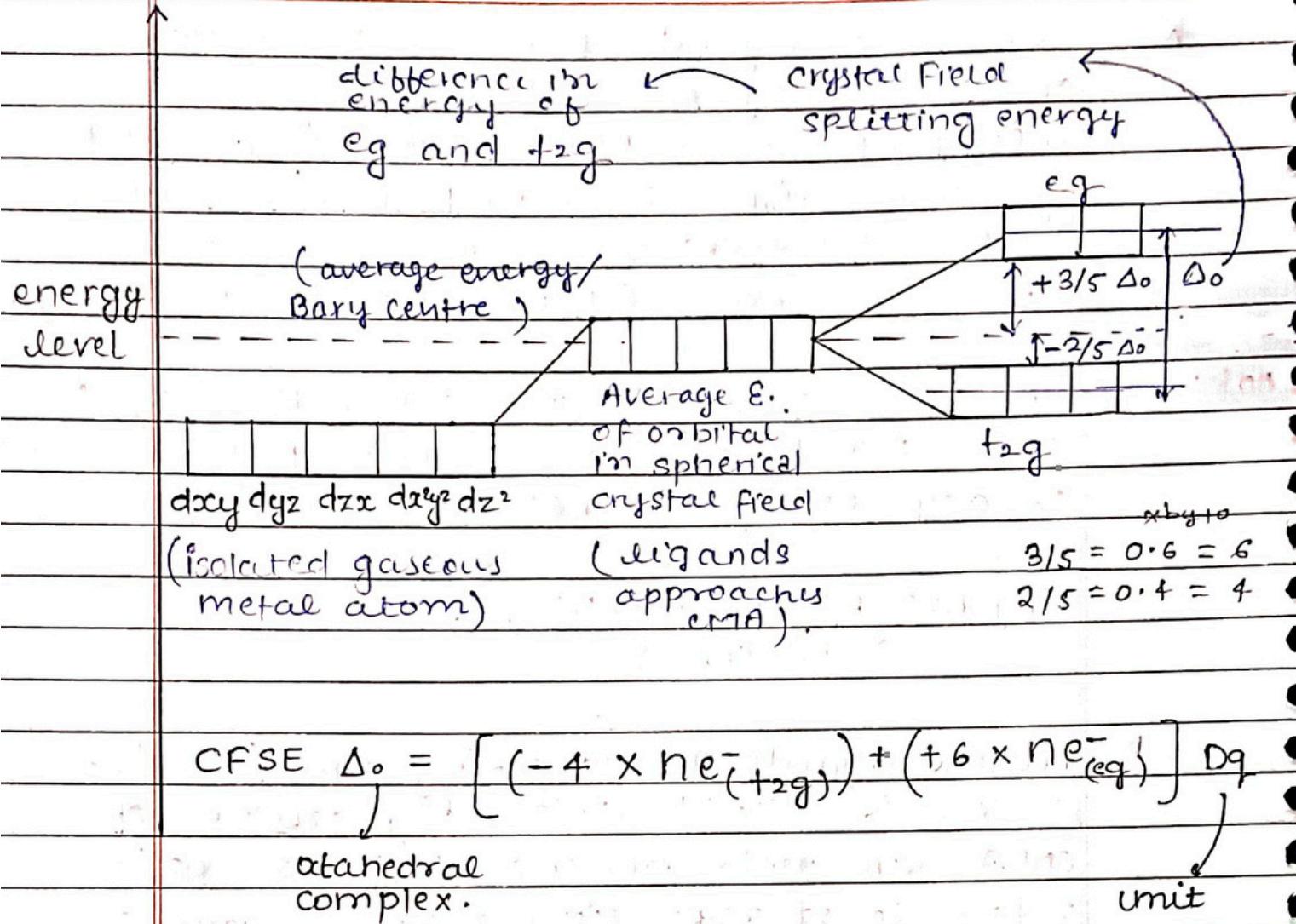


but $d_{x^2-y^2}$ and d_{z^2} orbital will feel greater repulsion from incoming ligands because of this we will observed CFS i.e. loss of degeneracy. (\uparrow in energy)

Note: In tetrahedral field complex, the d-orbital splitting is smaller. The orbital splitting energies are not sufficiently large for force pairing.

Octahedral.

Date: _____
Page _____



$$CFSE \Delta_0 = [(-4 \times n e^-_{(t_{2g})}) + (+6 \times n e^-_{(e_g)})] Dq$$

Octahedral complex.

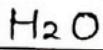
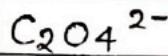
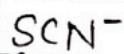
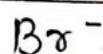
- * Δ_0 of d -orbital depends upon the field generated by the ligands. The arrangement of the ligand in the increasing order of their strength is called as 'SPECTROCHEMICAL SERIES'.

Ligand strength :-

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

CFSE (Δ_o) depends on -

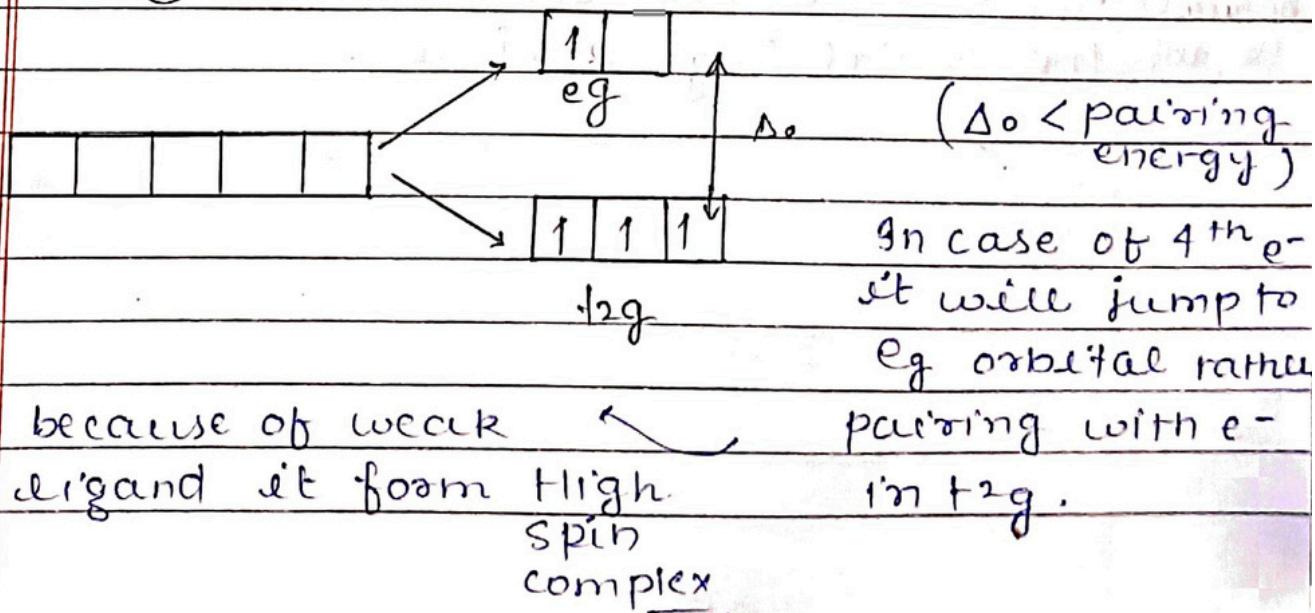
- (a) oxidation number of metals
- (b) size of metals
- (c) complex geometry
- (d) strength of ligands



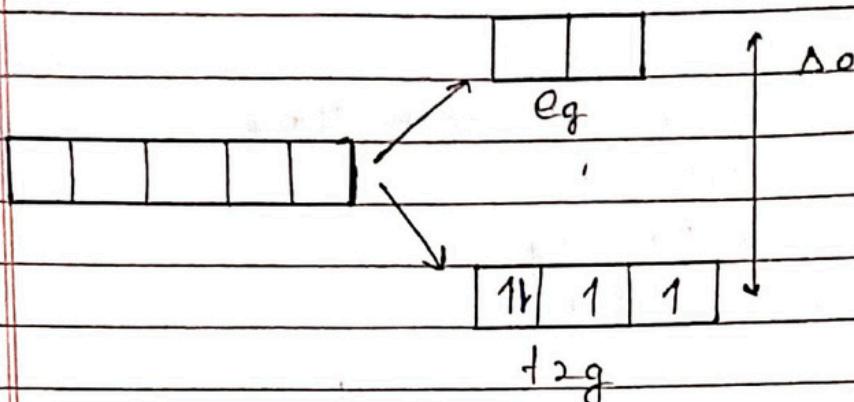
Increasing
strength.



* case ① :



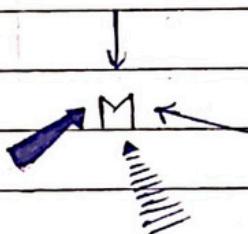
Ans ②



$\Delta_o >$ pairing energy
 hence, 4th e⁻ will pair with the electron of t_{2g} and e_g remain vacant.

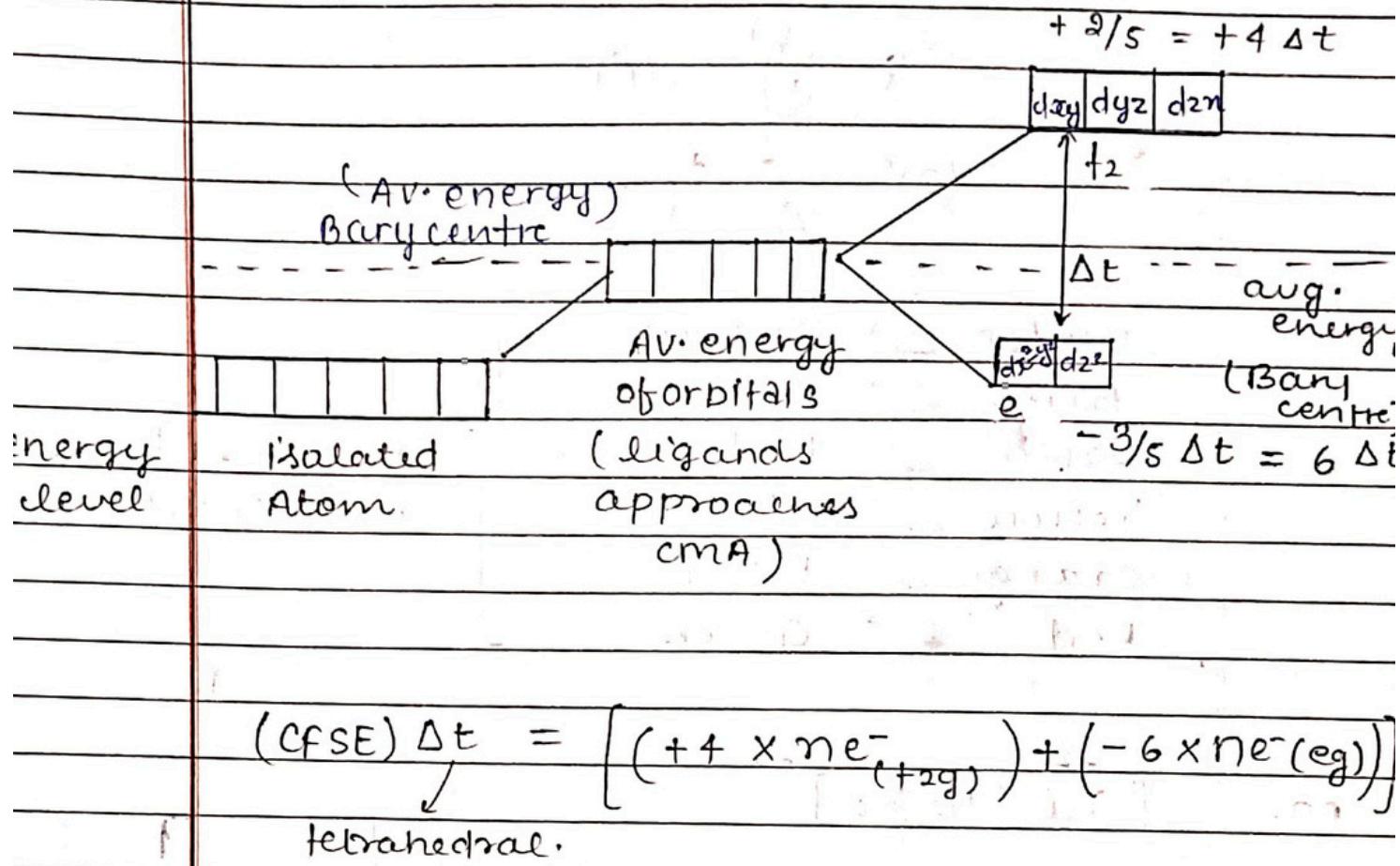
Δ_o is high because of strong ligands
 ∵ Low spin complex
 (because of ↑ in paired e⁻)

CFS in tetrahedral complex :-



In such complexes the ligand approaches the between or non-axial orbitals (t_{2g}) and not the axial (e_g) orbital.

(Tetrahedral.)



$$(CFSE) \Delta t = [(+4 \times n e^{-}_{(t_{2g})}) + (-6 \times n e^{-}_{(e_g)})]$$

tetrahedral.

unit $\Rightarrow \text{Dq}$

Colours in Coordination Compounds :-

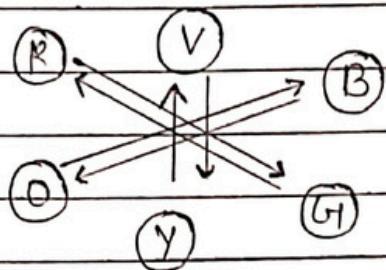
When a white light enter the co-ordination ion salt solution, it will absorb a light of a particular wavelength (λ) or frequency (ν)

$$C = \lambda \nu$$

$3 \times 10^8 \text{ m/s}$

$$\nu = \frac{c}{\lambda}$$

Hence, the solution will now indicate the colour of complementary type.



Violet \rightleftharpoons Yellow

Blue \rightleftharpoons orange

Green \rightleftharpoons Red

Yellow \rightleftharpoons violet

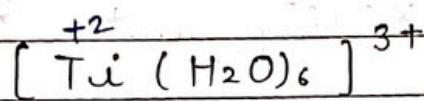
Orange \rightleftharpoons Blue

$$\text{Red} \rightleftharpoons \text{Green}$$

Complementary

Colour Chart

eq.



Tui⁺³

22

1 Valated

Ligand approach

eg

1

According to CFT:

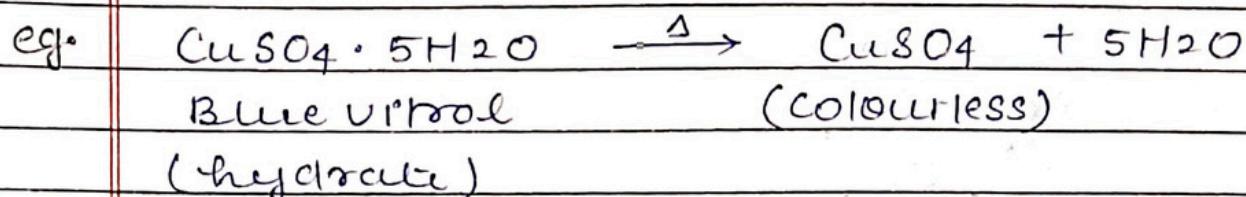
Ti^{+3} requires 498 nm. radiation

Yellow - Green light

after absorb the 498 nm hv, it will show d-d transition (transfer of e- from $t_{2g} \rightarrow e_g$)

Now, the complex will radicle purple - violet colour

* If ligands are removed then no loss of degeneracy or CFS and therefore the we will observe colourless behaviour from the compound.



Limitation of Crystal Field Theory :-

- i) Do not explain covalent bonding.
- ii) CFT suggest that ligands are anionic or neutral (dipole - where -ve part is towards metal).

According to this $X > O > N > C$ should be the strength order of ligands but reality is opposite.

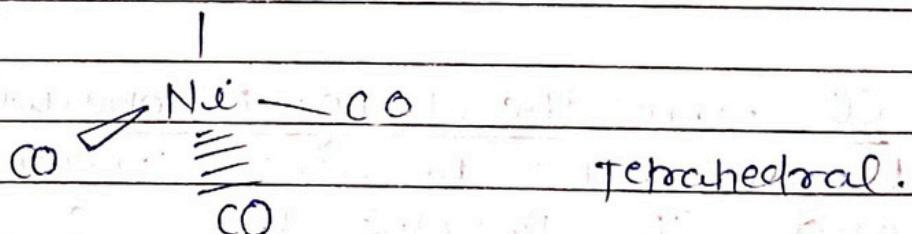
Bonding in Carbonyl Compound :

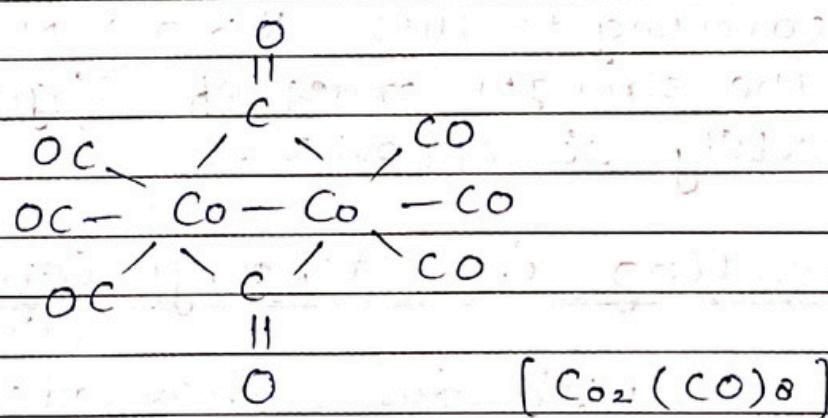
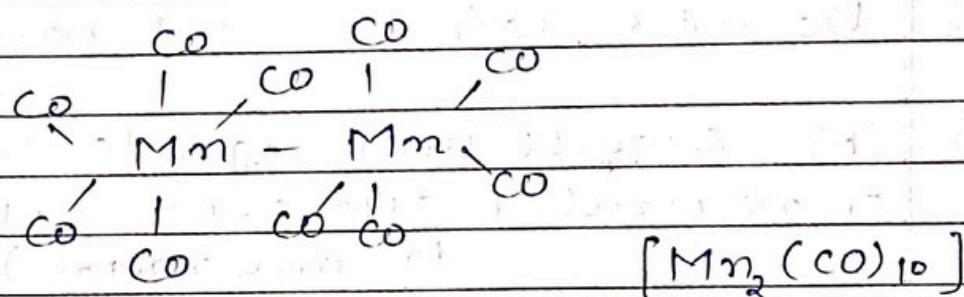
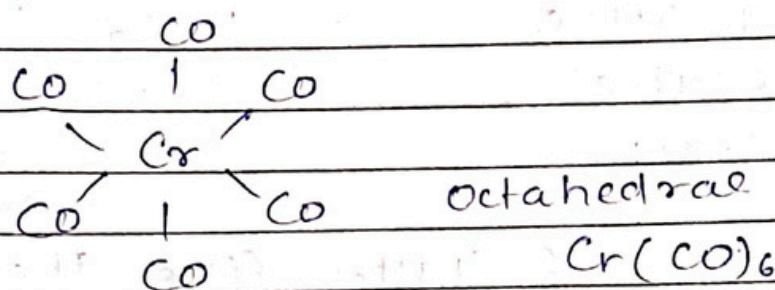
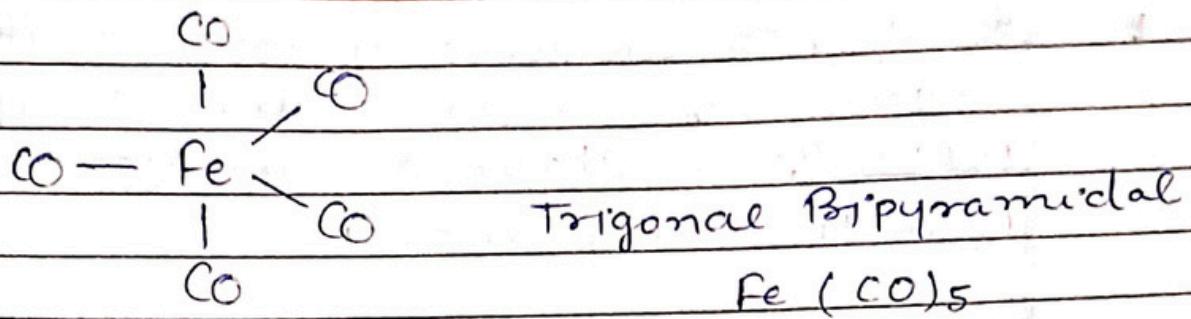
[Co]

Usually it form homoleptic complex

CO

eg.

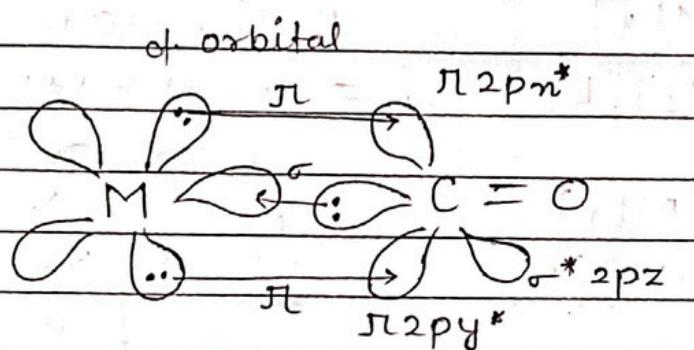




* CO forms the strongest bond with metals.
because the bonding between metals
and CO involve both s and p
orbital

i First σ bond between metal and carbonyl group is formed by the donation of lone pair from "carbon" of CO_{gray} to the vacant d-orbital of Metal M.

ii formation of π bond is observed when lone pair of metal is donated to the anti-bonding vacant orbital of CO ligand.



\Rightarrow This type of bonding is known as (SYNERGIC) BONDING.

because of formation of synergic bond CO ligand form strong bond with metal

(CO , CN^- , NO) \rightarrow form synergic bonding

STABILITY OF COORDINATION COMPOUND

The stability of a complex compound in solution refers to degree of association between two species involved in state of equilibrium.