

PARISHRAM



2026

Coordination Compounds

CHEMISTRY LECTURE-1

BY – BIJENDRA SIR (Biju Bhaiya)



Topic Covered

- Introduction ✓
- Terminology ✓

Coordination compound

Complex compound.



BIJENDRA SIR

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Which one among the following metals of 3d series has the lowest melting point?

- A Fe
- B Mn
- C Zn
- D Cu

mp < no. of unpaired e

$\rightarrow 4s^2 3d^{10}$

$n=0$.



Which of the following is not considered a transition element?

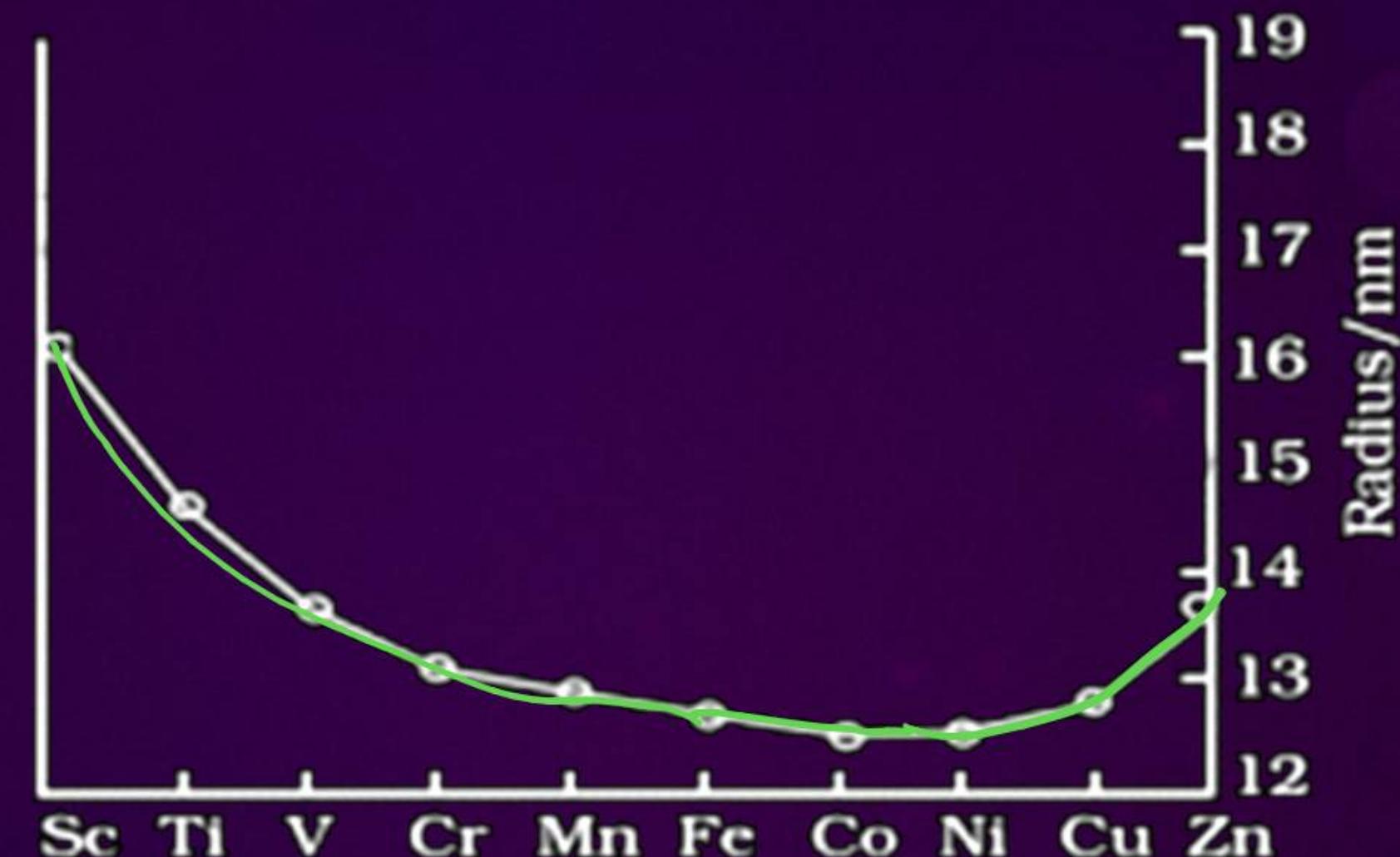
- A Scandium
- B Silver
- C Vanadium
- D Zinc

Zinc



The trend of which property is represented by the following graph?

- A ionization enthalpy
- B atomic radii
- C enthalpy of atomization
- D melting point



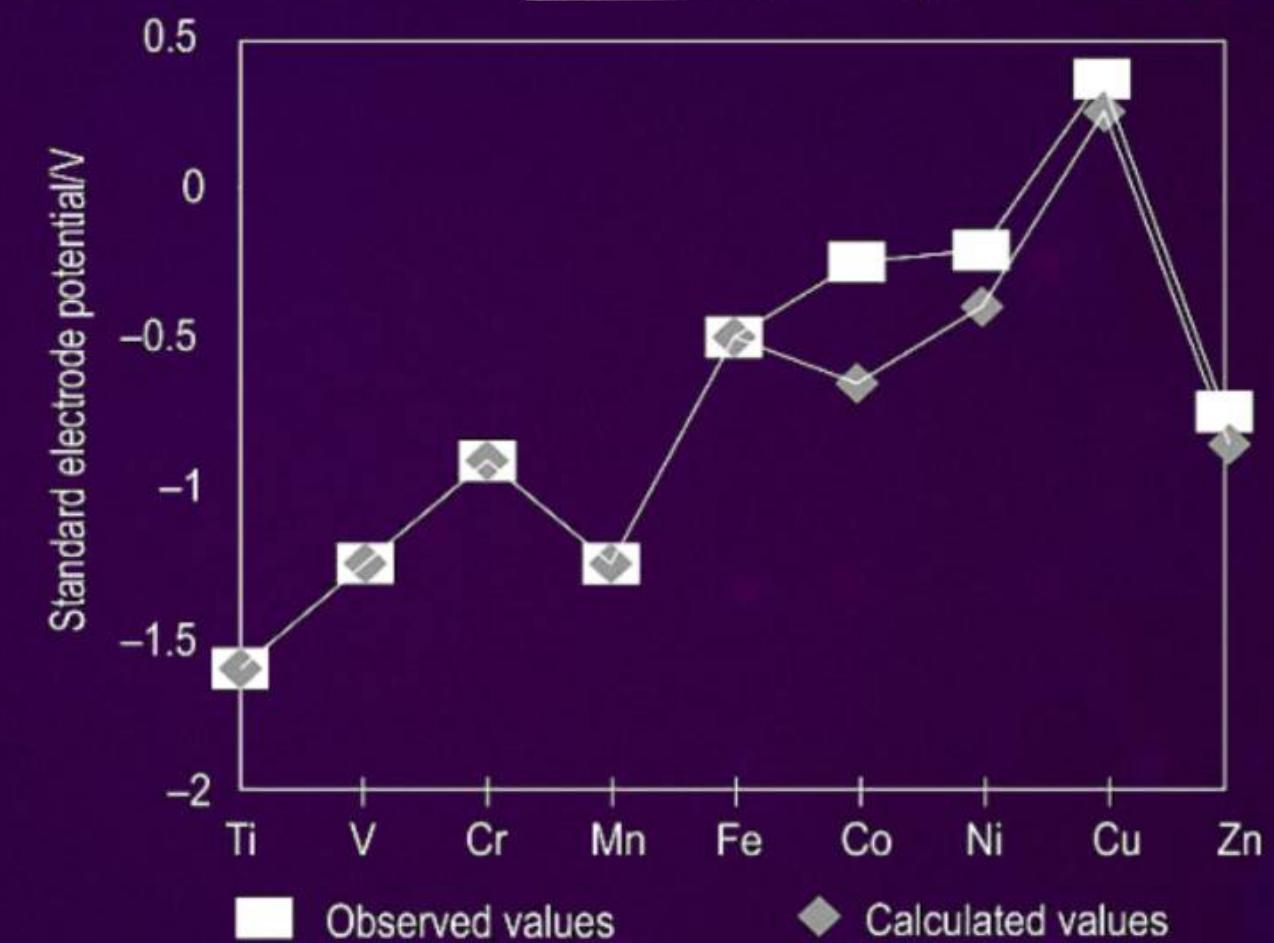
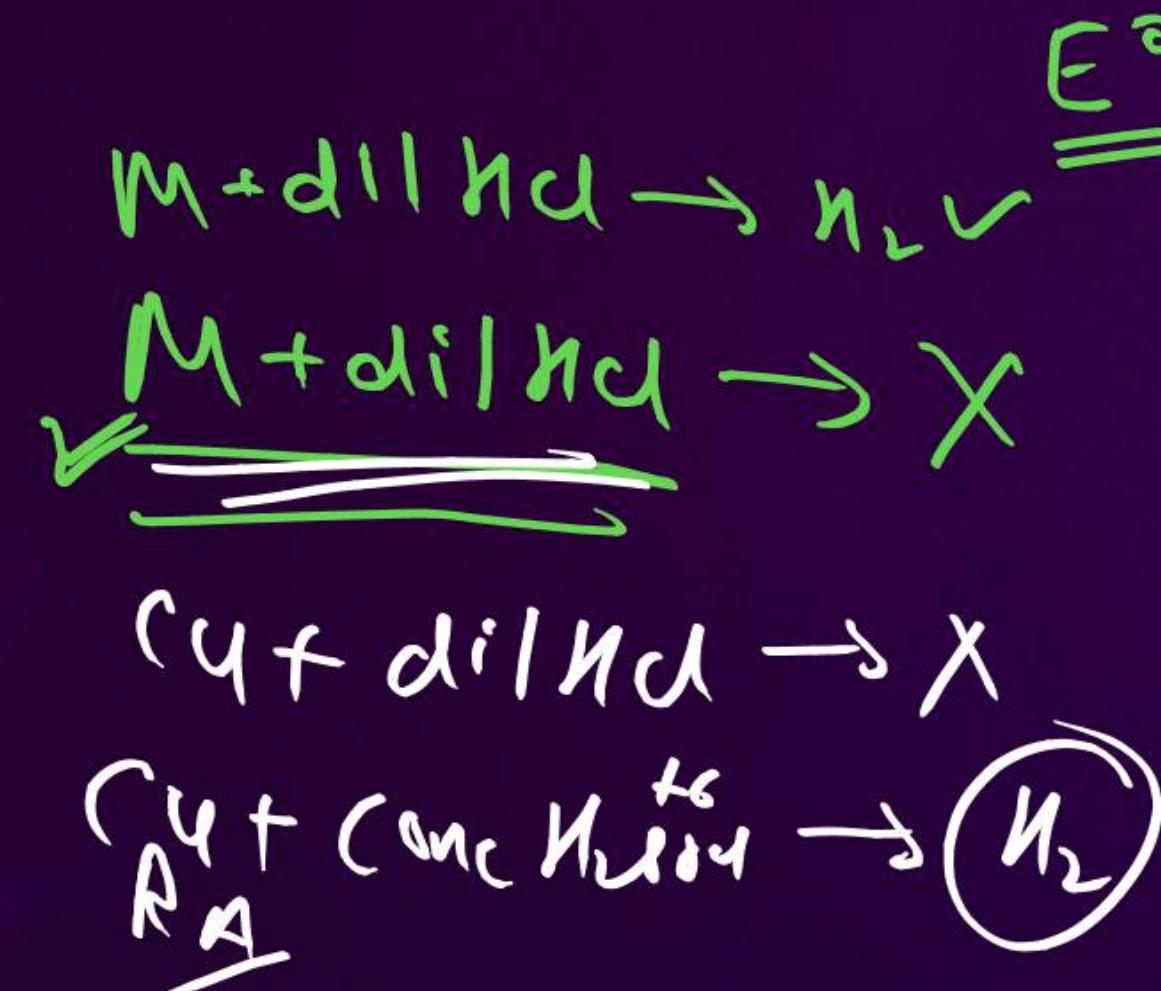


Study the graph given below.

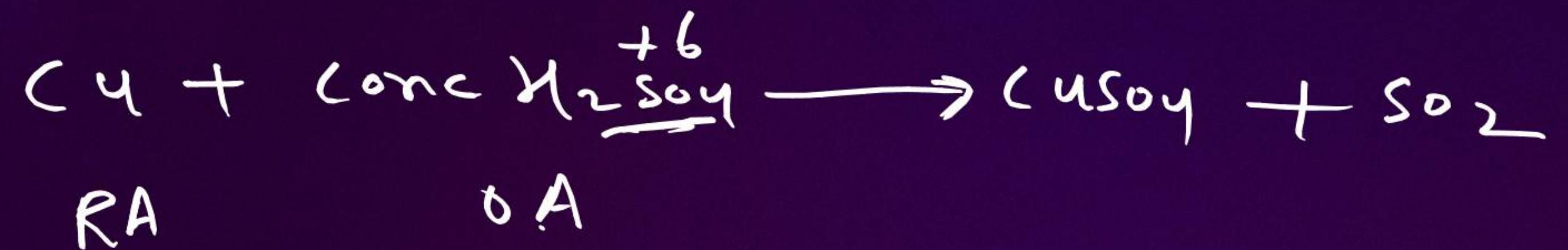
Based on the graph given, which element will MOST LIKELY be involved in the following reaction?



- A Cu
- B Co
- C Ti
- D Zn



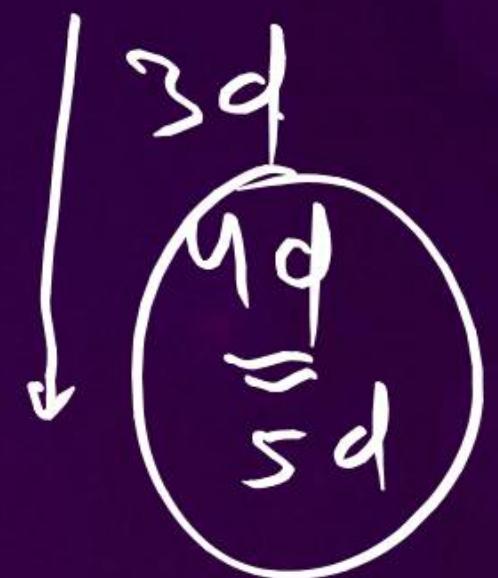
Observed and calculated values for the standard electrode potentials
 $(M^{2+} \rightarrow M^0)$ of the elements Ti to Zn





Which of the following options give the correct arrangement of the atomic radii of the 3d, 4d and 5d transition series of elements?

- A Atomic radii of 3d < atomic radii of 4d < atomic radii of 5d
- B Atomic radii of 3d < atomic radii of 4d = atomic radii of 5d
- C Atomic radii of 3d = atomic radii of 4d > atomic radii of 5d
- D Atomic radii of 3d > atomic radii of 4d > atomic radii of 5d



$$R(4d) = R(5d)$$

(l-c)



Which ion has maximum magnetic moment?

max no. of unpaired e.

A $\underline{V^{+3}}$

B $\underline{\underline{Mn^{+3}}}$ $4s^2 \underline{3d^5} \xrightarrow{-3e^-} 4s^0 \underline{3d^4} \quad n=4$

C $\underline{Fe^{+3}} \rightarrow 4s^0 \underline{3d^5} \quad n=5$

D $\underline{\underline{Cu^{+2}}}$



When KMnO₄ is reduced with oxalic acid in acidic solution, the oxidation number of Mn Changes from

- A 7 to 4
- B 6 to 4
- C 7 to 2
- D 4 to 2



Reduction.



Select the correct statement:



- A When d-block elements form ions, $(n - 1)$ d electrons are lost before ns electrons.
- B When d-block elements form ions, ns electrons are lost before $(n - 1)$ d electrons.
- C When d-block elements form ions, $(n - 1)$ f electrons are lost before ns electrons
- D None of these

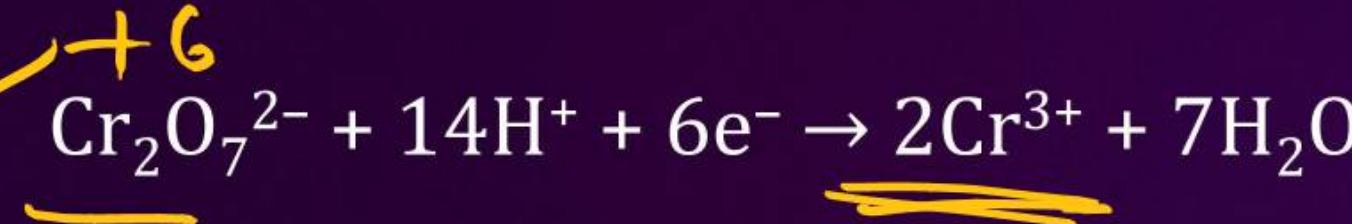


In acidic solution, oxidizing action of potassium dichromate can be represented as

A



B



C



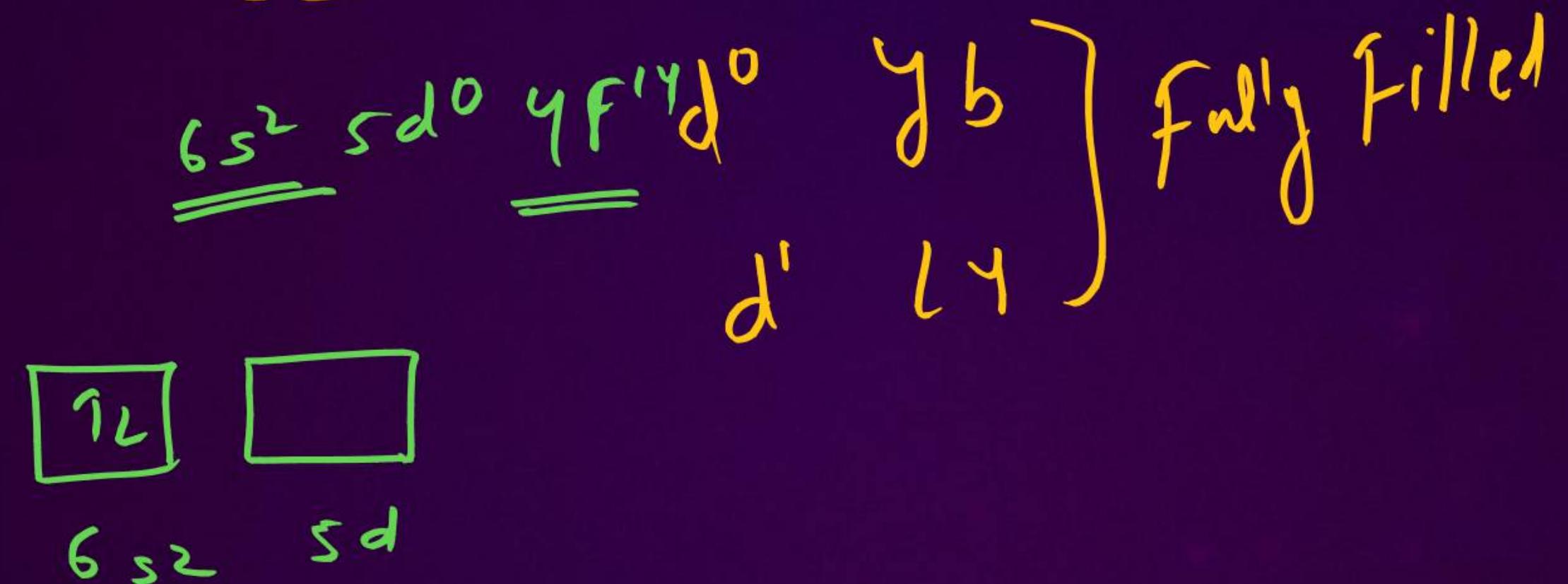
D





The number of unpaired electrons present, as per accepted electronic configuration in Yb(70) is/are :

- A 0
- B 1
- C 2
- D 7





Which of the following is paramagnetic?

- A Ni^{++}
- B Cu^+
- C Zn^{++}
- D Sc^{++}

$n \neq 0$





Introduction

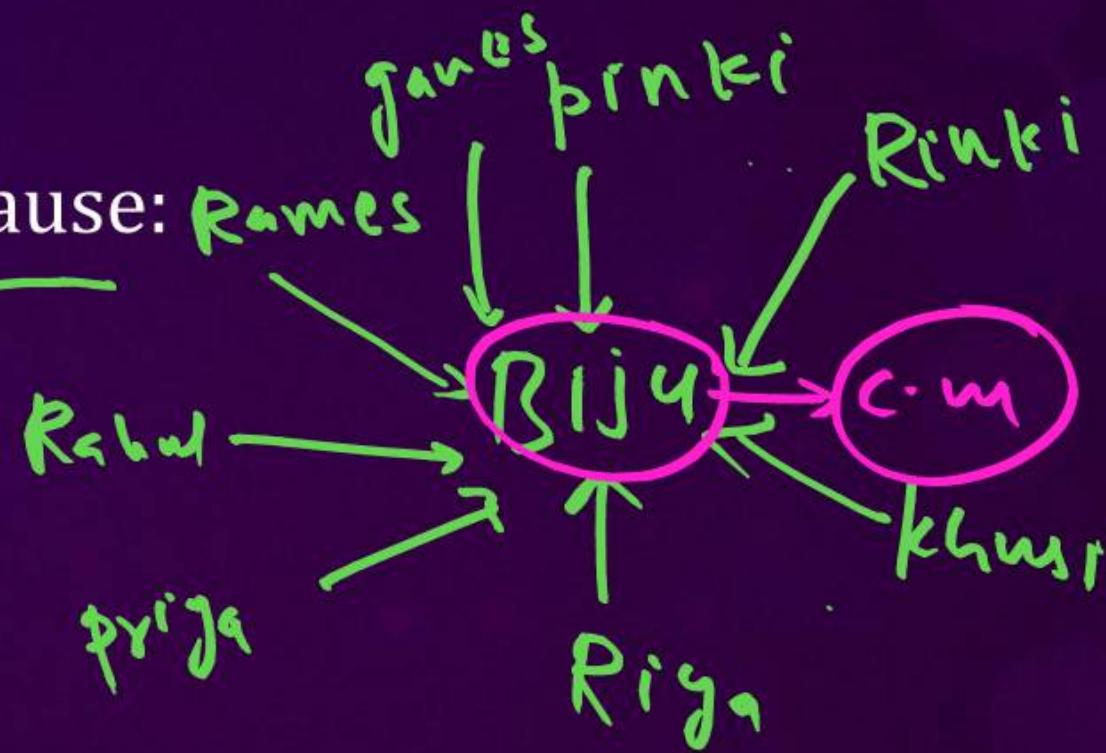
Coordination compound

A compound containing coordinate bonds, between a central metal atom and a number of other atoms or groups.

✓ The transition metal ions form co-ordinate compounds because:

1. They have small size.
2. They have vacant orbitals.
3. They can accept lone pairs of electrons.
4. high Ionic charge

Chlorophyll, haemoglobin and Vitamin B₁₂ are coordination compounds of Mg, Fe and Co respectively





↓
strong

bond length small
↓

size of metal small
≡

wedged

Radius dec.

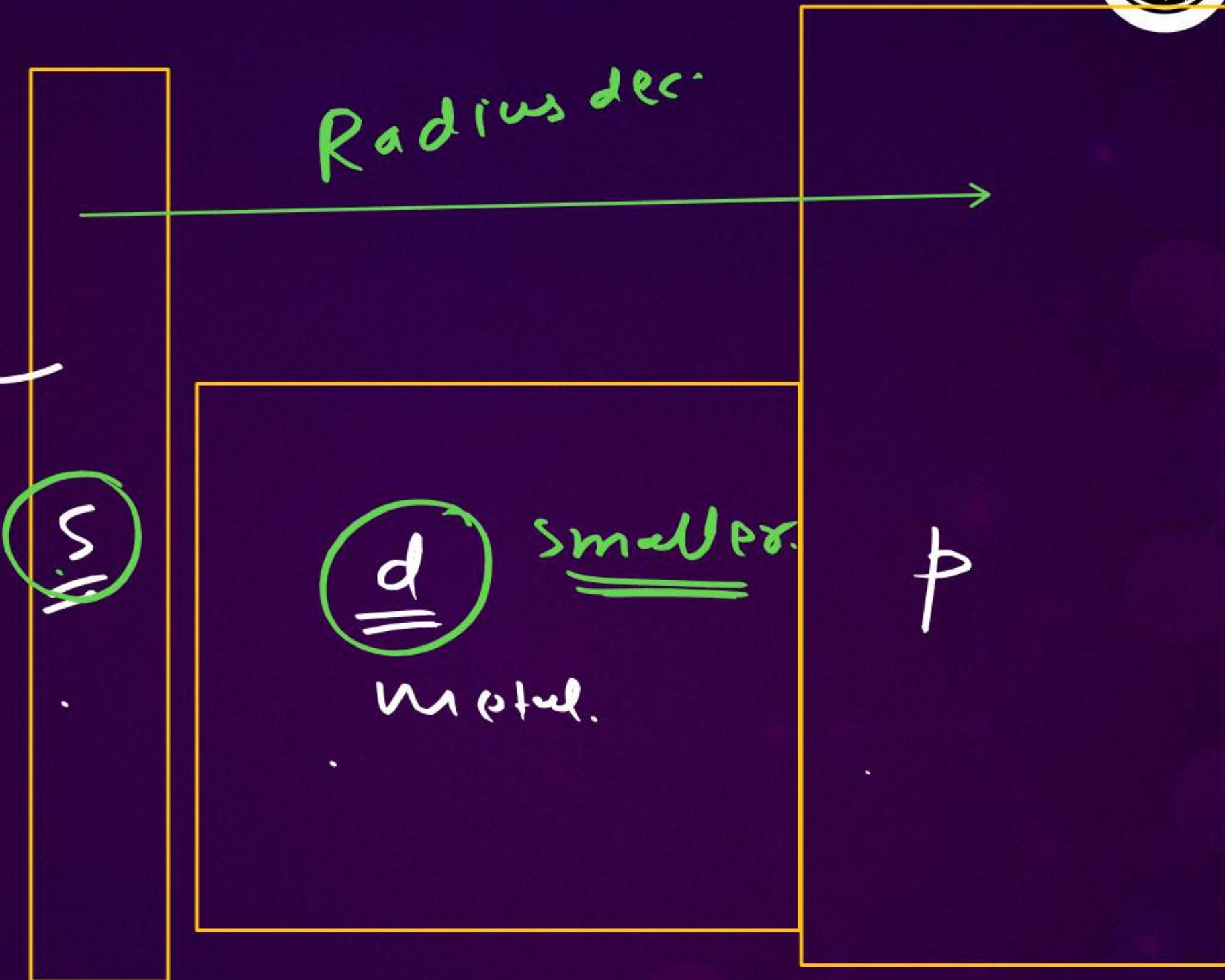
(S)

(d)

metal.

smaller

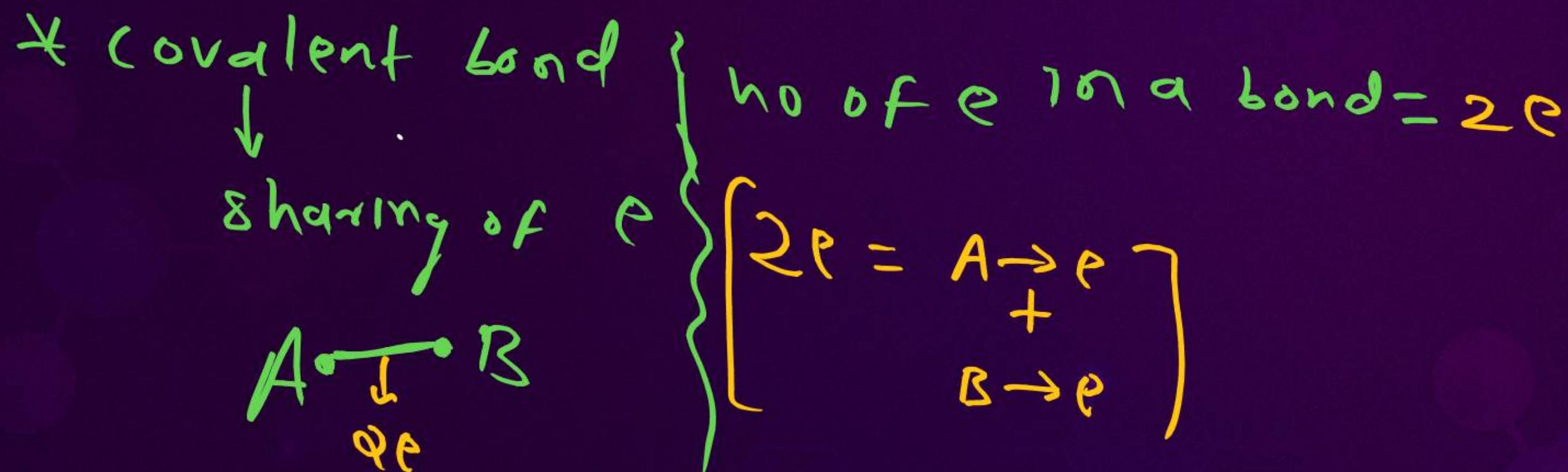
P



Coordination Compound.



coordinate bond. (ek Tarfa pyar)



Pankaj
50k

Pinki
50k

→ ~~golgap~~ → 1 lakh

Pankaj 50k → Theka

Oversman → 50k → Pinki

Pankaj 50k

Pankaj → Pinki

1 lakh

(50 + 50)

Pankaj

* group no

1

2

$13 - 10$

$14 - 10$

$15 - 10$

$16 - 10$

$17 - 10$

$18 - 10$

VE

1

2

3

4

5

6

7

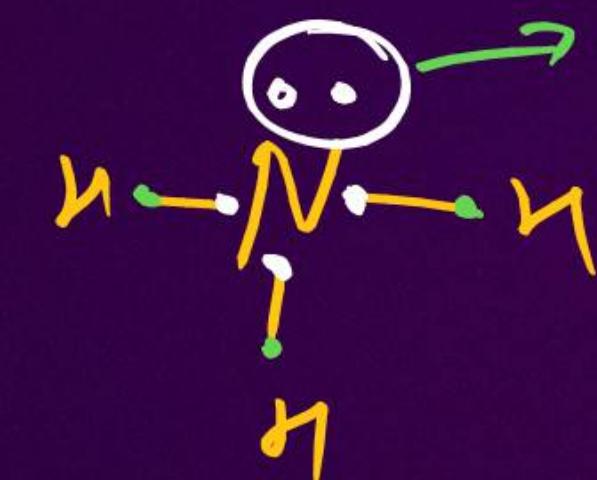
8

NH_3

$N \rightarrow \text{group no} \rightarrow 15$

$$VE = 15 - 10 = 5$$

lone pair



coordinate bond



↓
Donor Acceptor



↓
extra e
Vacant orbital.

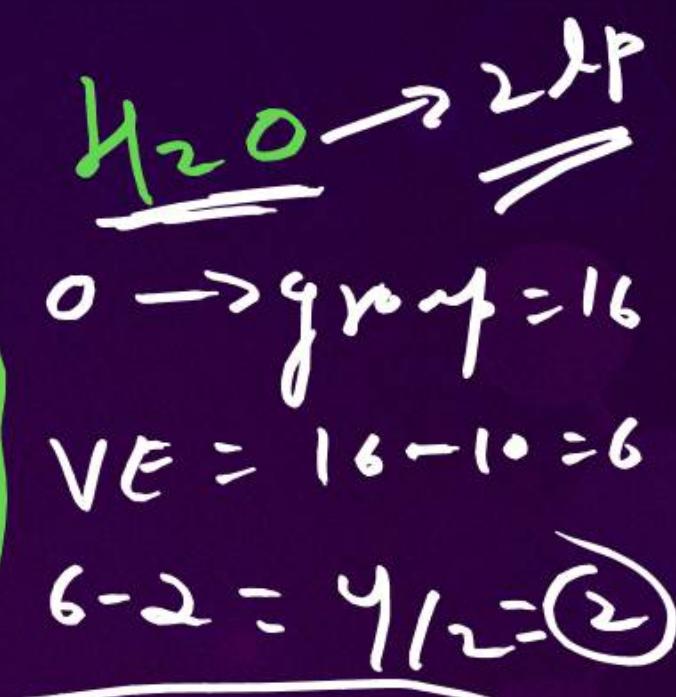
[lone pair / -ve charge]

both electrons are donated by single Atom.

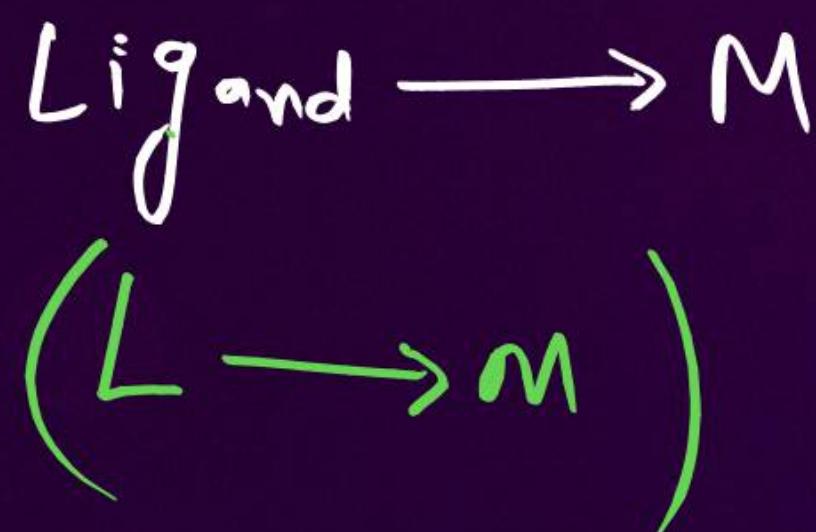
Lone pair

↓
e pair left after bonding.

H_3N^{\cdot} ↓ $5-3 = 2$ / $2 = 1$



Coordination compound \rightarrow A compound
containing coordinate bond b/w ligand &
metal is called



(Lewis Base) Coordination Compound.

$L \cdot B$

$L \longrightarrow M$

E donor E acceptor

Question

Vitamin B-12 contains:

A cobalt

B magnesium

C iron

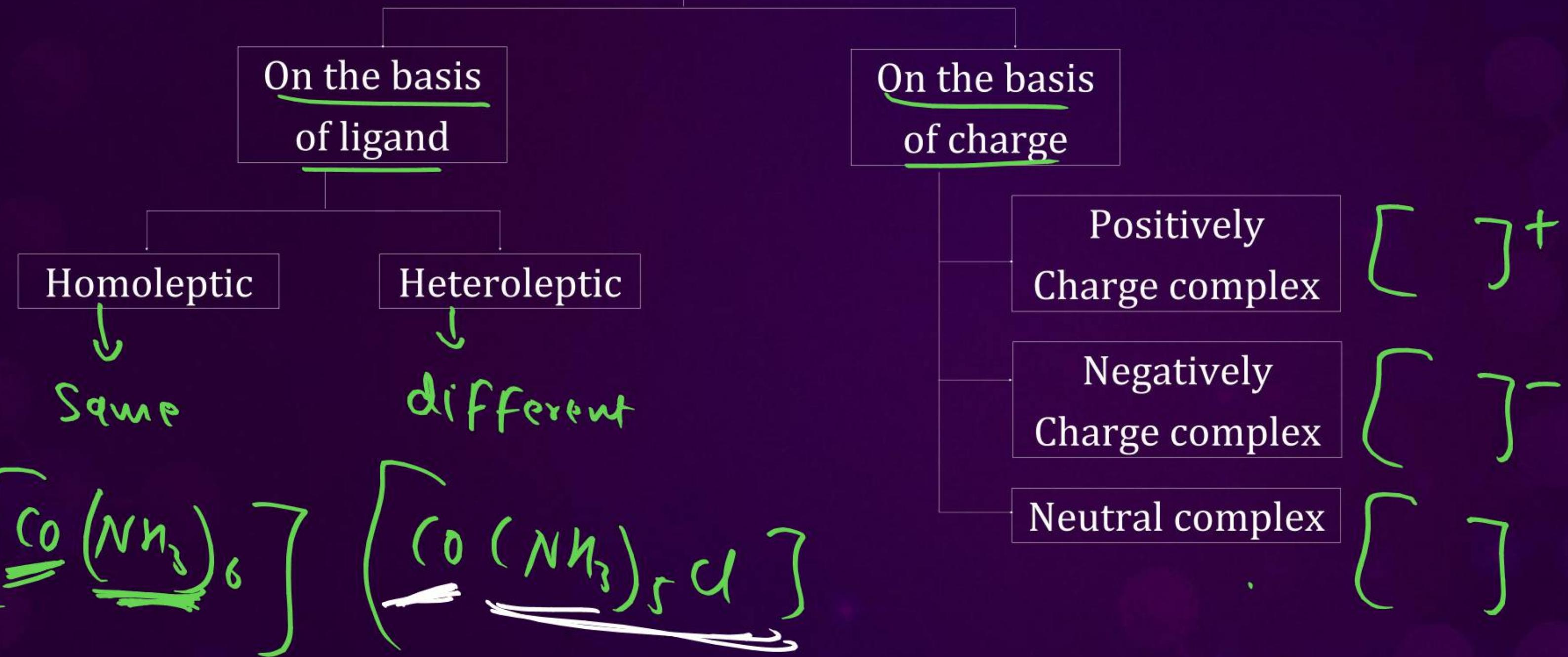
D nickel

Question

Chlorophyll contains:

- A magnesium
- B iron
- C cobalt
- D nickel

Classification of Coordination Compounds





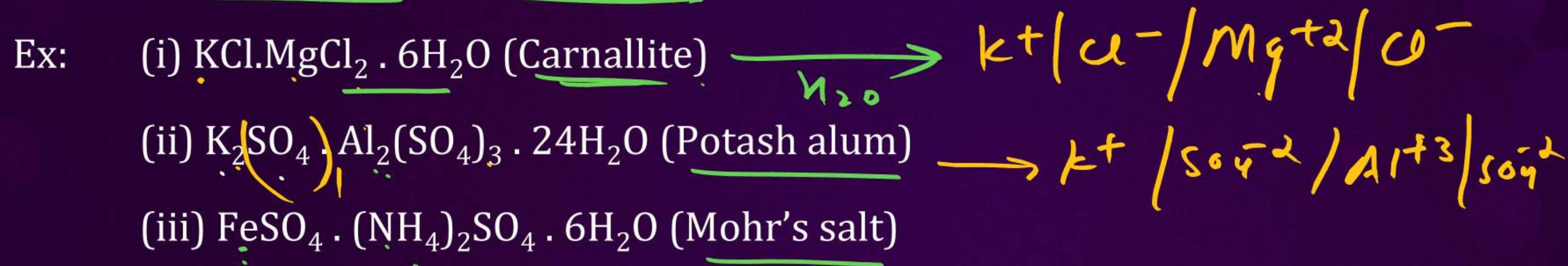
Double Salt

salt

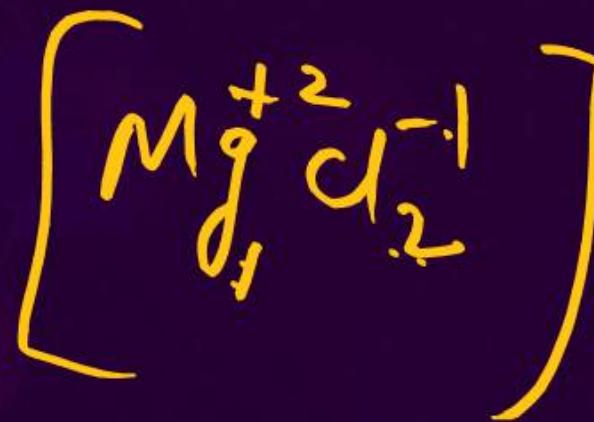
cation
Anion

Nad
 $\text{Na}^+ | \text{Cl}^-$

Double dissociate into simple ions completely when dissolved in water.



The carnallite gives the test for K^+ , Cl^- , Mg^{++} ions in aqueous solutions.



Question

Mohr's salt is

- A $\text{Fe}(\text{NH}_4)\text{SO}_4 \cdot 6\text{H}_2\text{O}$
- B $\text{Fe}(\text{NH}_4)_2 (\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$
- C $(\text{NH}_4)_2\text{SO}_4 \cdot \text{FeSO}_4 \cdot 6\text{H}_2\text{O}$
- D $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$



Question

An aqueous solution of potash alum gives

A

Two types of ions

B

Only one type of ion

C

Four types of ions

D

Three types of ions

Home Work

→ Pyo (D & F block).

PARISHRAM



2026

Coordination Compound

CHEMISTRY LECTURE-02

BY – BIJENDRA SIR (Biju Bhaiya)



Topic Covered

Terminology of Coordination Compound



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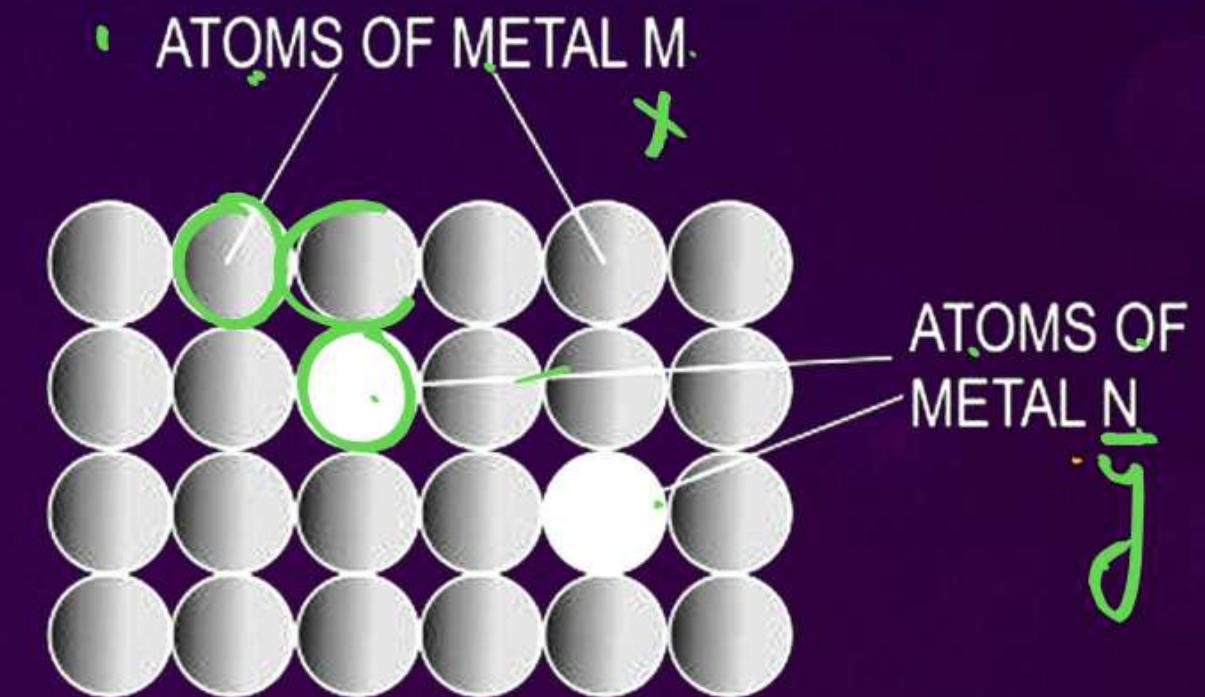
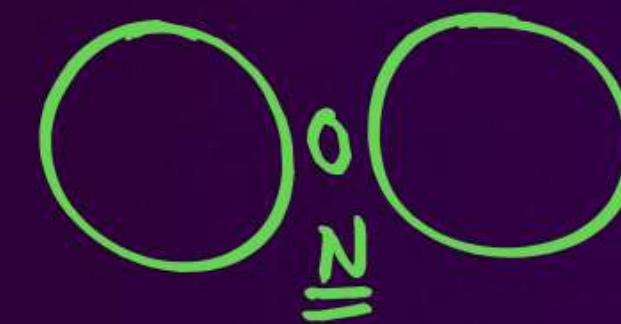
@BIJENDRASIRCHEMISTRY



Given below is an image showing a specific property of transition metals.

Which property of transition metals is shown in the image?

- A Catalytic action
- B Formation of alloy
- C Coloured complex formation
- D Interstitial compound formation



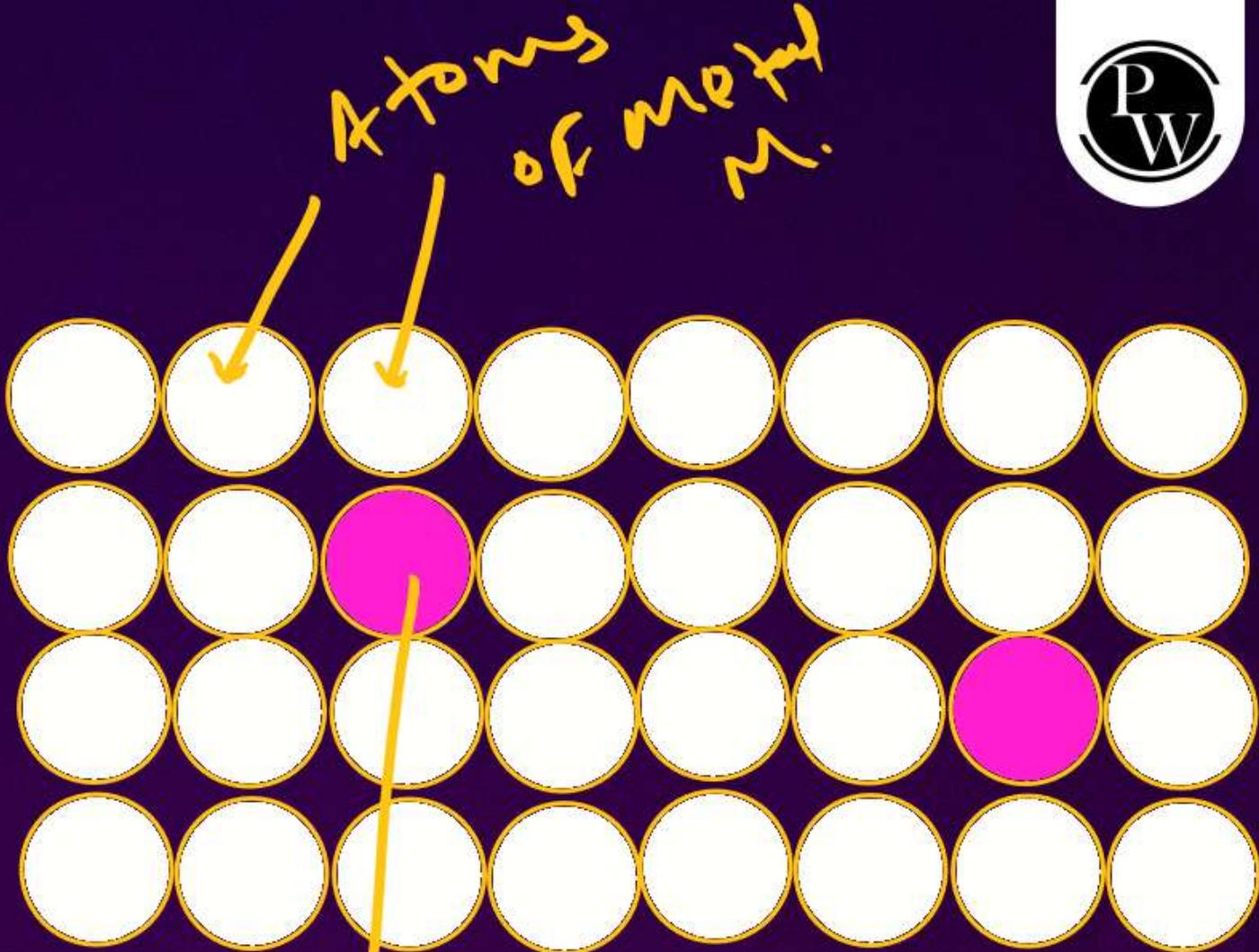
Alloy formation

M^3
 N
 Metal + metal

Radius simillar

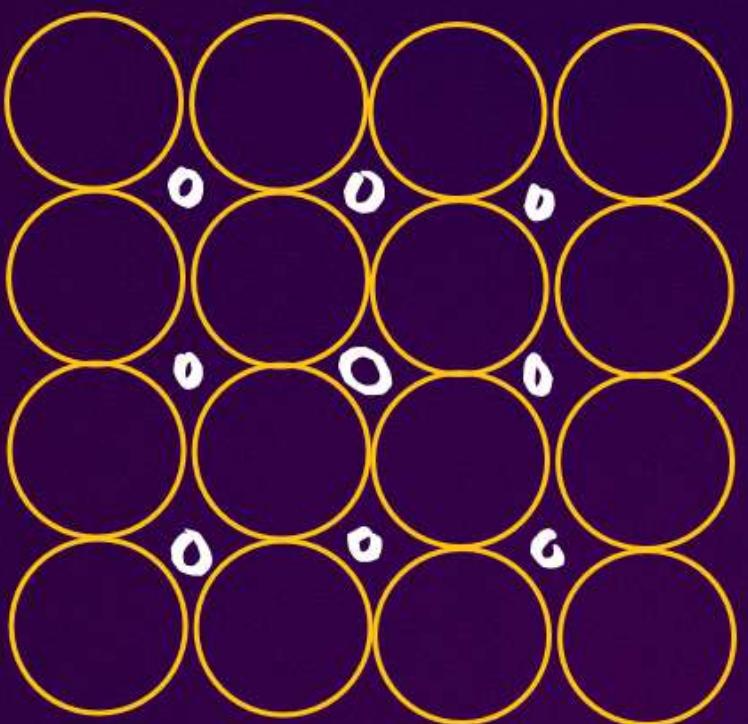


15% difference



Atoms
of metal
N.

Atoms of metal N





The highest oxidation state which is shown by transition metals is :

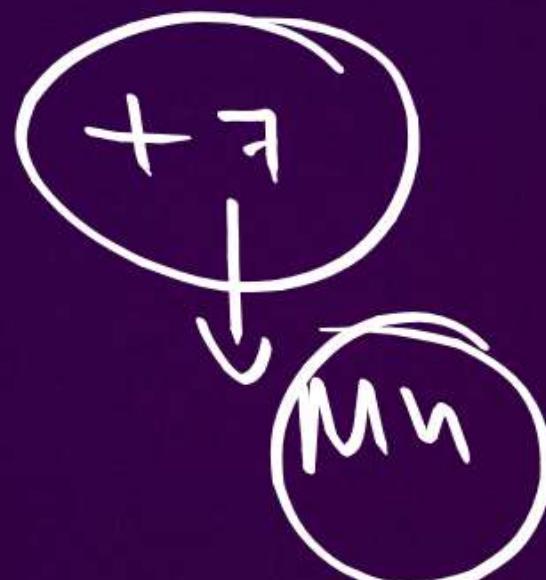
A +3

B +8 → Ru and Os.

C +7

D +5

3d series me





Which of the given options gives the correct magnetic properties of the given ions?

[At no. of : La = 57, Ce = 58, Yb = 70, Lu = 71] ✓

A Both La and La^{+3} is paramagnetic in nature.

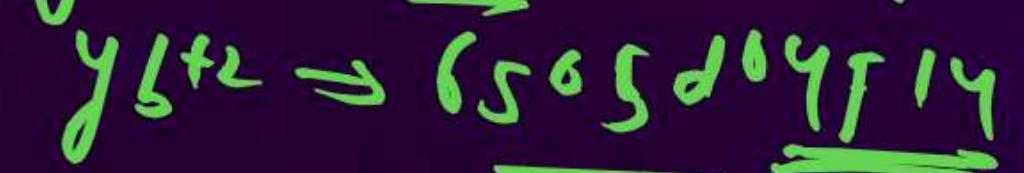
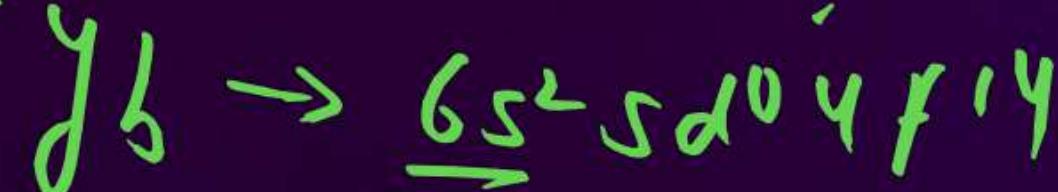
B Both La^{+3} and Lu^{+3} are repelled by the applied magnetic field

C Ce^{+2} is diamagnetic in nature.

D Yb^{+2} has a magnetic moment of 2.76 BM.



$$n=2$$





Which of the following is not an element of first transition series?

- A Fe ✓
- B Co ✓
- C Ni ✓
- D Ag ✗

3d

1st Cy 3d
2nd Aj 4d
3rd Ay 5d

Double salt



two salt



Cation Anion.

Complex Salt



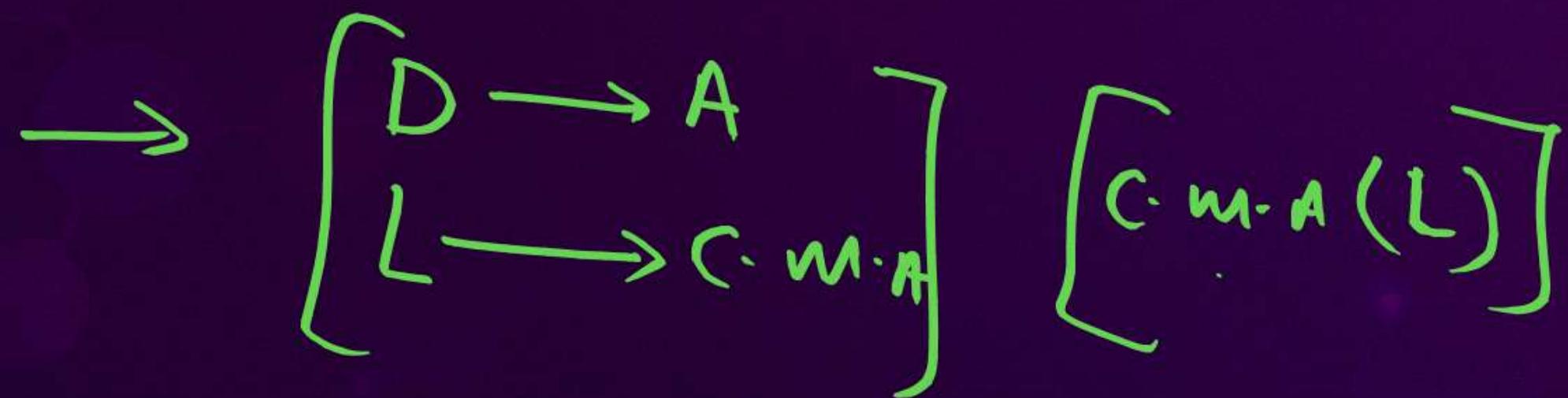
Cation Anion

→ Cation is written first

Complex compound

(coordination compound).

→ Jiske bich coordinate bond banta
hai unko [] me rakha Jata hai

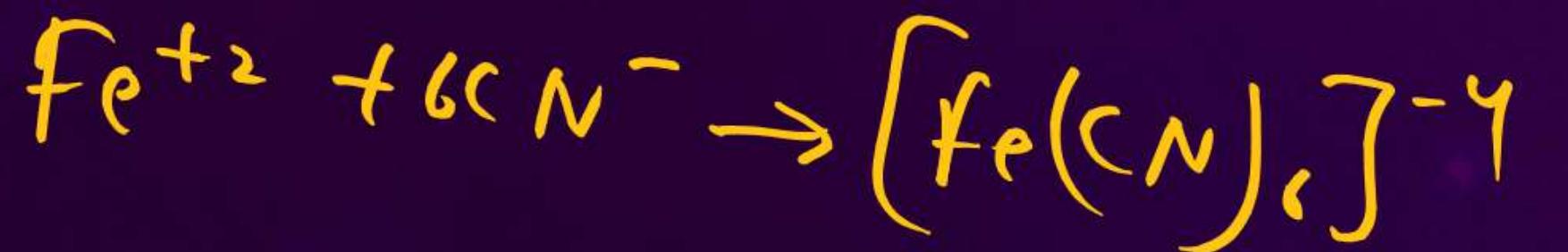
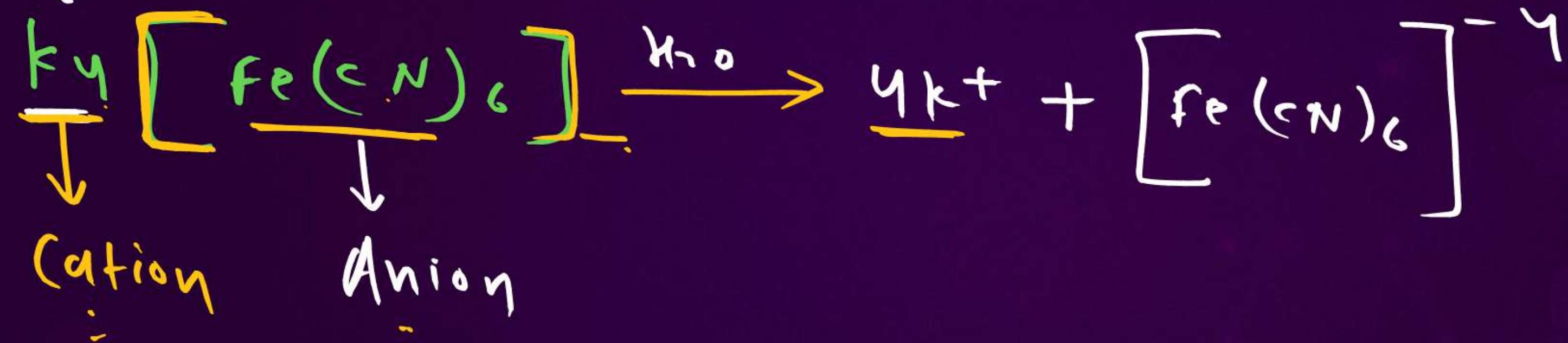




Complex Salt

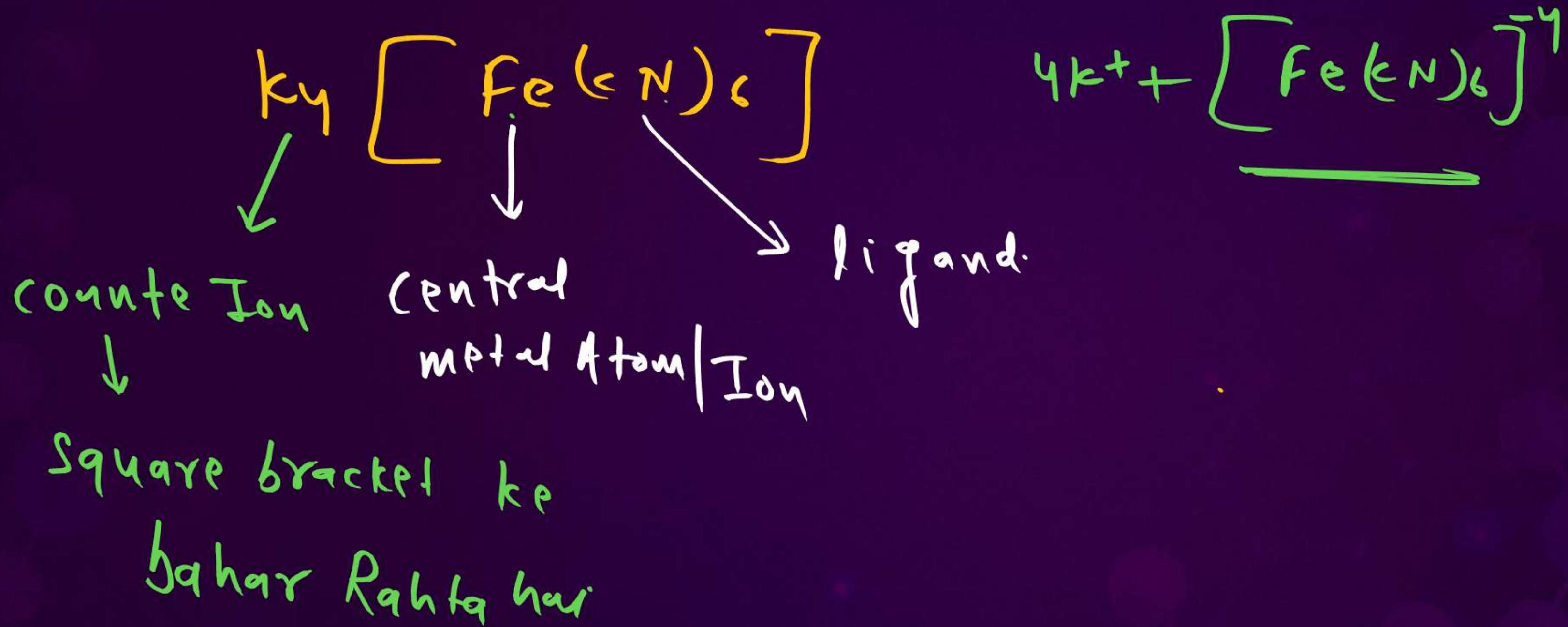


- ✓ Complex ions such as $[\text{Fe}(\text{CN})_6]^{4-}$ or $\text{K}_4[\text{Fe}(\text{CN})_6]$ do not dissociate into Fe^{2+} and CN^- ions.





Terminology of co-ordination compound





Terminology of co-ordination compound

Coordination Entity

$C \cdot M \cdot A + AP$ *Ligands*



Group of central metal and all ligands are collectively known as coordination Entity $[Ni(CO)_4]$, $[PtCl_2(NH_3)_2]$ are examples of coordination Entity

For example, $[CoCl_3(NH_3)_3]$ is a coordination entity in which the cobalt ion is surrounded by three ammonia molecules and three chloride ions.



$$C \cdot M = Ni$$

$$Ligand = CO$$

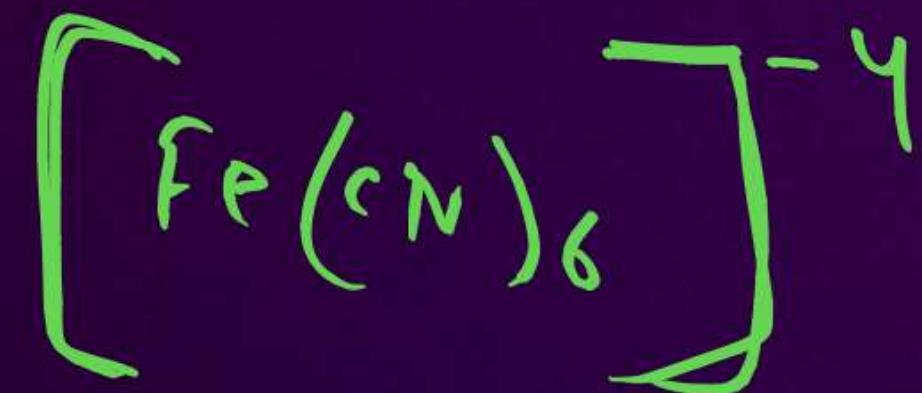


Terminology of co-ordination compound

✓ Coordination Sphere

Central metal atom and all ligands are enclosed in square brackets along with the total charge on sphere is known as coordination Sphere example: $[\text{Fe}(\text{CN})_6]^{4-}$.

In the complex $\text{K}_4[\text{Fe}(\text{CN})_6]$, the coordination sphere is $[\text{Fe}(\text{CN})_6]^{4-}$ and the counter ion is K^+

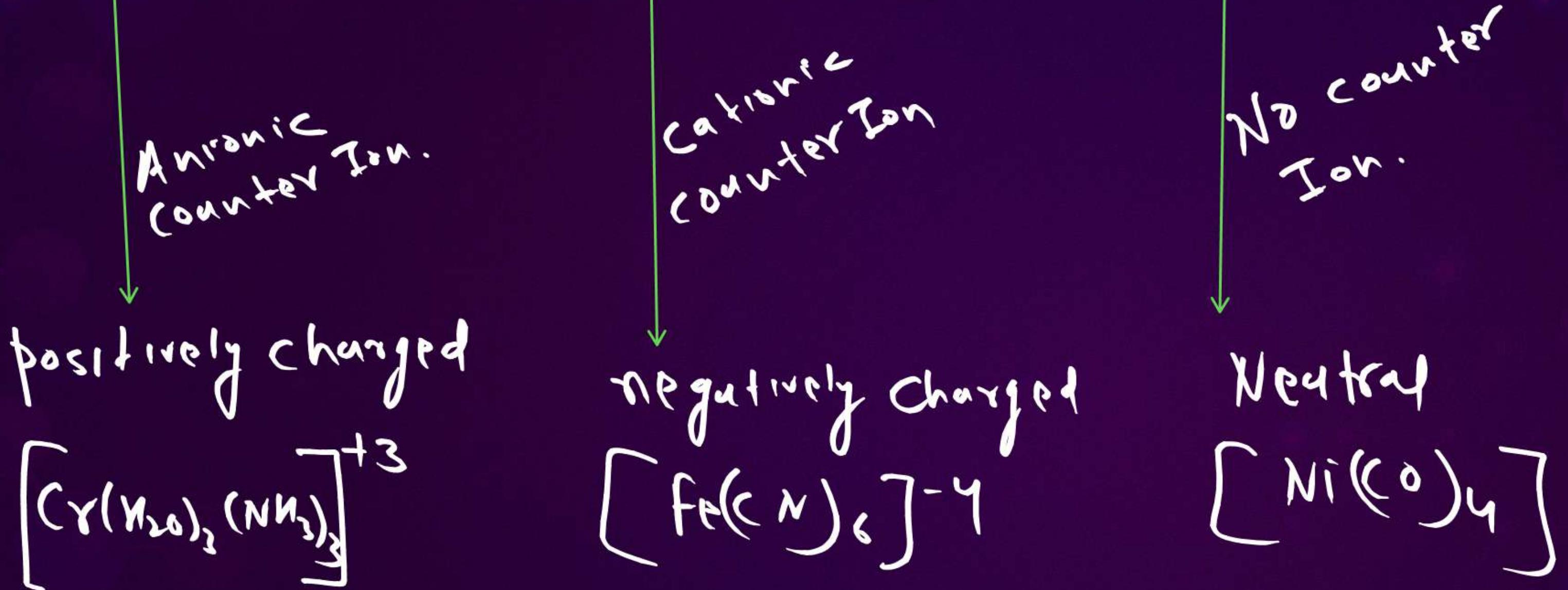


Counter Ion

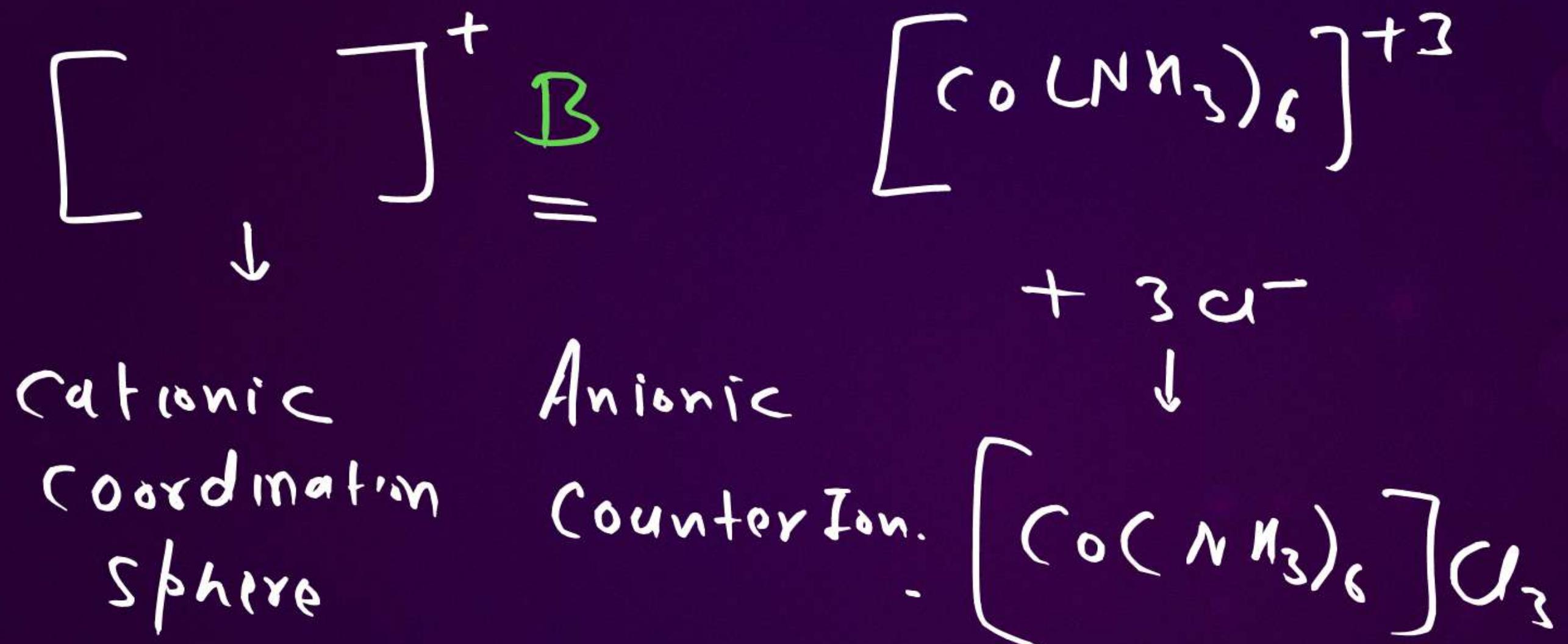
Counter ion is written outside of square brackets to neutralise the charge of coordination Sphere. In $K_4[FeCN_6]K^+$ is counter ion



Coordination Compound.



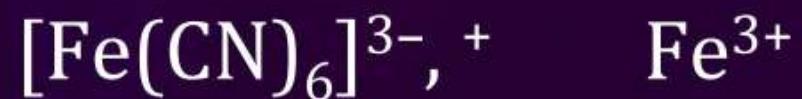
* Cation is written first



Central Atom/Ion

Central metal is the atom inside the coordination Entity which accept the pair of electrons from all the ligands. Central metal atom/ions in $[\text{Ni}(\text{CO})_4]$, $[\text{PtCl}_2(\text{NH}_3)_2]$ are Ni and Pt^{+2} .

- Central metal atom/ion acts as Lewis acid because they are electron acceptor



C - M - N ← ligand.
↓ ↓
Lewis Lewis Base
Acid

Ligands

e donor \rightarrow Lewis Base.

An ion or a molecule which can donate pair of electrons to a metal atom or a metal ion and can form dative bond is called ligand.

Classification of Ligands

Based upon charges



Based upon denticity

Based upon Interaction between Ligand and central atom

ku[Fe(N)₆]

-ve charge

Negative

Examples:

Cl^- (chlorido), CN^- (cyanido)

Br^- (bromido), OH^- (hydroxo),

CO_3^{2-} (carbonato), SCN^- (thiocyanato), SO_4^{2-} (sulphato), $\text{C}_2\text{O}_4^{2-}$ (oxalato), NO_2^- (nitrito) N

Charge

+ve charge

zero charge.

Positive

Neutral

Examples: sum

NO^+ (nitrosonium)

Examples:

CO (carbonyl) ✓
 $\text{H}_2\text{NCH}_2 \cdot \text{CH}_2\text{NH}_2$ (ethylenediamine)
 H_2O (aqua) ✓
 NH_3 (ammine) ✓



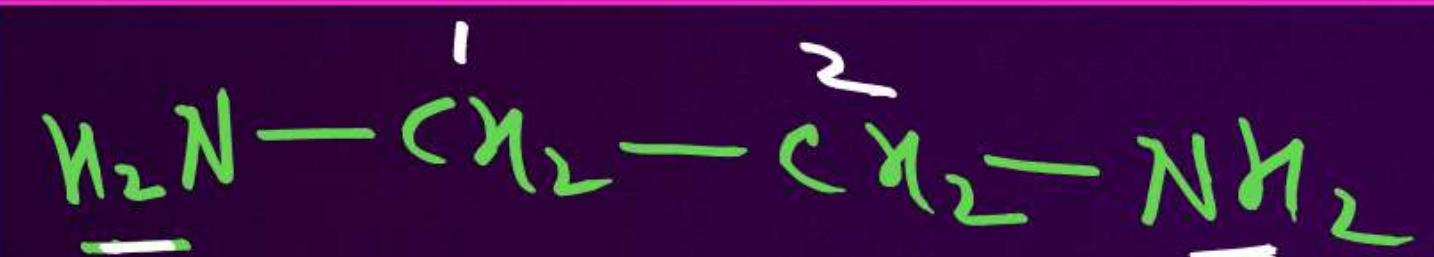
Ethane



ethyl



ethylene



Ethylenediamine

(en)

Ethane-1,2-diamine

Question

Ligands are:

- A Lewis acids
- B Lewis bases ✓
- C Neutral
- D none

Home Work

→ DPP

→ γ_0

PARISHRAM



2026

Coordination Compound

CHEMISTRY LECTURE-03

BY – BIJENDRA SIR (Biju Bhaiya)



Topic Covered

Ligands ✓

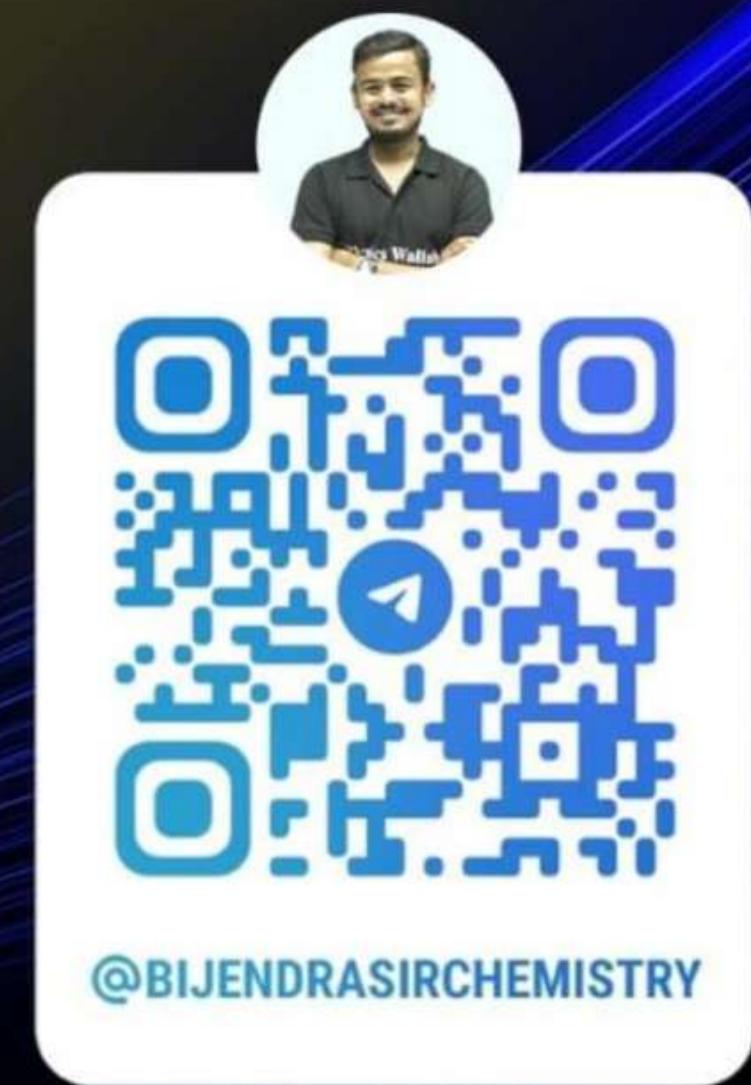
Coordination Number ✓

Oxidation Number ✓



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?

Assertion (A) : Cu^{2+} iodide is not known.

Reason (R) : Cu^{2+} oxidises I^- to iodine.



A

Both A and R are true, and R is the correct explanation of A.

B

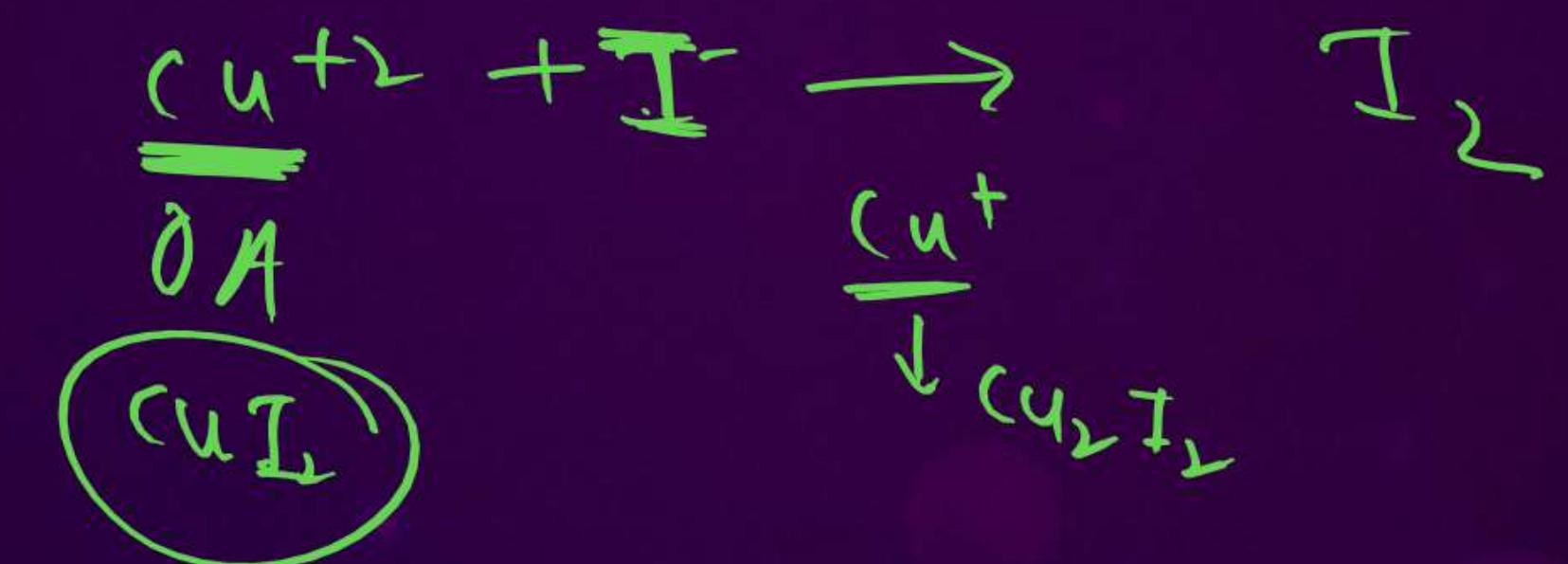
Both A and R are true, but R is not the correct explanation of A.

C

A is true, but R is false

D

A is false, but R is true.





Assertion (A) : Cuprous ion (Cu^+) is colourless whereas cupric ion (Cu^{++}) is blue in the aqueous solution.

Reason (R) : Cuprous ion (Cu^+) has unpaired electrons while cupric ion (Cu^{++}) does not.

- A Both A and R are true, and R is the correct explanation of A.
- B Both A and R are true, but R is not the correct explanation of A.
- C A is true, but R is false
- D A is false, but R is true.



Assertion (A) : Fe³⁺ is more stable than Fe²⁺.

Reason (R) : Half filled and completely filled subshells are more stable.



A Both A and R are true, and R is the correct explanation of A.



B Both A and R are true, but R is not the correct explanation of A.



C A is true, but R is false



D A is false, but R is true.



Assertion (A) : The atomic density of copper is less than that of chromium.

Reason (R) : The atomic mass of copper is more than that of chromium.

A Both A and R are true, and R is the correct explanation of A.

B Both A and R are true, but R is not the correct explanation of A.

C A is true, but R is false

D A is false, but R is true.

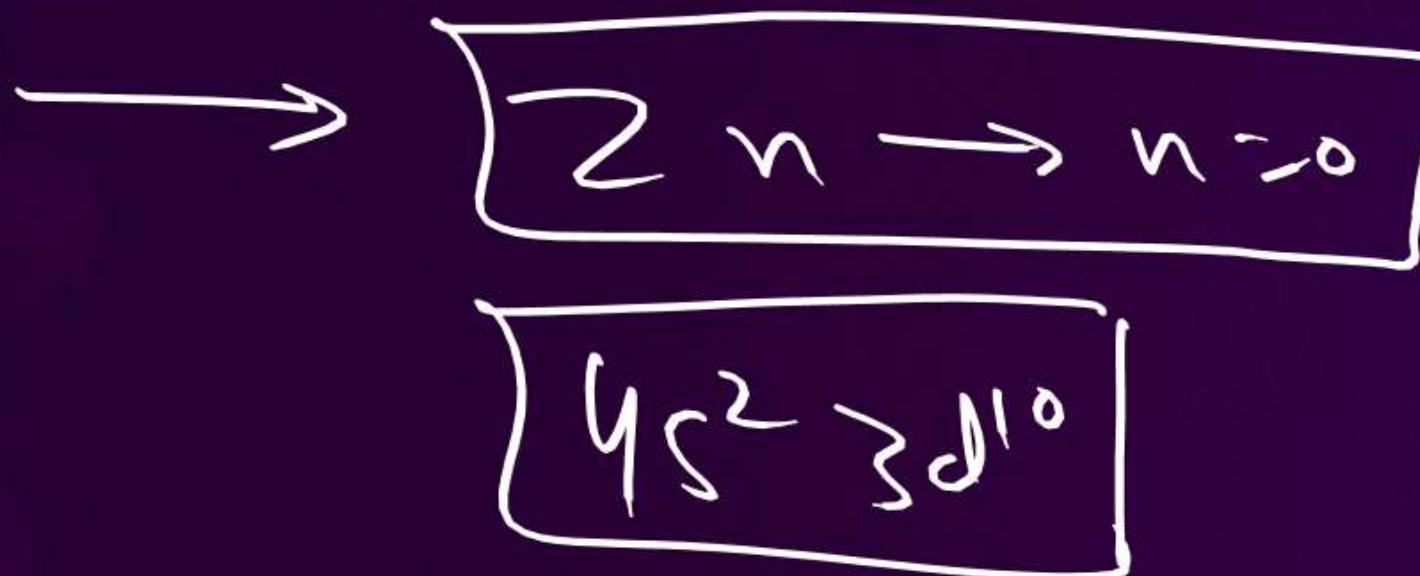
increases up to c_4

c_3

c_4

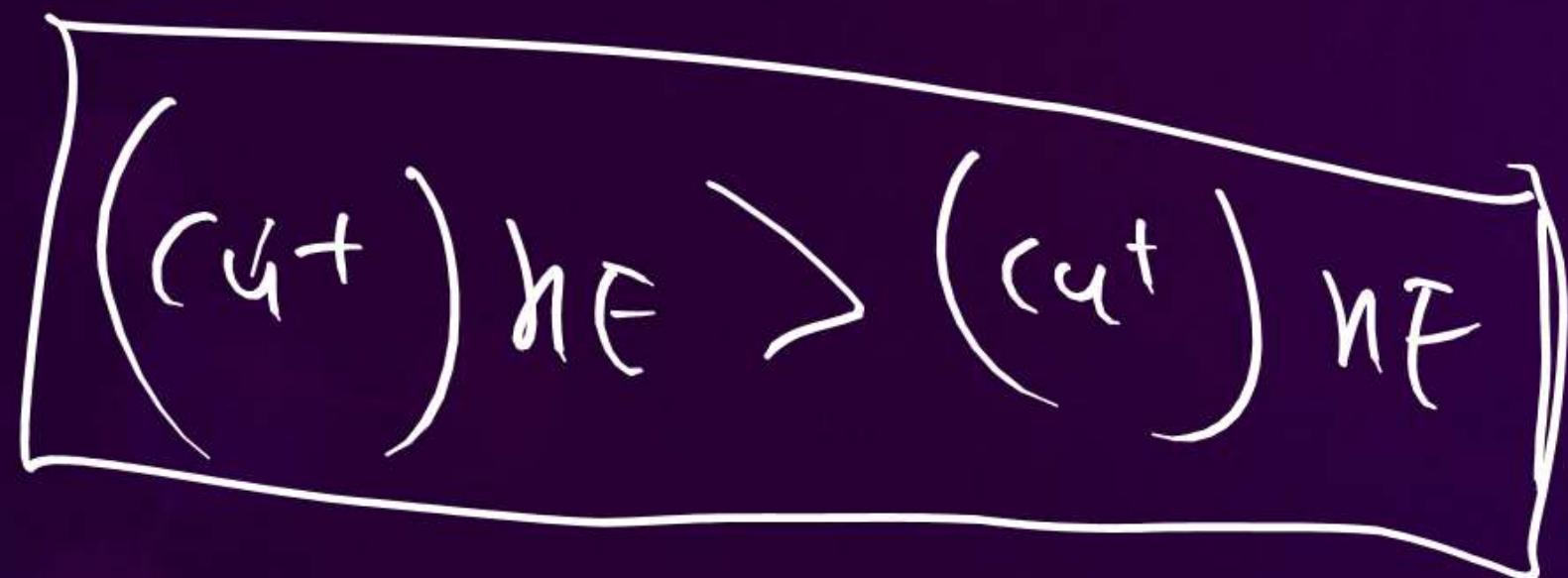


In the series Sc ($Z = 21$) to Zn ($Z = 30$), the enthalpy of atomization of zinc is the lowest, i.e., 126 kJ/mol. Why?





Explain why Cu^+ ion is not stable in aqueous solutions?



Ligands \rightarrow e donor
 \rightarrow extra electron
↓
lone pair / -ve charge.
↓
N/O

* Cl^- , OH , $(\text{SO}_4^{2-})_2$, NH_3 H_2O^- :

Denticity of a Ligand.

No. of coordinate bond formed by a ligand.

Number of donor site present in a ligand is called denticity of the ligand, in other words we can say that number of coordinate bond a ligand can make with a central metal atom is called denticity of that ligand.

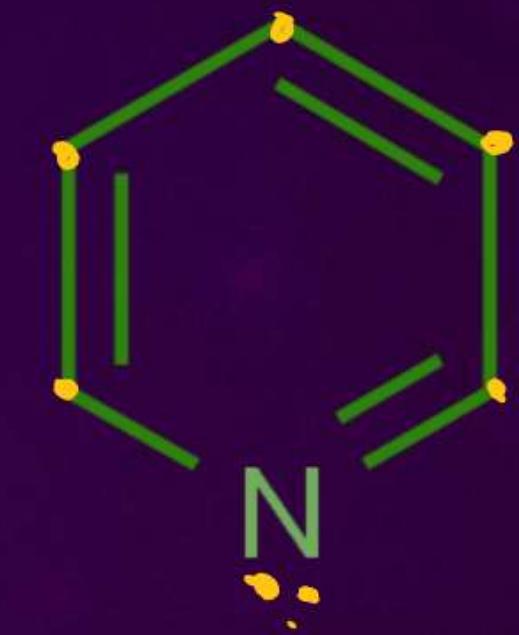
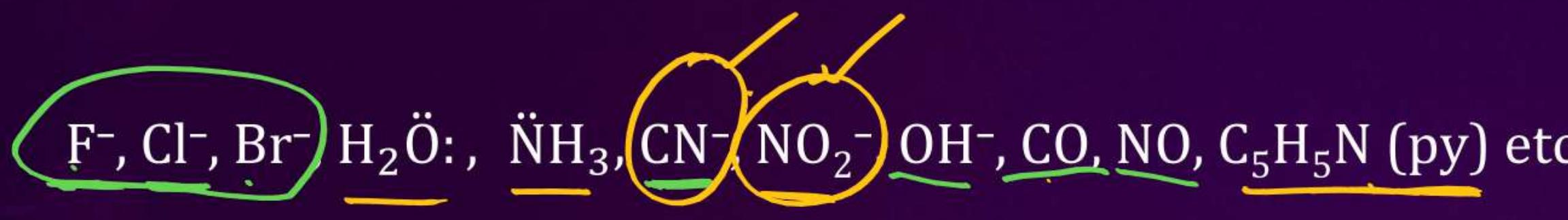
Donor Atom → Jis atom se ligand bond banata hai

Jis atom par lone pair / -ve charge ho.



monodentate
Unidentate ligands \longrightarrow Denticity = 1

If ligand is bonded to central metal through single donor atom then it is called unidentate ligand example.



bidentate
Didentate Ligands

Denticity = 2.
Donor atom = 2.

When a ligand donates electrons through two atoms to the central metal or we can say when a ligand is bonded to central metal through two atoms then it is called didentate Ligand.

Ex.: oxalato - $\text{C}_2\text{O}_4^{2-}$, (ox)
ethane - 1, 2 - diamine $\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2$



ethylenediamine
(en)

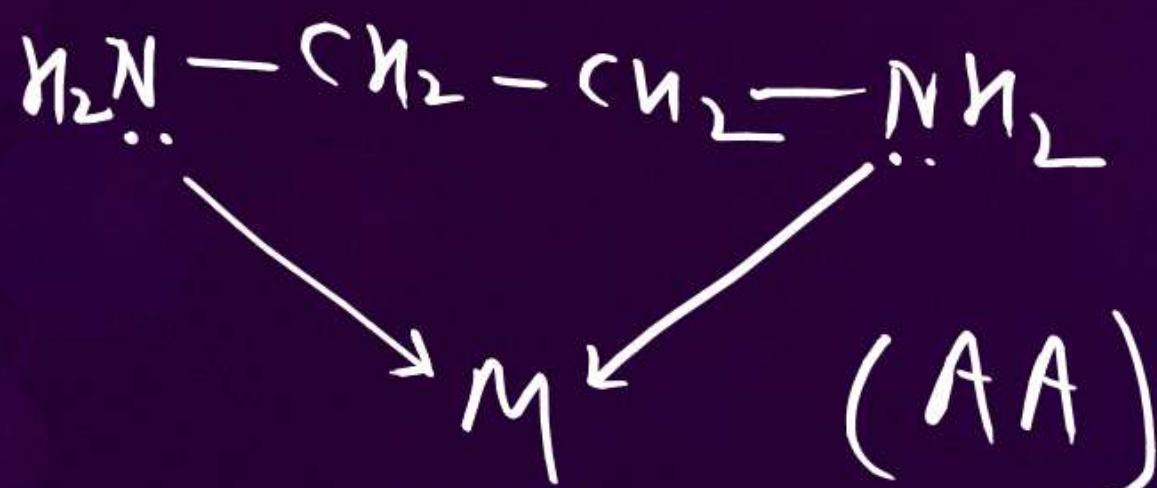


Denticity = 2.

Symmetrical
bidentate ligand

→ Both Donor

atoms = Same



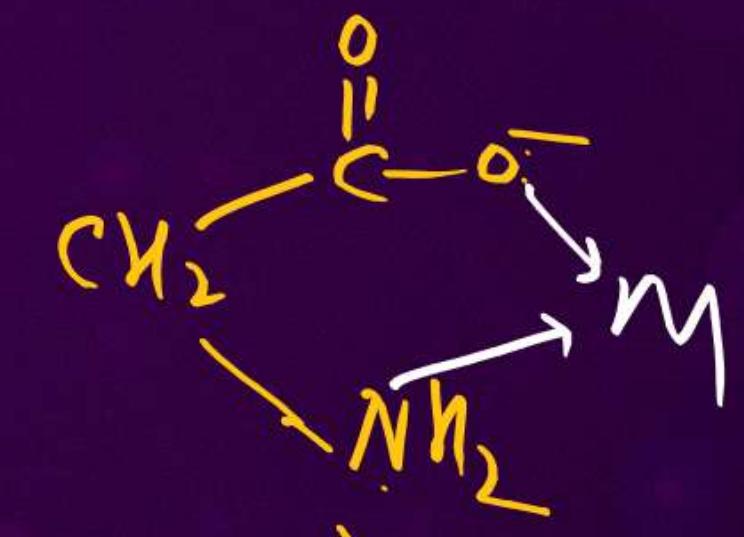
Unsymmetrical
bidentate ligand-

Both donor atom

different.

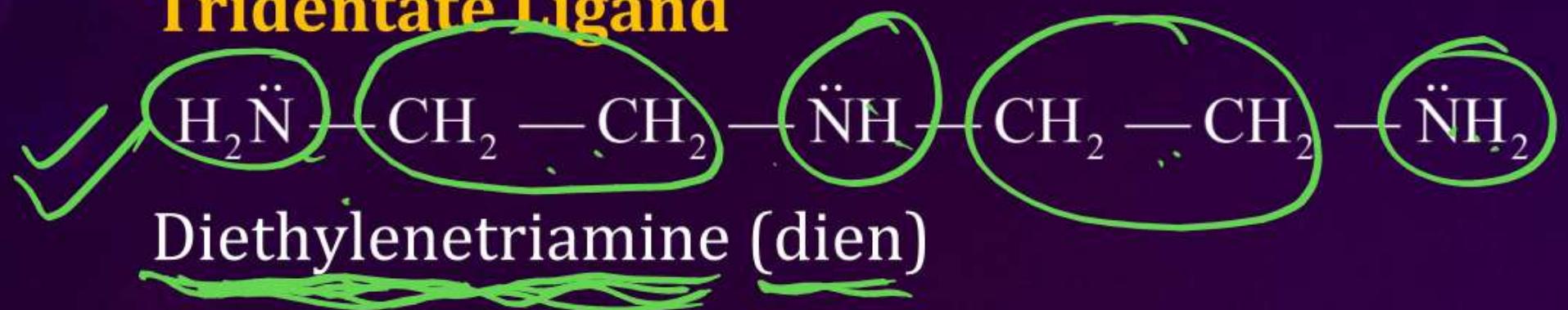
glycinate-gly

(AB)



Denticity = 3.

Tridentate Ligand



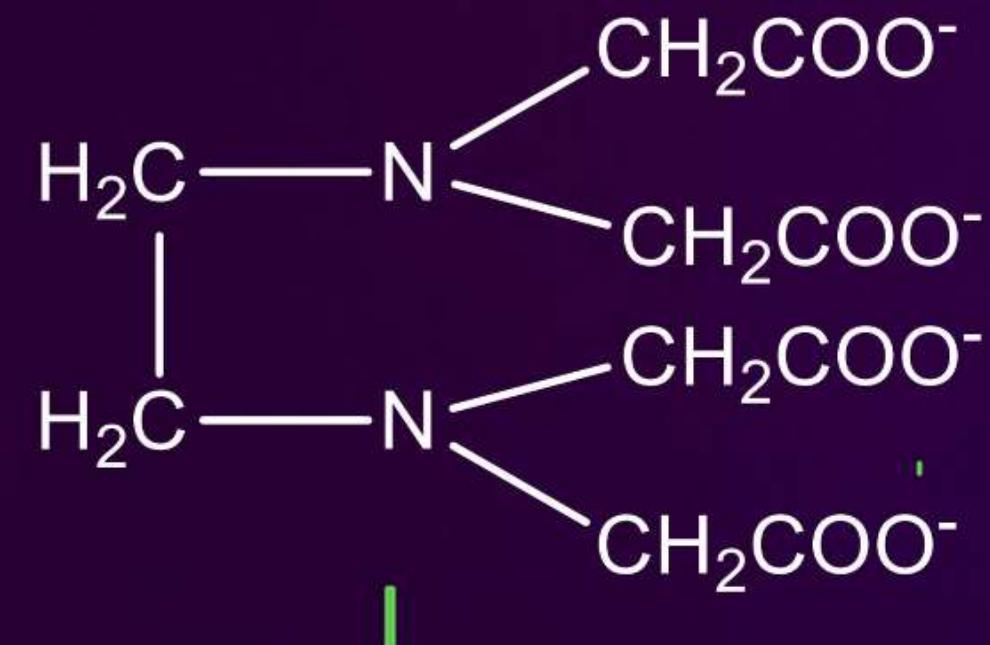
When a ligand donates electrons through three atoms to the central metal or we can say when a ligand is bonded to central metal through three atoms then it is called tridentate Ligand

Polydentate Ligands

Denticity > 2.

When a ligand is bonded to central metal through more than two atoms/ bonds then it is called polydentate Ligands

Ex.: EDTA ⁴⁻ ethylene diamine tetra acetate can donate six pair of electrons and know as hexadentate ligand

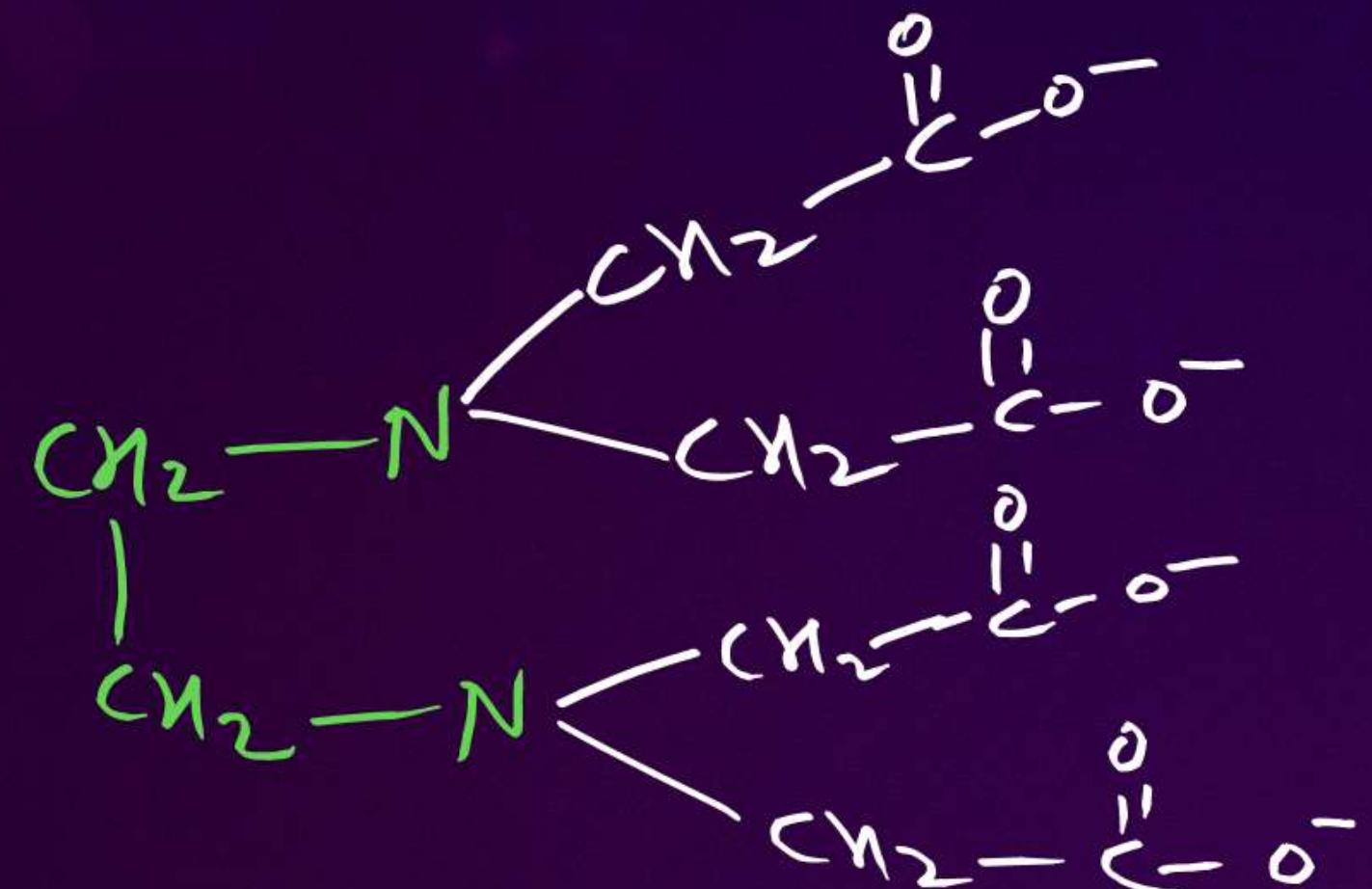


EDTA

E → Ethylene → -CH₂-CH₂-

D → Diamine NH₂

T → Tetraq.
A → Acetate -CH₂-C(=O)-O⁻

EDTA

Denticity

= 6

hexadentate

Question

Ethylene diamine is an example of a _____ ligand.

- A monodentate
- B bidentate
- C tridentate
- D hexadentate



Denticity = 2

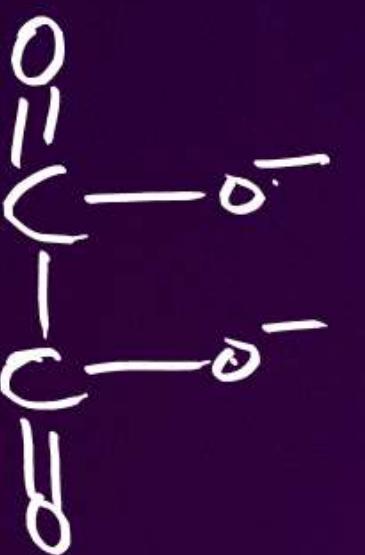
$C_{20}O_4^{-2}$

Ⓐ 1

~~Ⓑ~~ 2

Ⓒ 3

Ⓓ 4



CN^-

Denticity

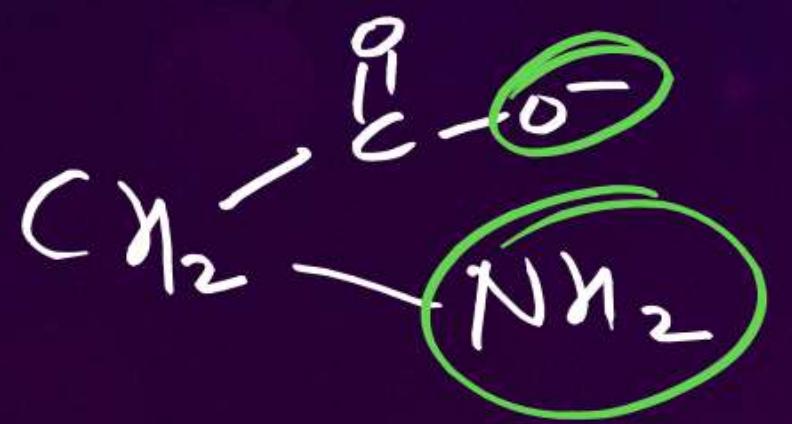
~~a~~ 1

b 2

c 3

d 4

gly



① 1

~~②~~ 2

③ 3

④ 4

Chelate Ligand

Denticity ≥ 2 .

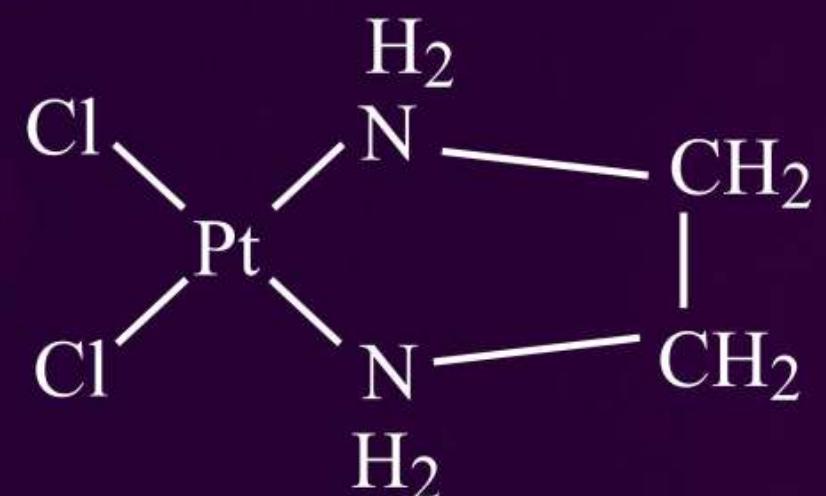
Chelate ligand is a di or polydentate ligand which uses its two or more donor atoms to bind a single metal ion producing a ring.

The complex formed is referred to as a chelate complex and the process of chelate formation is called chelation.

Chelate rings may have any number of atoms; the most common five or six atoms, including the metal ion. Smaller rings have angles and distances that lead to strain; larger rings frequently result in crowding both within the ring and between adjoining ligands.

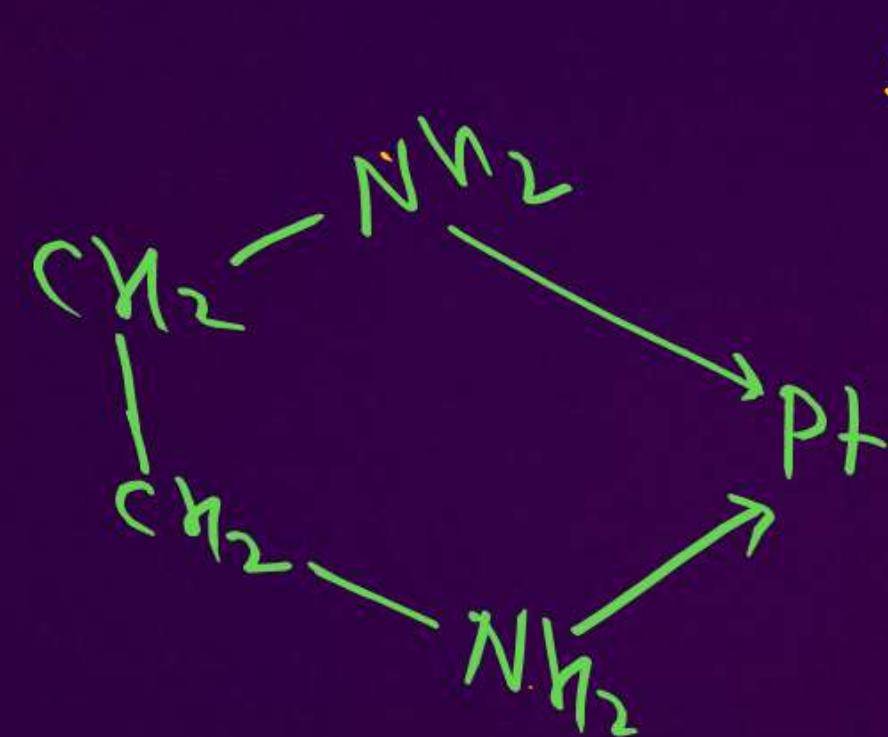
Chelate Ligand

In $[\text{PtCl}_2(\text{en})]$, en represents the didentate ligand, $\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2$ (1, 2-ethanediamine or ethylenediamine)



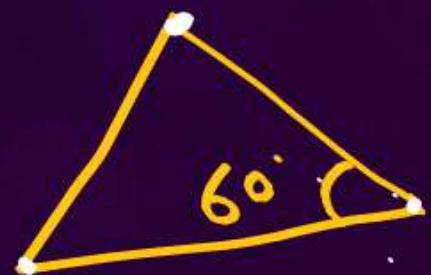
$[\text{PtCl}_2(\text{en})]$

(a)

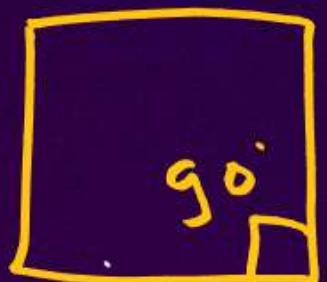


Ring formation
↓
stability increases
↓
5 or 6 member.

5 or 6 membered ring



Angle strain



Angle strain

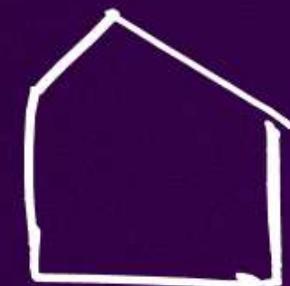
$$SP^3 \rightarrow 109.28^\circ$$

$$SP^2 \rightarrow 120^\circ$$

$$SP \rightarrow 180^\circ$$



(6)



(5)



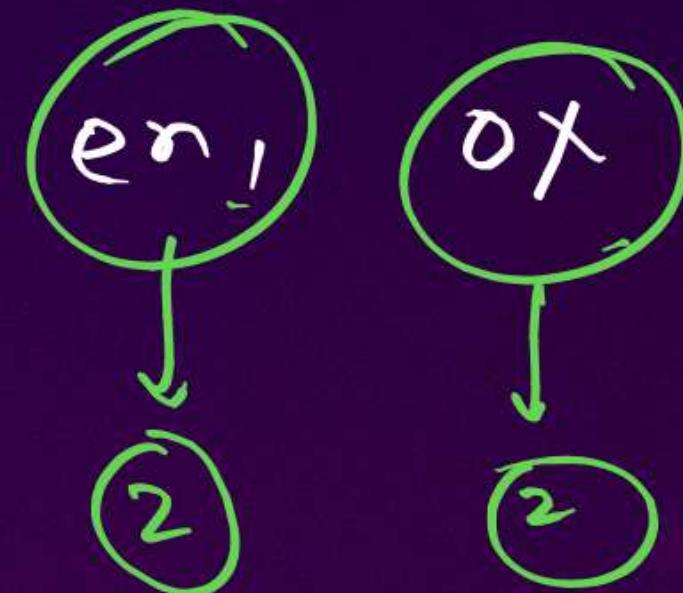
Stable.

Find Total no. of chelate ligands.

$\frac{1}{1}$ $\frac{1}{1}$ $\frac{1}{1}$ $\frac{1}{1}$ $\frac{1}{1}$
 F^- , C^- , Br^- , OH^- , H_2O , NH_3 ,

$\frac{1}{1}$ $\frac{1}{1}$
gly, CO , CN^-

↓
②



Flexidentate Ligand

or

Flexidentate Ligands are the type of ligands which can vary their denticity according to the type of complex compound,

for example SO_4^{2-} has two Oxygen atom having negative charge on it, so denticity of SO_4^{2-} is 2, but it can show denticity 1 also in some complex compounds.

$[\text{Co}(\text{NH}_3)_4\text{SO}_4]^{+2}$ here denticity of SO_4 is 2 $[\text{Co}(\text{NH}_3)_5\text{SO}_4]^+$ here denticity of SO_4 is 1

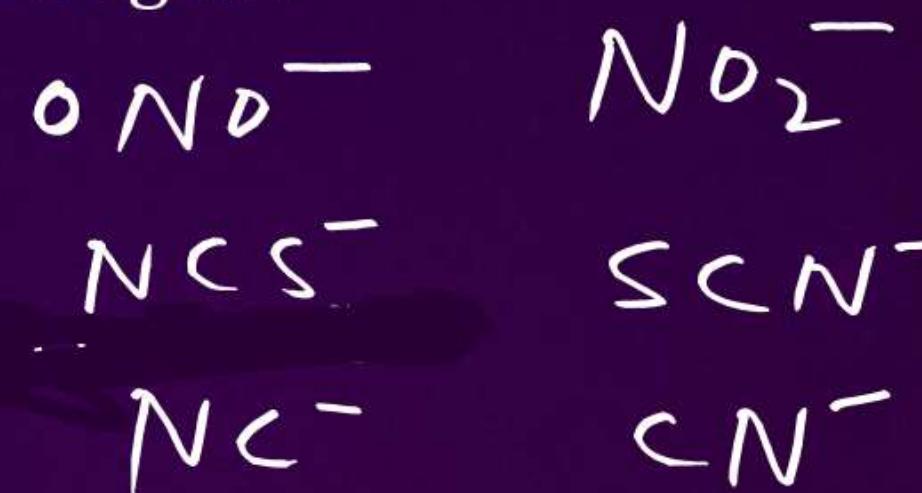
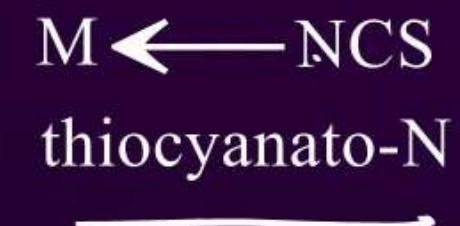
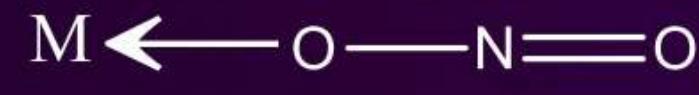
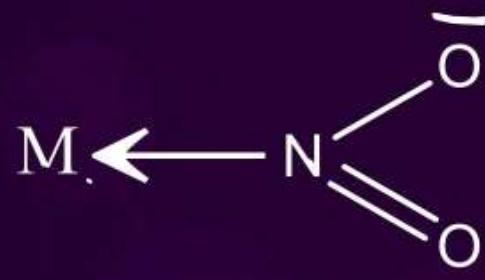
Other examples of Flexidentate Ligands are : CO_3^{2-} , EDTA $^{4-}$

Ambidentate Ligand

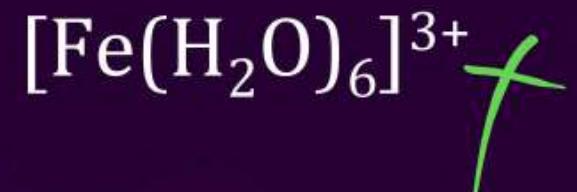
Donor atom = 2.

If a ligand has two donor atoms and it can donate through either of them then it is called ambidentate ligand Examples of ambidentate ligands - : NO₂⁻ Here this ligand can donate through either oxygen or nitrogen.

SCN⁻ this ligand can donate through either sulphur or nitrogen .



The stabilization of coordination compounds due to chelation is called the chelate effect. Which of the following is the most stable complex species?

A**B****C****D**

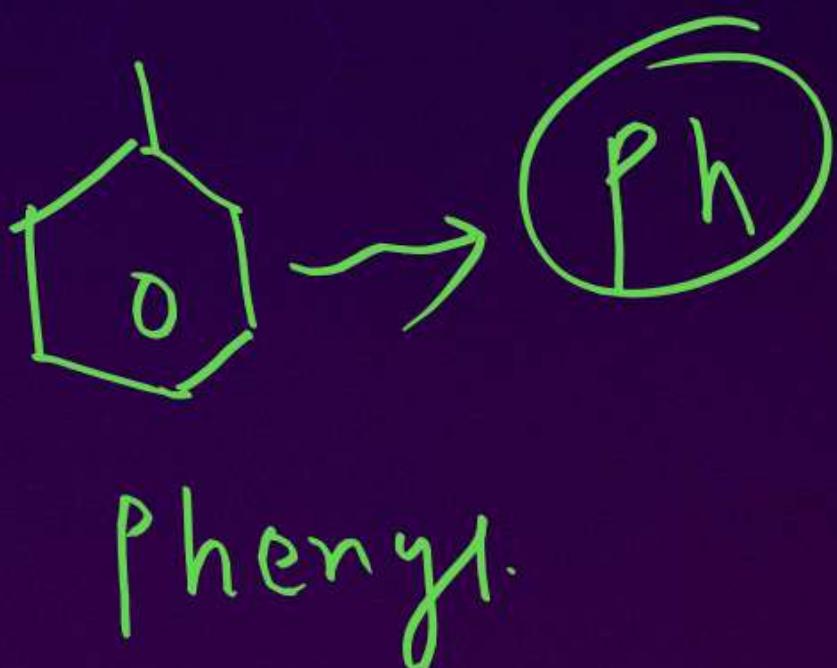
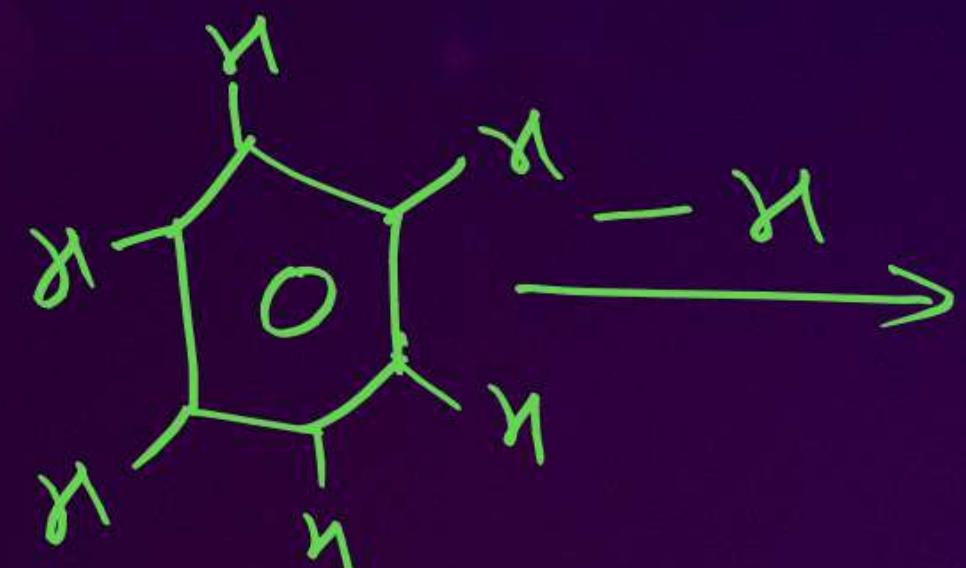
A chelating agent has two or more than two donor atoms to bind to a single metal ion. Which of the following is not a chelating agent?

- A** thiosulphato 
- B** oxalato 
- C** glycinate 
- D** ethane-1,2-diamine 

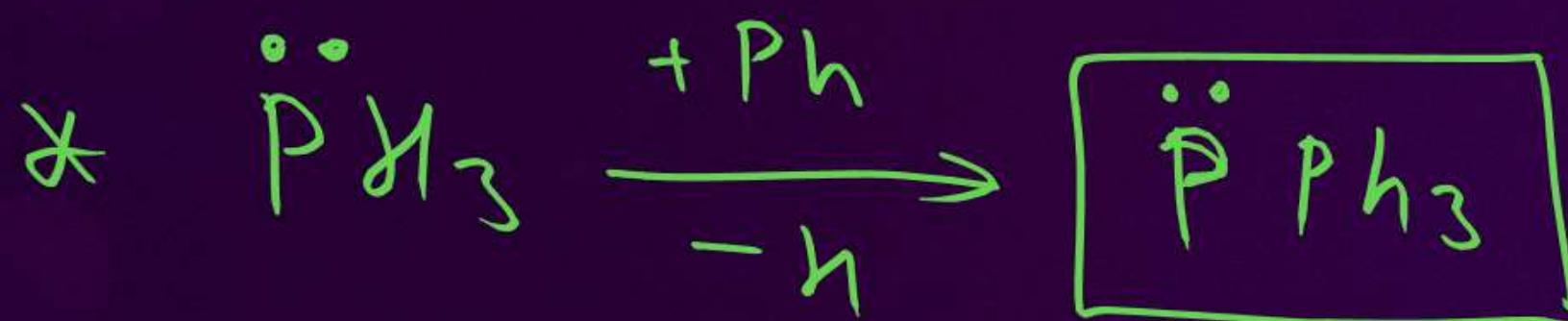
Table: Some common Monodentate Ligands

Common name	IUPAC Name	Formula
Triphenyl Phosphine	Triphenyl Phosphine / triphenyl phosphane	PPh_3
Pyridine	Pyridine	$\text{C}_5\text{H}_5\text{N}$ (py)
Ammonia	Ammine	NH_3
Water	Aqua	H_2O
Carbonyl	Carbonyl	CO
Nitrosyl	Nitrosyl	NO
Fluoro	Fluoro or fluorido	F^-
Chloro	Chloro or chlorido	Cl^-
Bromo	Bromo or bromido	Br^-
Iodo	Iodo or iodido	I^-

PPh_3



Benzene



Triphenyl phosphine.

Common name	IUPAC Name	Formula
Cyano	Cyanido or cyanido-C (C-bonded)	CN^-
Isocyano	Isocyanido or cyanido-N (N-bonded)	NC^-
Thiocyanato-S	Thiocyanato-S(S-bonded)	SCN^-
Isothiocyanato-N	Thiocyanato-N (N-bonded)	NCS^-
Hydroxo	Hydroxo or hydroxido	OH^-
Nitro	Nitro, nitrito-N (N-bonded)	NO_2^-
Nitrito	Nitrito-O (O-bonded)	ONO^-

Homoleptic and Heteroleptic Complex Compound

Homoleptic Complex

same

The complex in which the central metal atom (or) ion bound with only one kind of ligand.



different

Heteroleptic complex

The complex in which the central metal atom (or) ion bound with more than one kind of ligands.



Which of the following complexes are homoleptic?

- A $[\text{Co}(\underline{\text{NH}_3})_6]^{3+}$ *Homogeneous*
- B $[\text{Co}(\underline{\text{NH}_3})_4\text{Cl}_2]^+$ *Heterogeneous*
- C $[\text{Ni}(\underline{\text{CN}})_4]^{2-}$ *Homogeneous*
- D $[\text{Ni}(\underline{\text{NH}_3})_4\text{Cl}_2]$ *Heterogeneous*

Which of the following complexes are heteroleptic?

A**B****C****D**

Home Work

→ Do not solve Today's DPP.

* remember all ligands with Dentricity.

PARISHRAM



2026

Coordination Compound

CHEMISTRY LECTURE-04

BY – BIJENDRA SIR (Biju Bhaiya)



Topic Covered

coordination no.
oxidation no.



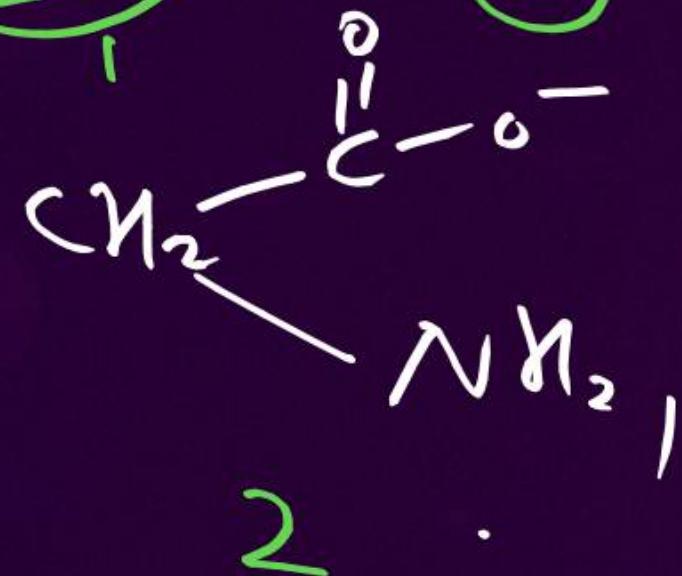
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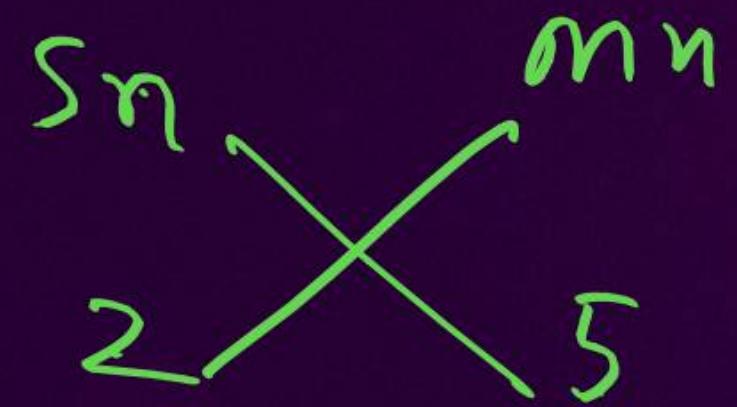


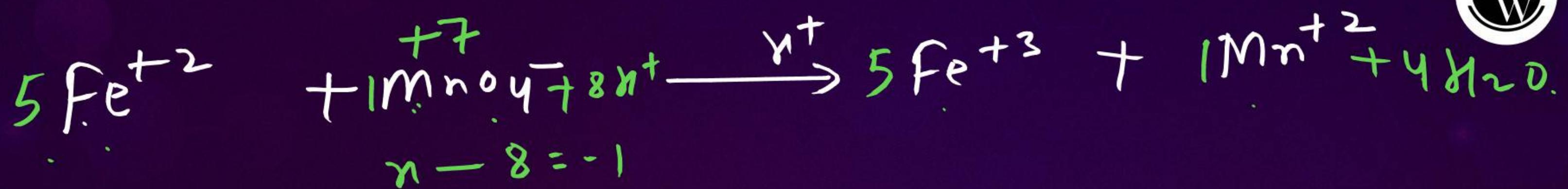
Find Total no. of chelate ligands.

≥ ②









✓



Coordination Number

C.M.A \Rightarrow no. of coordinate bonds formed by CM

Number of coordinate covalent bonds formed by Central metal atom/ ion is called coordination number.

$$C.N = \text{no. of ligands} \times \text{Denticity}$$

In $K_4[Fe\text{CN}_6]$ coordination number of Fe is 6 because there are 6 co-ordinate bonds formed by 6 CN^- Ligands with central metal ion Fe^{+2} .

$$C.N = 6 \times 1 = 6.$$

$[Co(\text{en})_3]^{2+}$ here coordination number of Co is 6 because denticity of en is 2 so one en can make two coordinate bonds with Co so $3 \times 2 = 6$

$$C.N = 3 \times 2 = 6.$$

$[Cr\text{EDTA}]^{3+}$ here coordination number of Cr is 6 because of EDTA is 6 so it can form total 6 co-ordinate bonds with Cr

$$C.N = 1 \times 6 = 6.$$



$$CN = 6 \times 1 = 6.$$



$$CN = 4 \times 1 \\ = 4.$$



$$CN = 2 \times 1 + 2 \times 1 = 4$$



$$CN = 5 \times 1 + 1 \times 1 \\ = 6.$$

$CN = \text{No. of Ligands} \times \text{Denticity}$

Total no. of Atoms

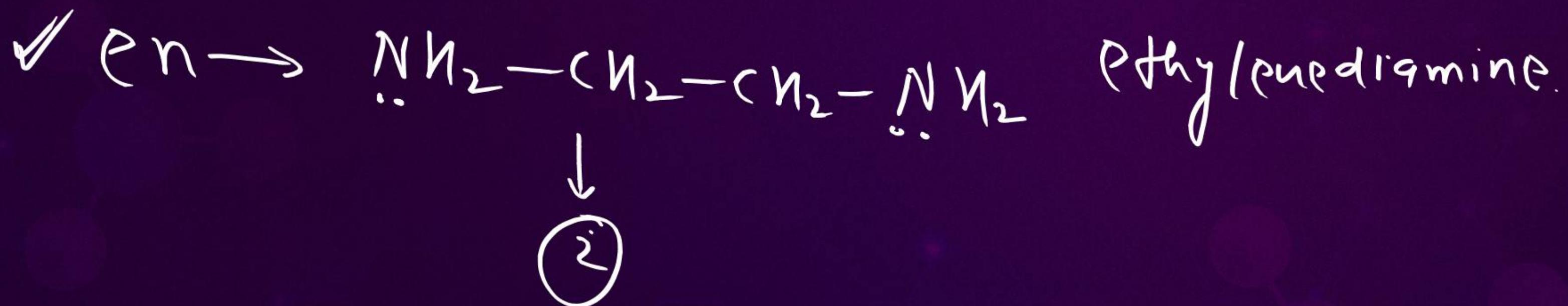
1, 2 \rightarrow Denticity = 1

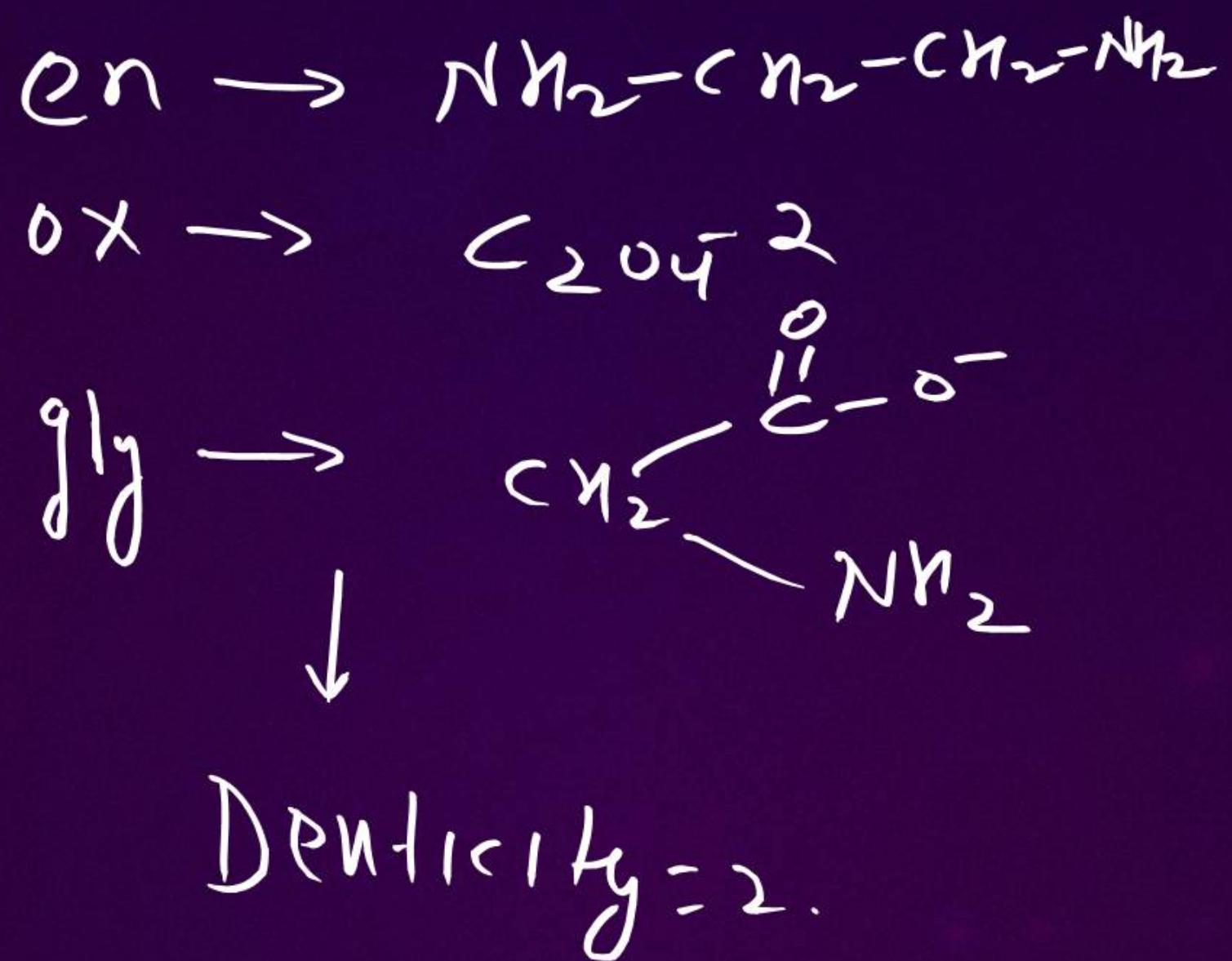
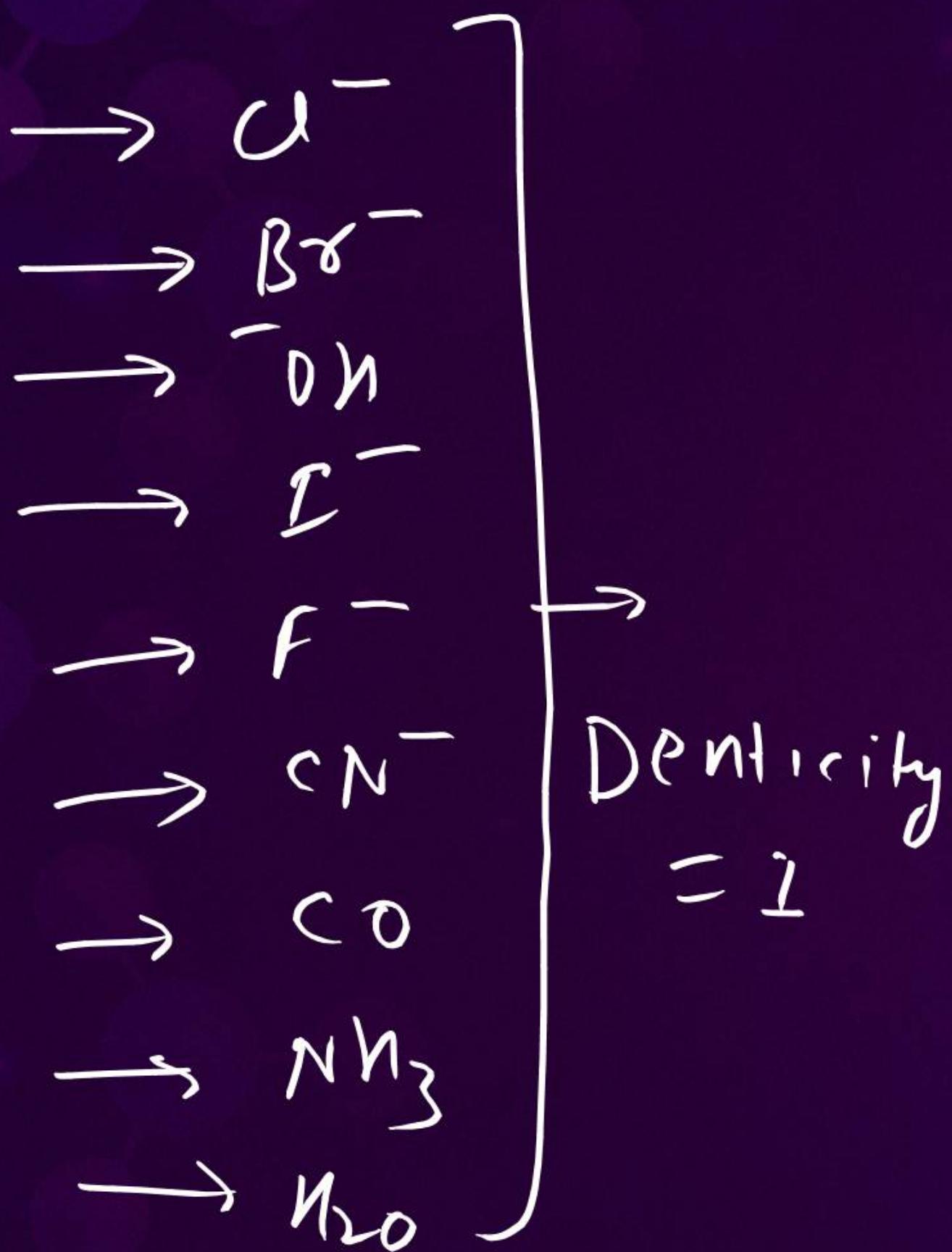


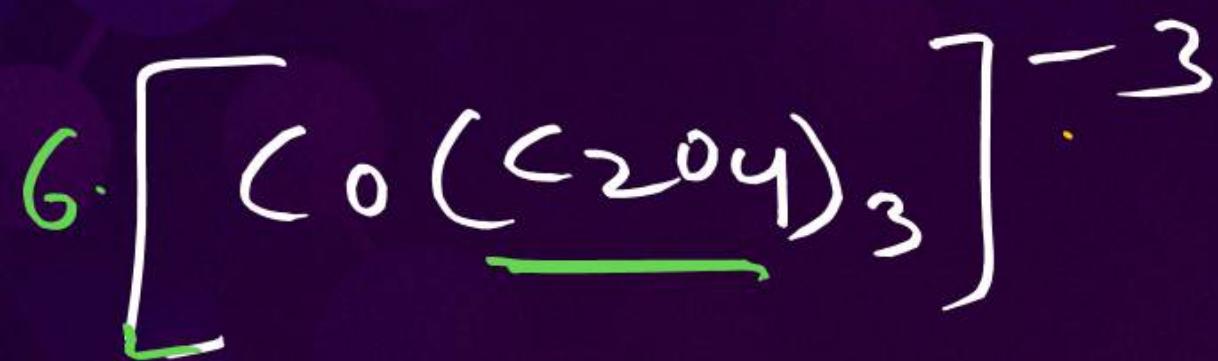
$$CN = 2 \times 2 + 1 \times 2$$

$$= 4 + 2$$

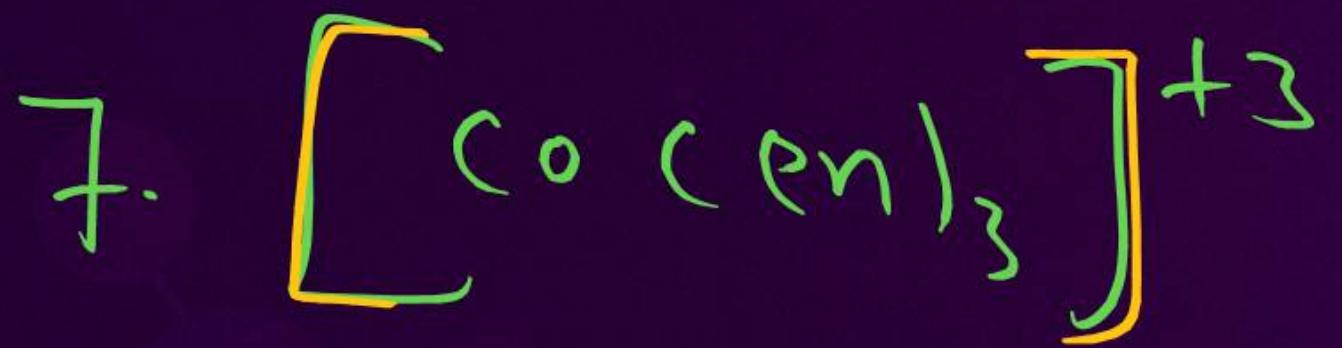
$$= 6.$$



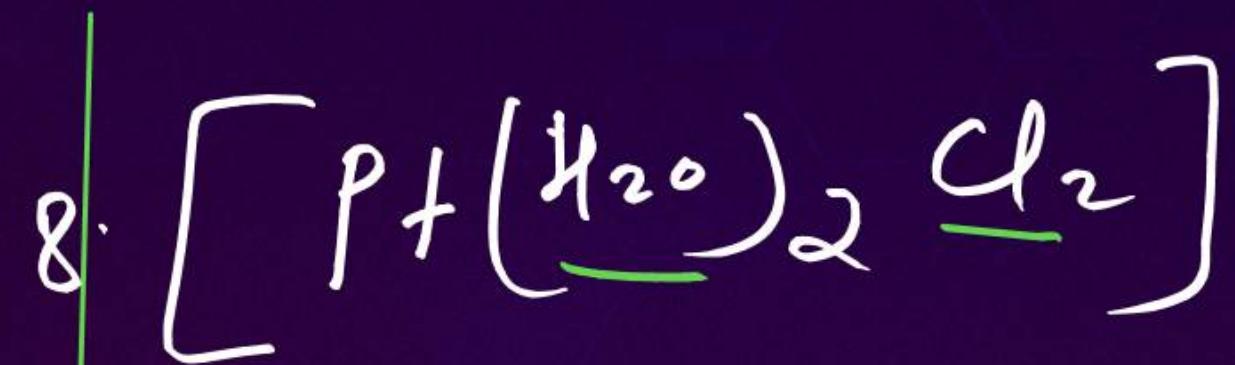




$$\begin{aligned}CN &= 3 \times 2 \\&= 6\end{aligned}$$



$$\begin{aligned}CN &= 3 \times 2 \\&= 6.\end{aligned}$$



$$\begin{aligned}CN &= 2 \times 1 + 2 \times 1 \\&= 4.\end{aligned}$$



$$\begin{aligned}CN &= 4 \times 1 \\&= 4.\end{aligned}$$

[]



- C_2H_3 methyl $CN = 2 \times 1 + 1 \times 1 + 1 \times 1 = 4.$

$NH_2-C_2H_3$ methylamine.

Coordination Number

✓ The coordination number is generally 2, 4 (or) 6, occasionally 8 (in Osmium complexes).

Shape of the complex species depends on its coordination number.

✓ Note : Only Sigma bonds are counted in coordination number, if pie bonds are formed between central metal and ligands that will not be counted in coordination number.

Coordination Number (C.N.) of Metal Ions

Metal ion	C.N.
* Ag^+	2

Metal ion	C.N.
Fe^{3+}	6
Co^{3+}	6
Zn^{2+}	4

Metal ion	C.N.
Sc^{3+}	6
Cr^{3+}	6
Pt^{2+}	4
* Pt^{4+}	6

Block → for 3d series

E^{+2} CN=4, E^{+3} CN=6.

Table: Shape of the complexes depending upon their Coordination No.

Coordination Number	Shape of the Complexes
2	Linear
3	Trigonal planar
4	Tetrahedral (or) Square planar
5	Square pyramidal (or) Trigonal bipyramidal
6	Octahedral
7	Pentagonal bipyramidal



Coordination Polyhedron



The spatial arrangement of the ligand atoms which are directly attached to the central atom/ion defines a coordination polyhedron about the central atom.

The most common coordination polyhedral are octahedral, square planar and tetrahedral.

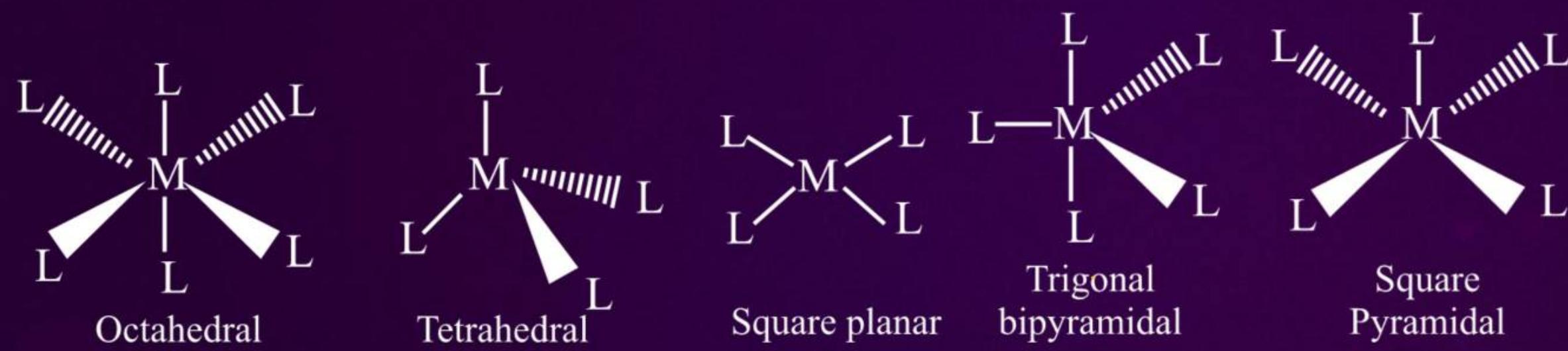


Fig: Shapes of different coordination polyhedral.

M represents the central atom/ion and L, a unidentate ligand.

Oxidation Number of Central Atom

Oxidation number is actual charge on central metal atom when all ligands along with donated electrons are removed.

For example oxidation number of Fe in $K_4[FeCN_6]$ is 2

To calculate oxidation number follow following steps

Let assume oxidation number be x

Total charge on compound = 0

$$4 + x - 6 = 0$$

$$x = 2$$

Oxidation number of Pt in $\text{PtCl}_2(\text{NH}_3)_2$ is 2

$$\begin{aligned} & \eta + 2(-1) + 2(0) = 0 \\ & \eta = 2 \end{aligned}$$



$$1 \times 4 + \eta + 6 \times (-1) = 0$$

$$4 + \eta - 6 = 0$$

$$\boxed{\eta = 2}$$

Group 2

Li
N_g
K
R_b
Cs

+1

Group 2

Be
Mg
Ca
Sr
Ba
Ra

+2

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



$$x - 1 + 0 - + 2 \quad n = 3$$



$$x - 1 - 1 + 0 = +1 \quad n = 3$$



$$x + 0 - 1 - 1 = 0 \quad n = 2$$



$$x + 0 - 3 = 0 \quad n = 2$$



$$x + 0 - 1 + 0 - 1 = 0$$



Home Work

kal wala DPP

PARISHRAM



2026

Coordination Compound

CHEMISTRY LECTURE-05

BY – BIJENDRA SIR (Biju Bhaiya)



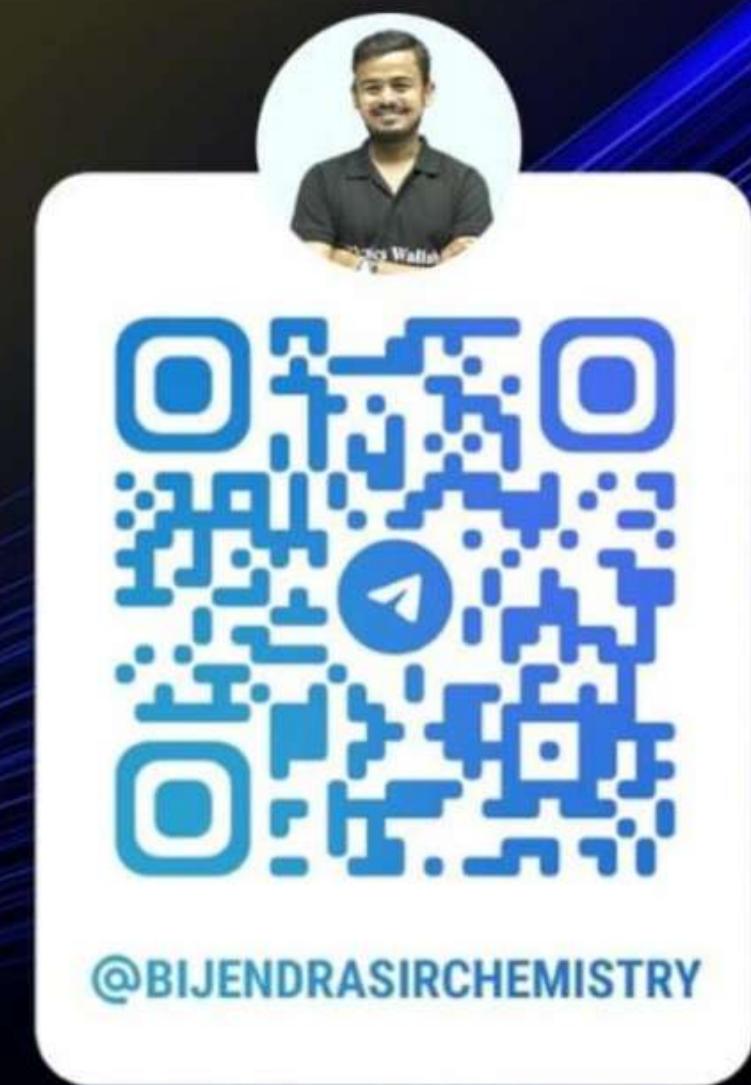
Topic Covered

IUPAC
Nomenclature



BIJENDRA SIR

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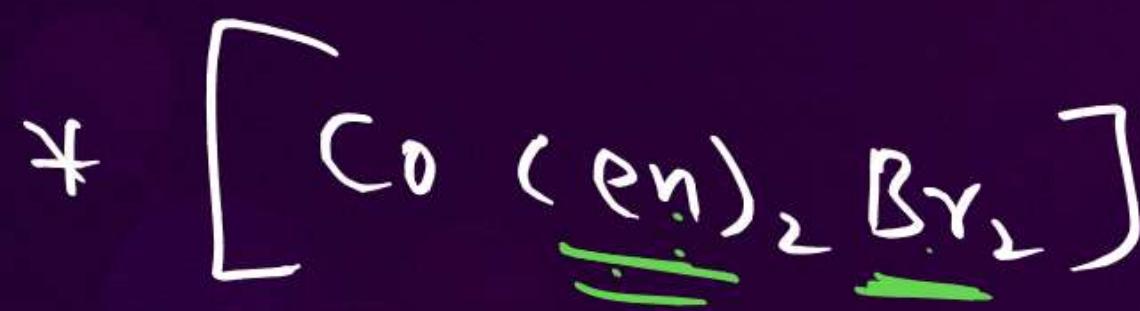




$CN = \text{no. of ligands} \times$
Denticity.

$$CN = 1 \times 6$$

$$= 6 \checkmark$$



$$CN = 2 \times 2 + 2 \times 1$$

$$= 4 + 2 = 6.$$

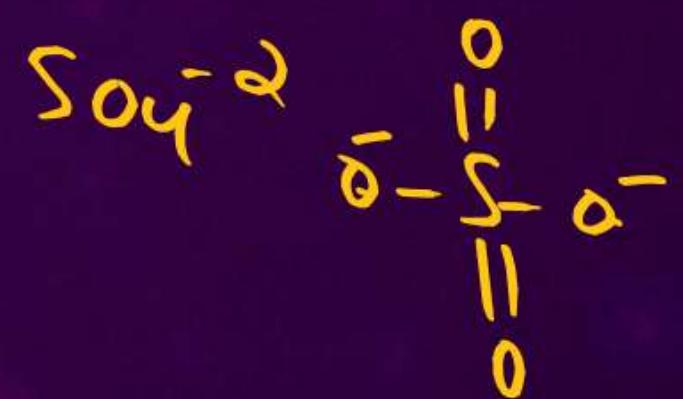
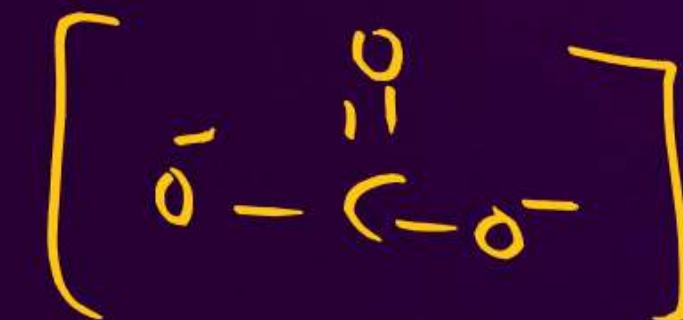
Variable \rightarrow Denticity.
Flexidentate Ligand or

✓ Flexidentate Ligands are the type of ligands which can vary their denticity according to the type of complex compound,

for example SO_4^{2-} has two Oxygen atom having negative charge on it, so denticity of SO_4^{2-} is 2, but it can show denticity 1 also in some complex compounds.



Other examples of Flexidentate Ligands are : CO_3^{2-} , EDTA^{4-}



bidentate ligand

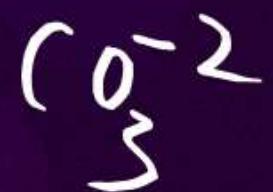
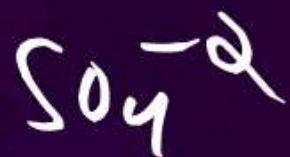
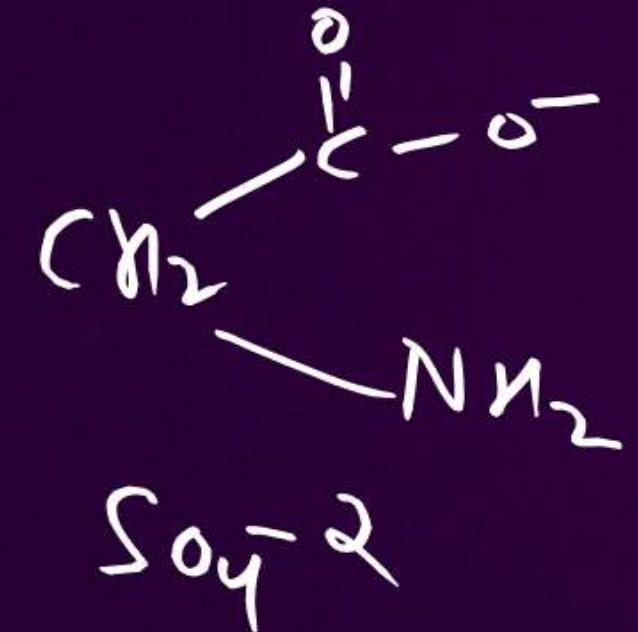
en



ox



py



IUPAC Nomenclature of Coordination Compounds

✓ To write name of anionic Ligand replace e with o like Chloride will be converted to Chlorido or Chloro, Bromide will be converted to Bromido or Bromo

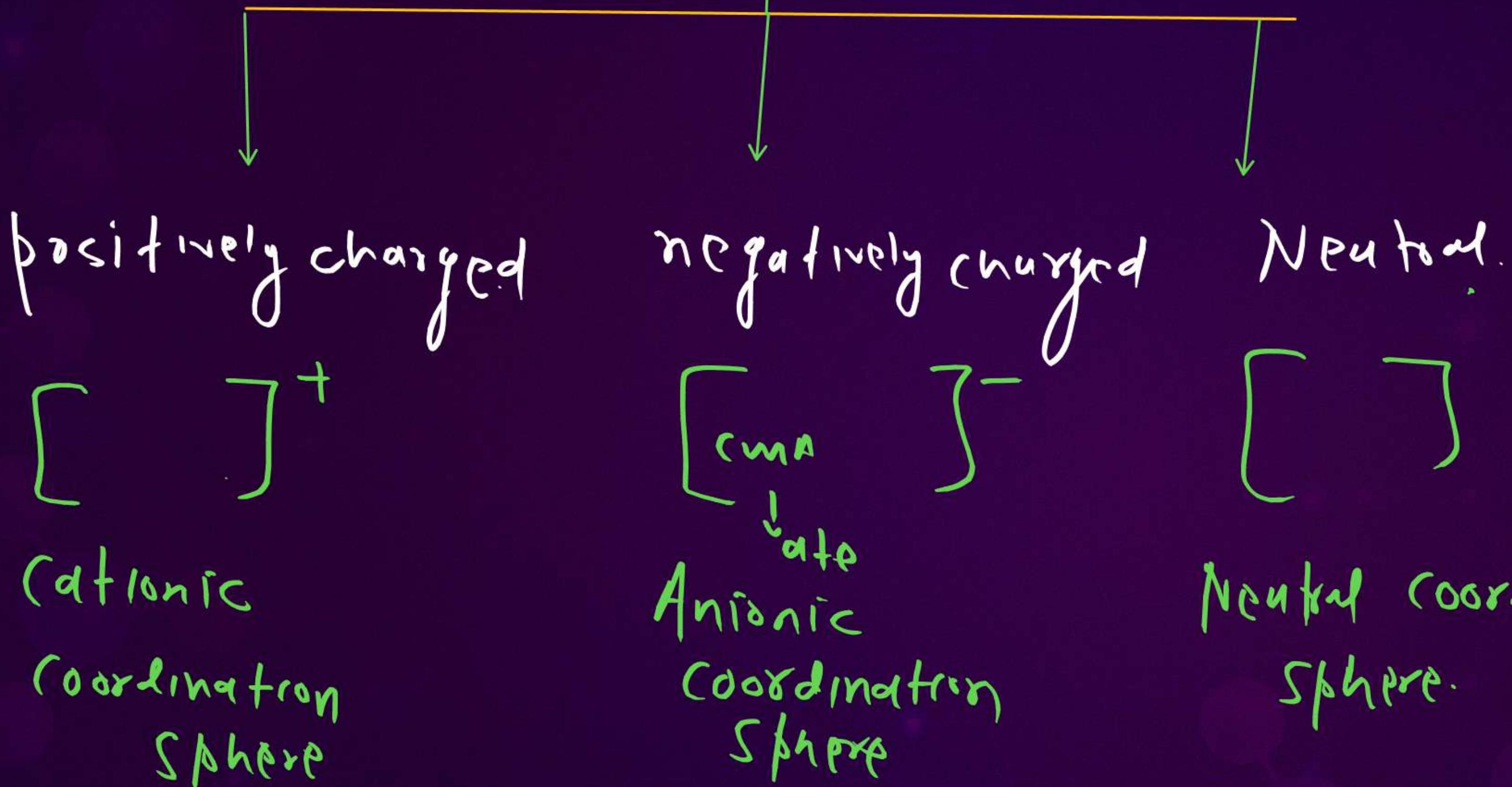
Cl^-	Chlorido or Chloro	-○	NC^-	Isocyanido	- 1
Br^-	Bromido or Bromo	-○	S^{2-}	Sulphido	
OH^-	Hydroxido	- ○	SO_3^{2-}	Sulphito	
H^-	Hydrido	- ○	* SO_4^{2-}	<u>Sulphato</u>	2
CN^-	Cyanido/ Cyano	-○	* CH_3COO^-	Acetato	1
O^{2-}	Oxido		* $\text{C}_2\text{O}_4^{2-}$	Oxalato	2
O_2^{2-}	Peroxido		* CO_3^{2-}	Crabonato	2
			* SCN^-	Thioscyanato	-○
			* NO_2^-	Nitrito -N	-○

IUPAC Nomenclature of Coordination Compounds

Name of Some Neutral Ligands

NH_3	Ammine
H_2O	Aqua
CO	Carbonyl
NO	Nitrosyl
$\text{C}_5\text{H}_5\text{N}$	Pyridine
$\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2$	Ethylenediammine
PPh_3	Triphenyl Phosphene

Coordination compound.



Rules for writing name of central metal of Coordination Compounds



If Central metal atom is present in anionic coordination Sphere then add ate at the end of the name

Example : $[\text{Ni}(\text{CN})_4]^{2-}$ tetracyanonickelate (II)

Bijendra + ate

→ Bijendrate

Fe Iron - Ferrate

Pb Lead - plumbate

✓Au Gold - Aurate ✓

Pt Platinum - Platinate

Al Aluminium - Aluminate

Ag Silver - Argentate ✓

Co Cobalt - Cobaltate

Sn Tin - Stannate

Zn Zinc - Zincate

Cu Copper - Cuprate

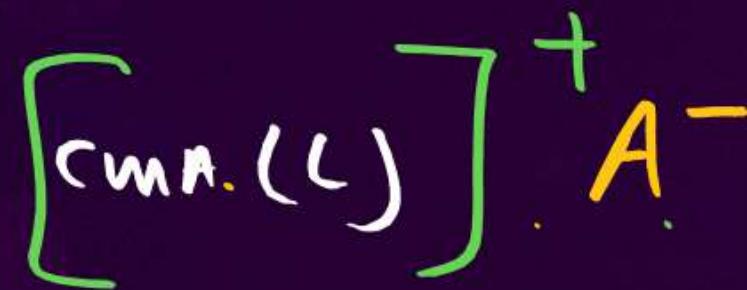
Rahul + ate

Rahulate.

cation is added first
written first
NaCl

Coordination compound.

positively charged



Cationic
Coordination
Sphere

negatively charged



Anionic
Coordination
Sphere

Neutral.

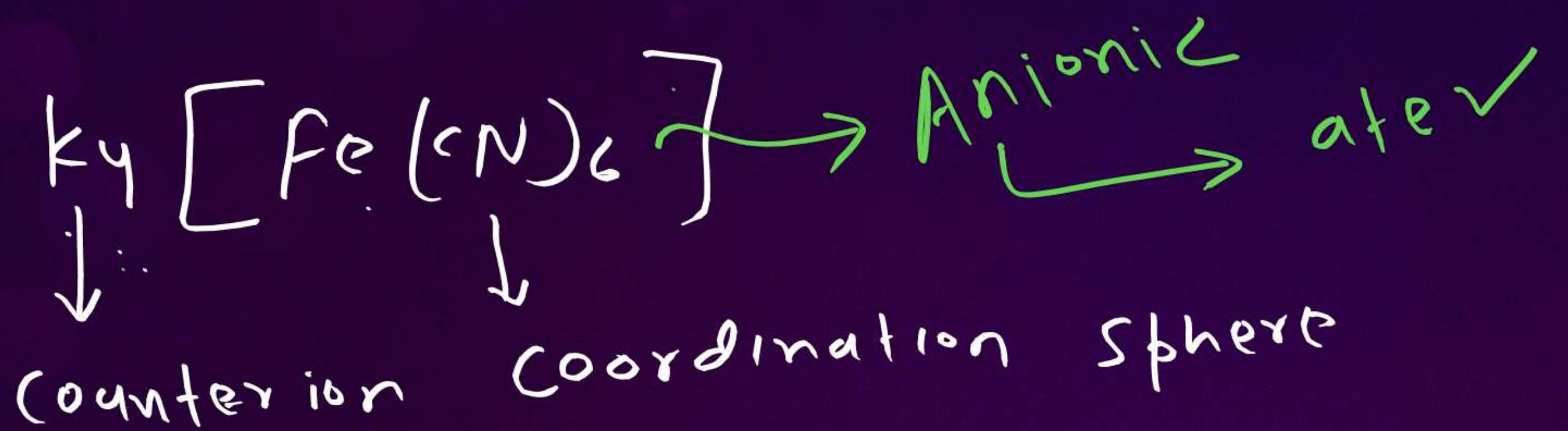


Neutral Coordination
Sphere.

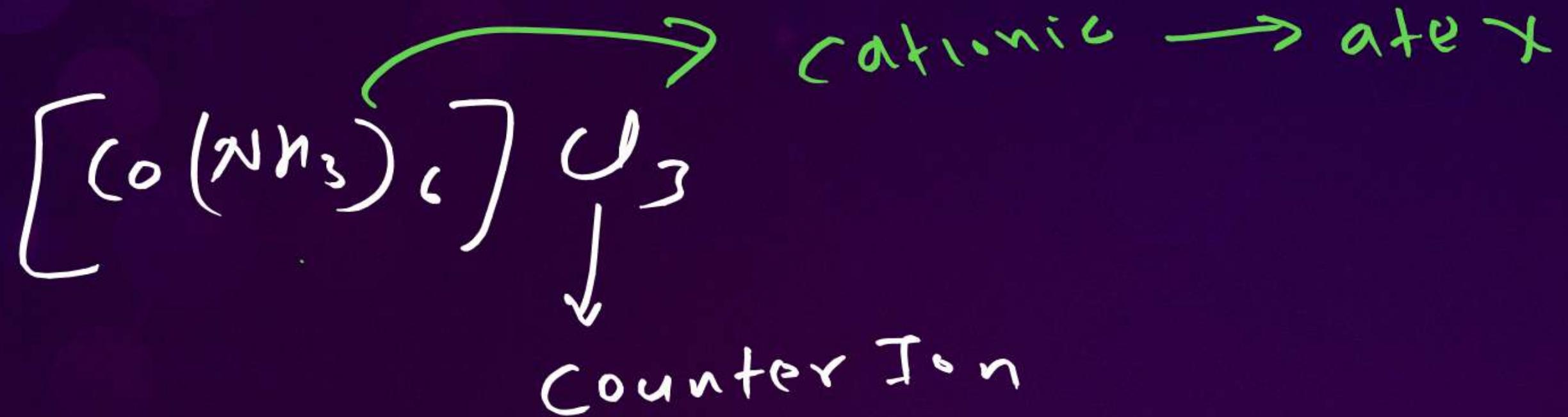
Rules for writing name of Coordination Compounds

1. We Write name of cation first
2. Name of Ligands should be written before writing the name of central metal ion with oxidation number
 - Cationic Counter ion + Name of Coordination Entities
 - Name of Coordination Entities + Anionic Counter Ion

Name of Coordination Entities - Ligand + Central metal Atom/Ion



Name of Counter Ion + Name of Coordination Entities.



Name of coordination + Name of counter Ion.
Entities

$[\text{Ligand} + \text{C.-m-A(ON)}] +$ Name of counter Ion.

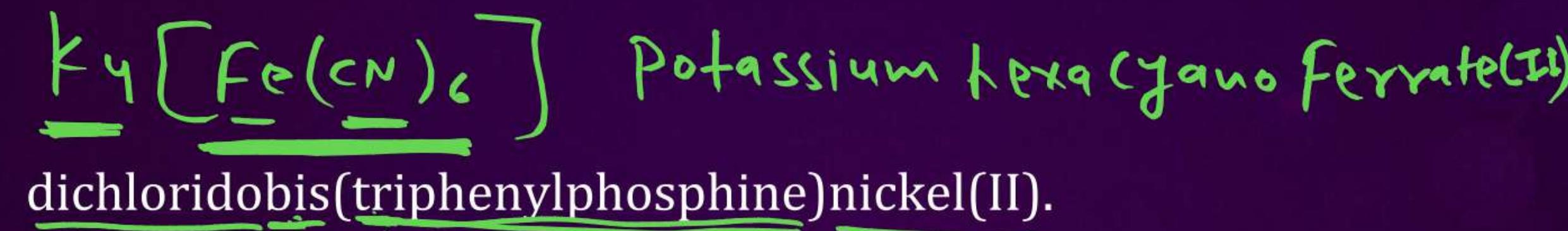
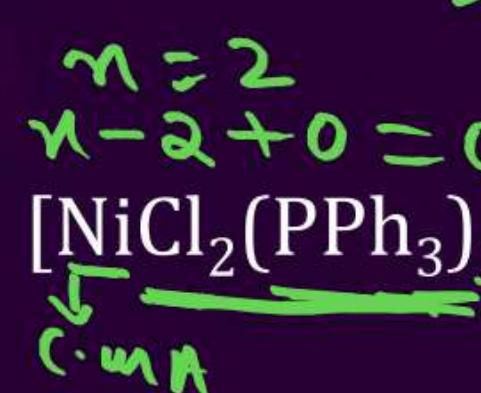
Rules for writing name of Coordination Compounds

1. First Write the name of Ligands and use prefix di, tri, tetra, penta, hexa etc for number of ligands 2, 3, 4, 5 & 6 respectively.
2. Write name of ligands in alphabetical order ignore the prefix di, tri, tetra while deciding the priority order
3. If multiple polydentate Ligands are present in the complex use prefix bis, tris, tetrakis, etc
$$(\text{en})_2 \rightarrow \text{di} (\text{etylendiamine})X$$
4. After writing the name of ligands write the name of central metal atom with oxidation number in Roman numeral inside ()
$$\underline{\hspace{10cm}}$$

Rules for writing name of Coordination Compounds

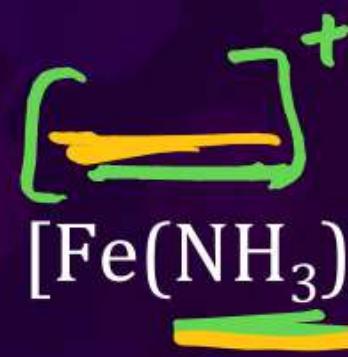
5. Like we write the name of NaCl as Sodium Chloride - **Cation is written First.**
We also follow same rule for complex compounds **Cation is written first**

6. Example $K_4[FeCN_6]$ here K^+ is cation so that should be written first as - Potassium hexacyanoferate(II)



$$2n + 0 + 3(-2) = 0$$

$$2n = 6 \quad n = 3.$$



$[\text{Fe}(\text{NH}_3)_6]\text{Cl}_3$ Hexaammine Iron(III) Chloride

$[\text{CoCl}(\text{NH}_3)_5]^{+2}$ Pentaamminechlorocobalt (III) Ion

$[\text{Co}(\text{Cl})(\text{NO}_2)(\text{NH}_3)_4]^+$ Tetraamminechloronitrocobalt(III) Ion ✓

$[\text{Pt}(\text{NH}_3)_2\text{Cl}(\text{NO}_2)]$ Diamminechloronitrito-N-Platinum(II)

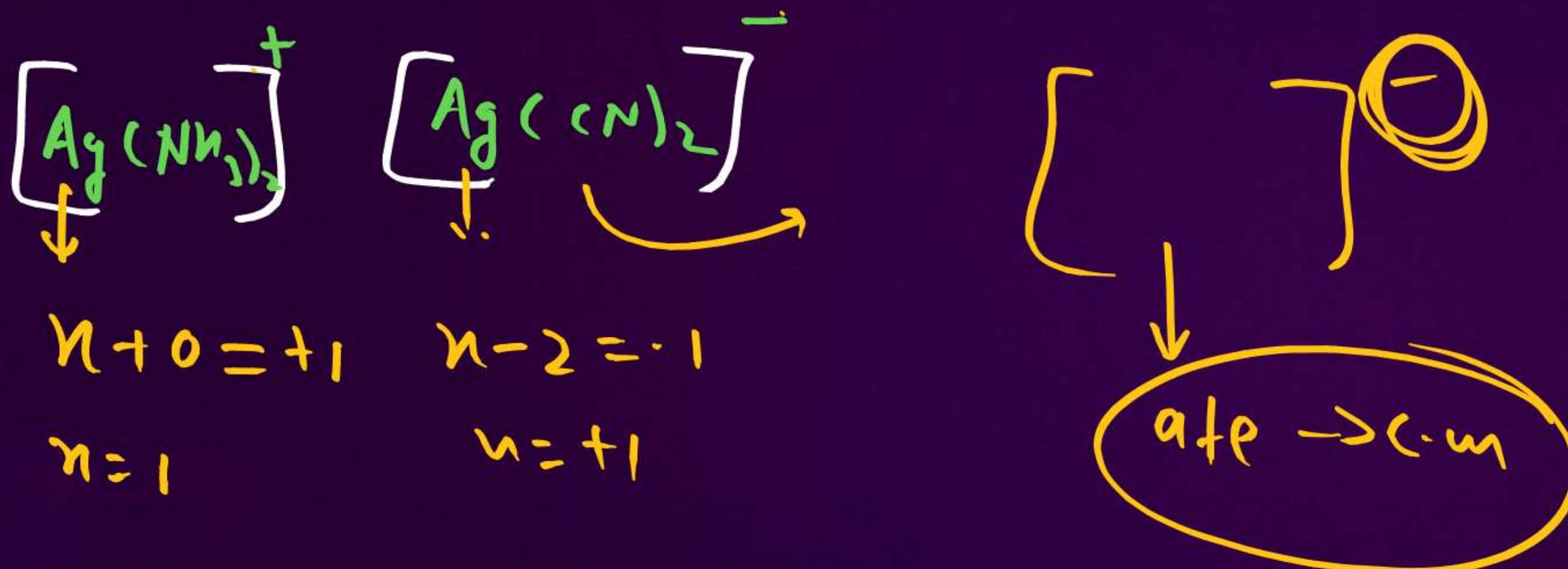
$[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$ Hexaammine Cobalt (III), Chloride

$[\text{Pt}(\text{NH}_3)_2\text{Cl}(\text{NH}_2\text{CH}_3)]\text{Cl}^-$ Diamminechloromethyamine Platinum(II) Chloride ✓

$[\text{Co}(\text{NH}_3)_4\text{Cl}(\text{NO}_2)]\text{Cl}$. TetraammineChloronitrito-N- Cobalt (III) Chloride

$$\cancel{x} + \cancel{4x} 0 - 1 - 1 - 1 = 0$$

$$\eta = 3.$$



Question

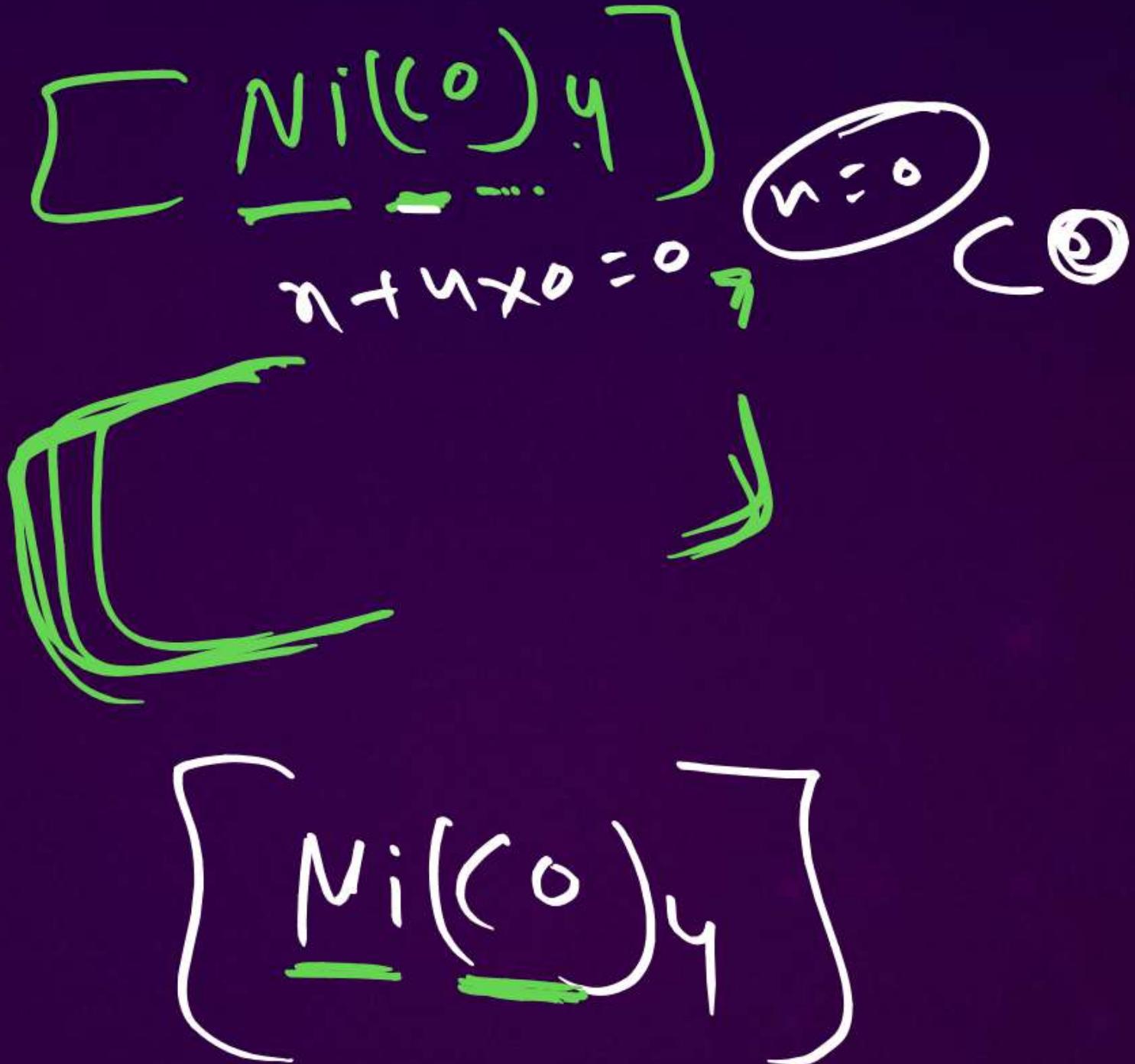
$(\text{NH}_3), \text{NO}_2^-$ $n + 0 - 2 = 0$ $n = 3$.
The IUPAC name for the complex $[\text{Co}(\text{NH}_3)_5(\text{NO}_2)]\text{Cl}_2$ is:

- A Nitrio-N-pentaammine cobalt (III) chloride
- B nitrio-N-pentaamine cobalt (II) chloride
- C pentaammine nitrito-N-cobalt (II) chloride
- D pentaammine nitrito-N-cobalt (III) chloride

Question

The IUPAC name of $\text{Ni}(\text{CO})_4$ is:

- A tetracarbonyl nickelate (0)
- B tetracarbonyl nickelate (II)
- C tetracarbonyl nickel (0)
- D tetracarbonyl nickel (II)



Question

$K_4[Fe(CN)_6]$ is called :

A

potassium hexacyanoferrate (II)



B

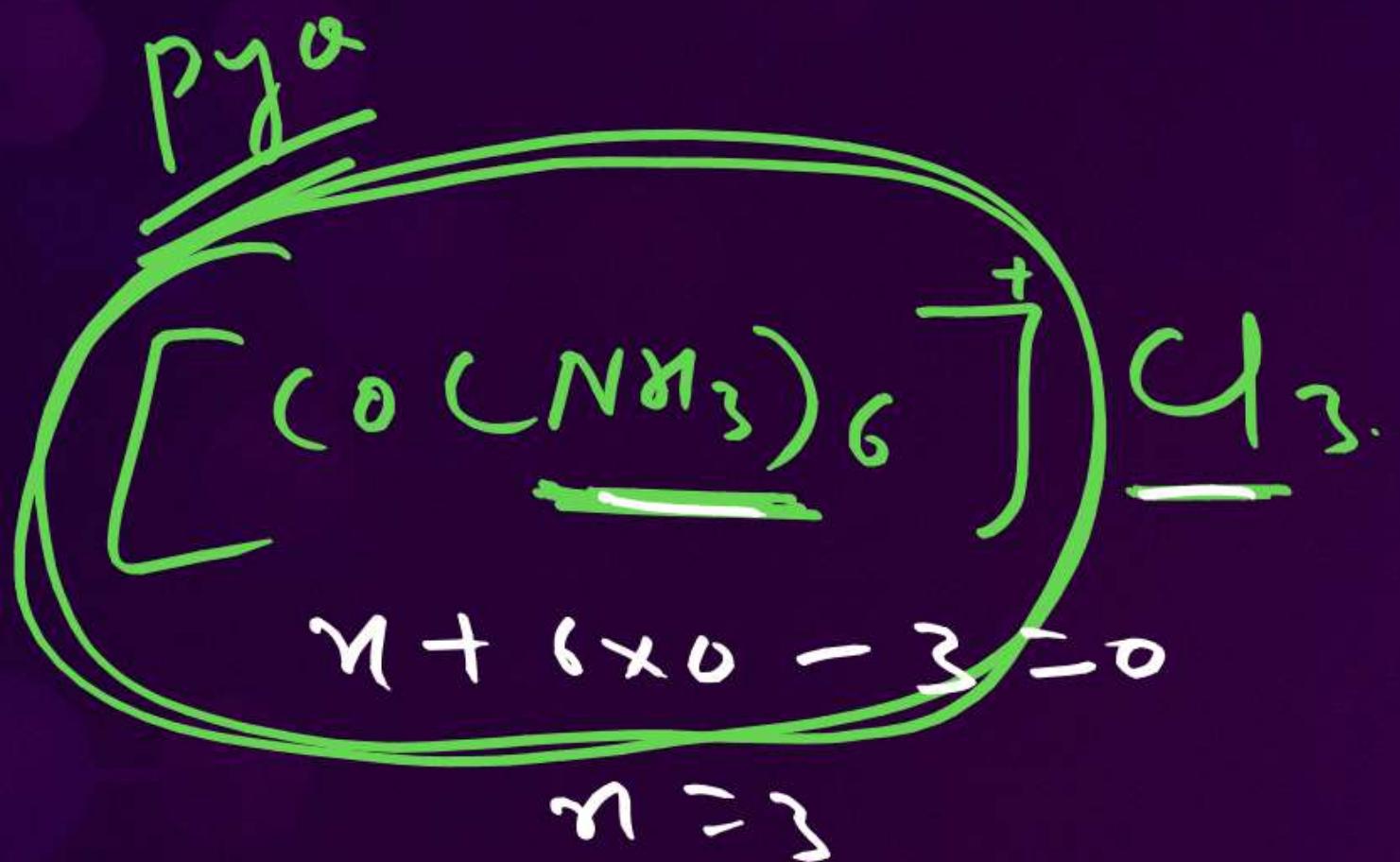
potassium ferricyanate

C

potassium ferricyanide

D

prussian blue



hexaammine cobalt(III) chloride

2023



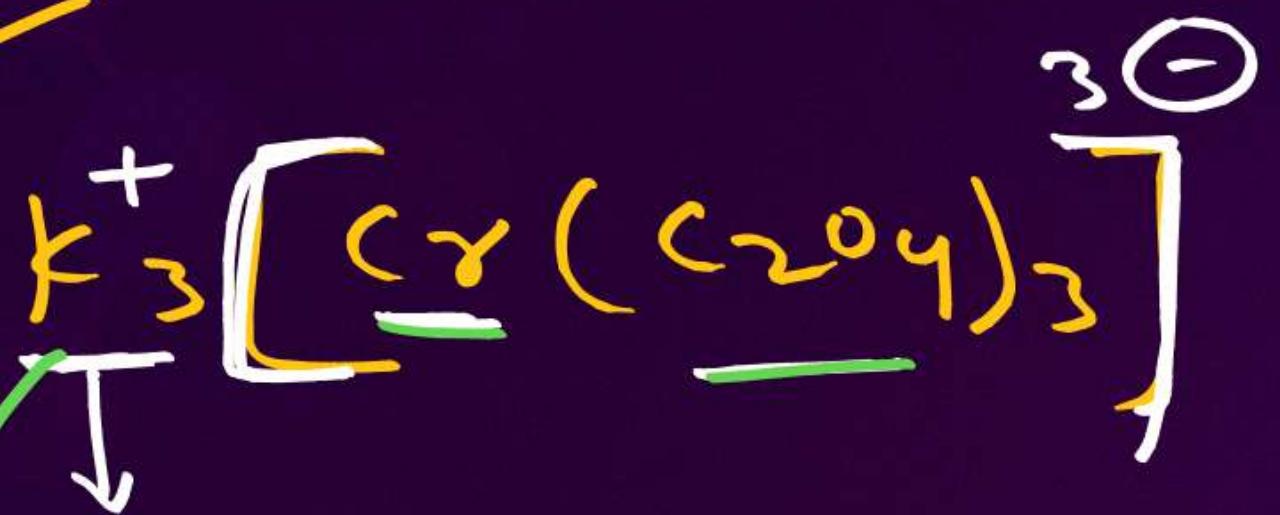
$$n + 5 \times 0 - 1 - 2 = 0$$

$$n = 3$$

Pentaammine Nitro-N

(cobalt(III)) chloride

Pyo.

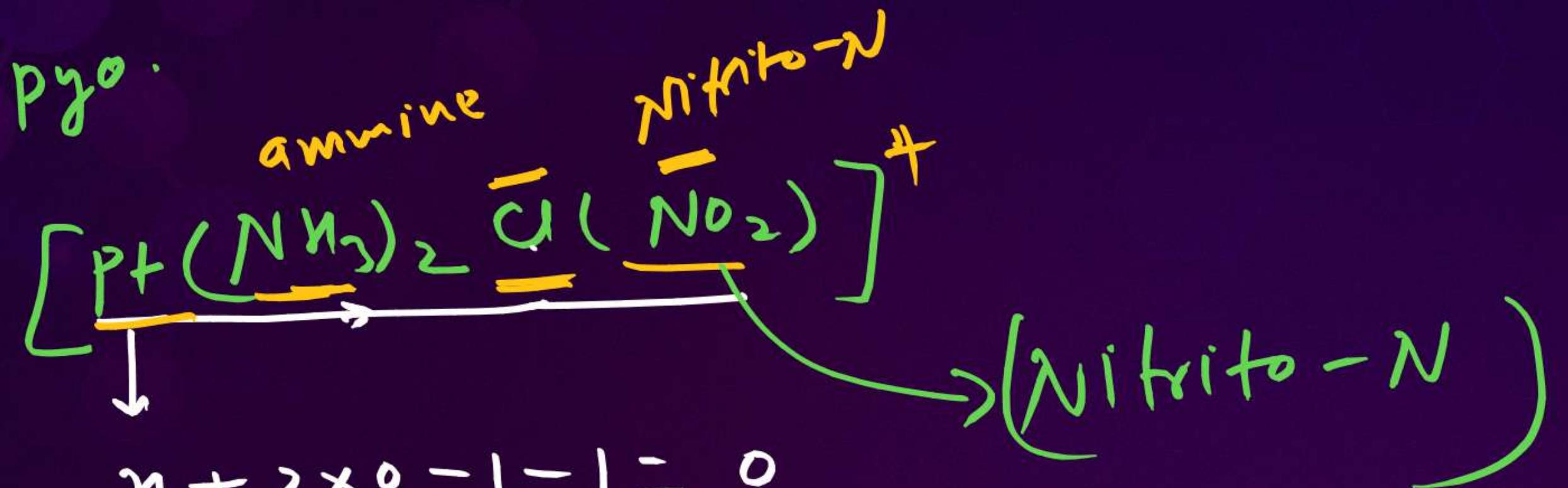


Potassium tri oxalato chromate(III)

$$3+n+3(-2)=0$$

$$3+n-6=0$$

$$n=3.$$



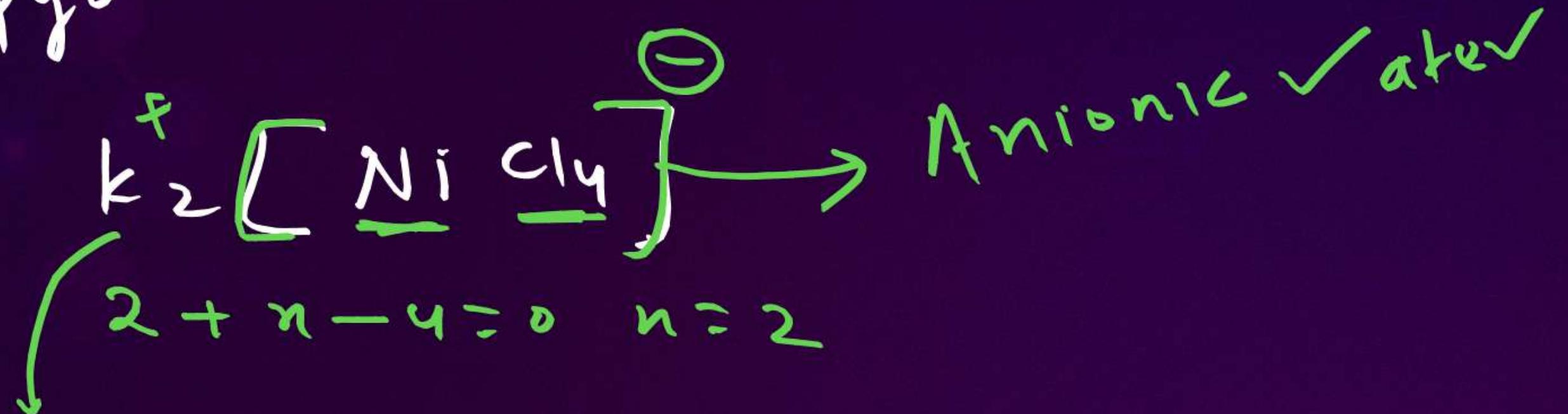
$$n + 2 \times 0 - 1 - 1 = 0$$

$$n = 2$$

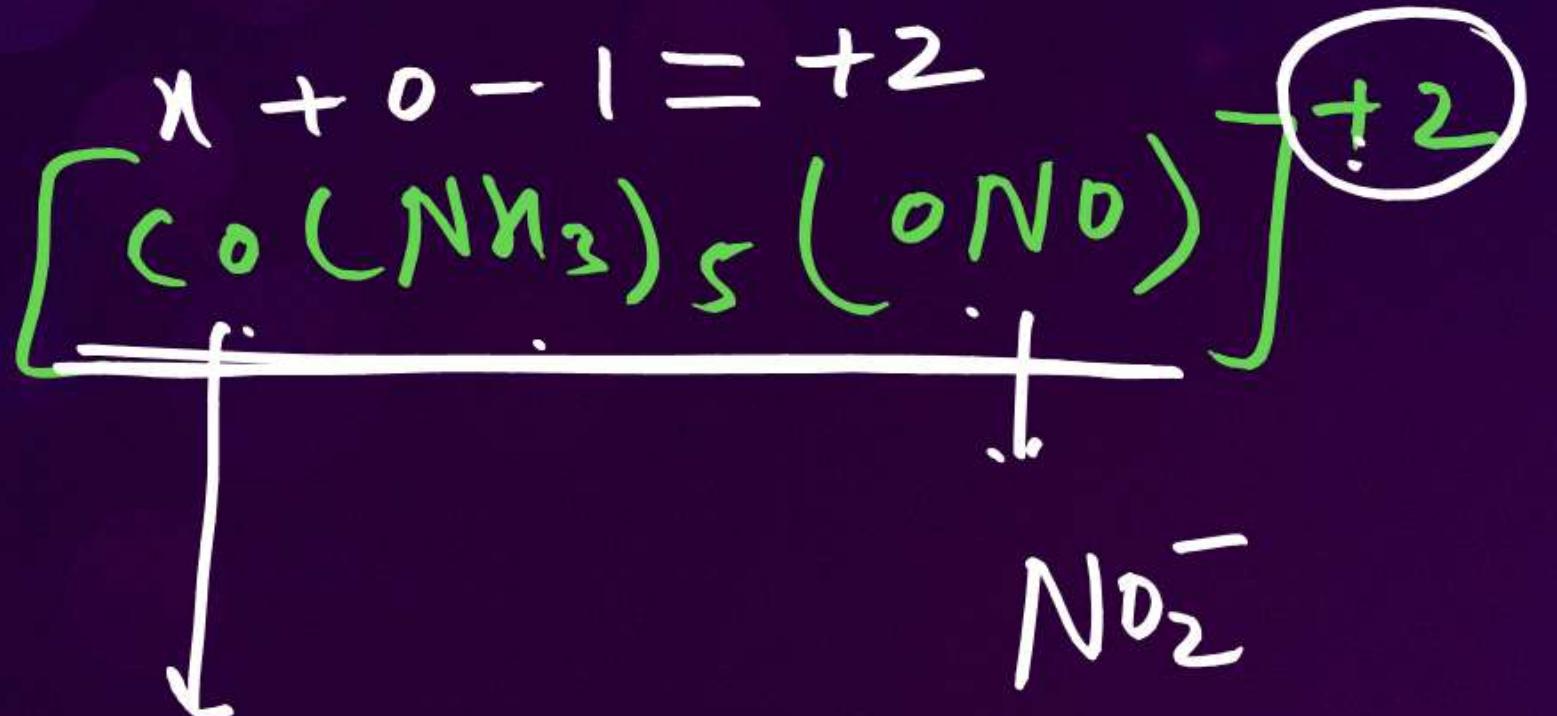


di ammine chlorido Nitrito-N platinum(II)

PyO



Potassium tetra chlorido Nickelate (II)



Pentaammine nitri- σ -cobalt(III) Ion.



Home Work

→ DPP ⇐

PARISHRAM



2026

Coordination Compound

CHEMISTRY LECTURE-06

BY – BIJENDRA SIR (Biju Bhaiya)



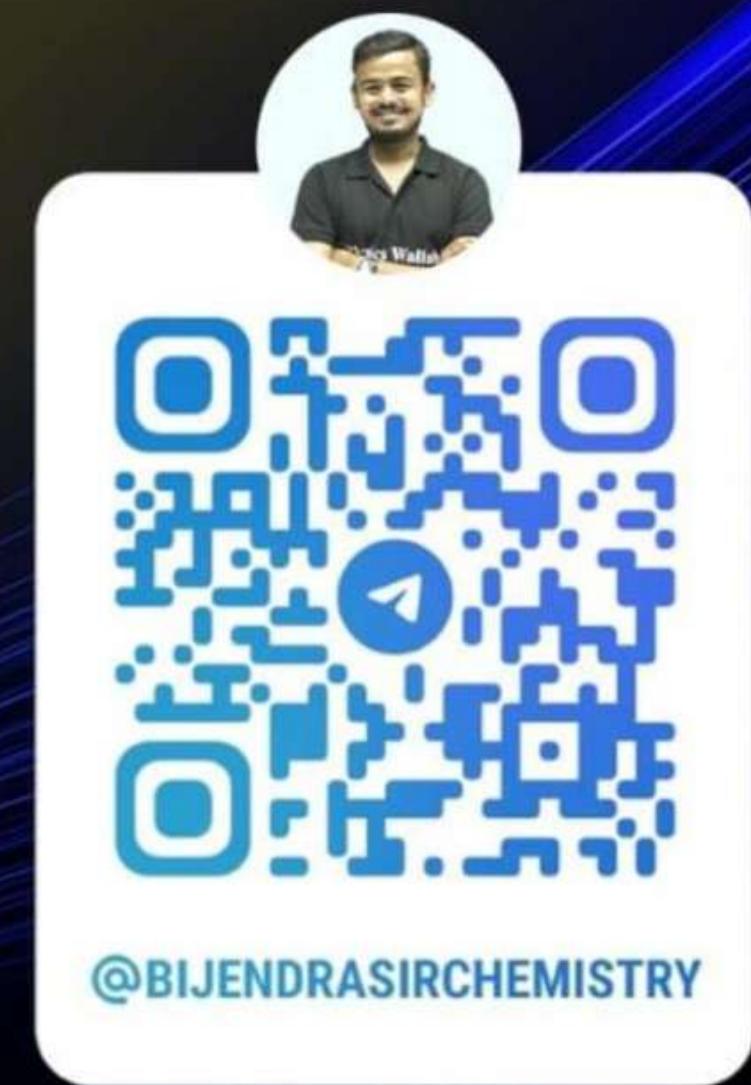
Topic Covered

Werner Theory



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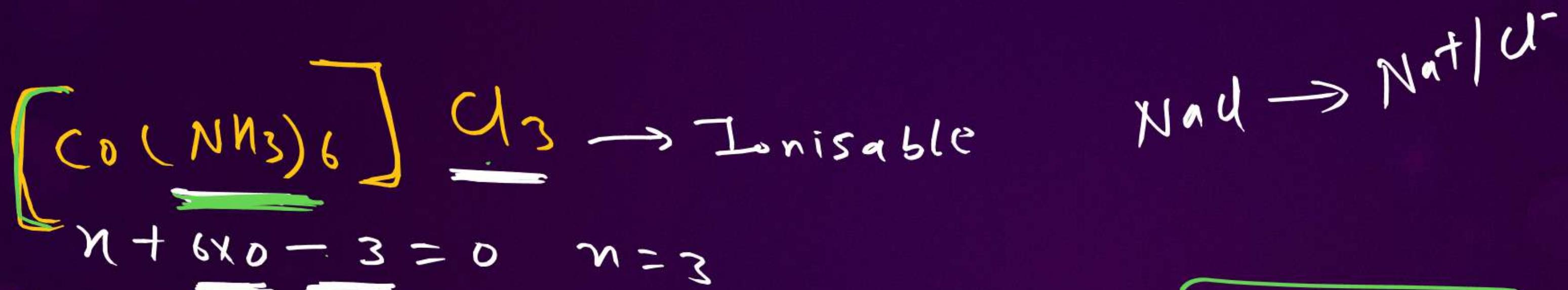


Werner theory of Coordination Compound

According to Werner (father of Co-ordination chemistry), transition metals possess two types of valencies:

- (a) Primary valency (Ionisable valency) \rightarrow oxidation no.
- (b) Secondary valency (non ionisable valency) \rightarrow coordination no.

1 mol	CoCl ₃ .6NH ₃ (Yellow)	gave	3 mol AgCl
1 mol	CoCl ₃ .5NH ₃ (Purple)	gave	2 mol AgCl
1 mol	CoCl ₃ .4NH ₃ (Green)	gave	1 mol AgCl
1 mol	CoCl ₃ .4NH ₃ (Violet)	gave	1 mol AgCl



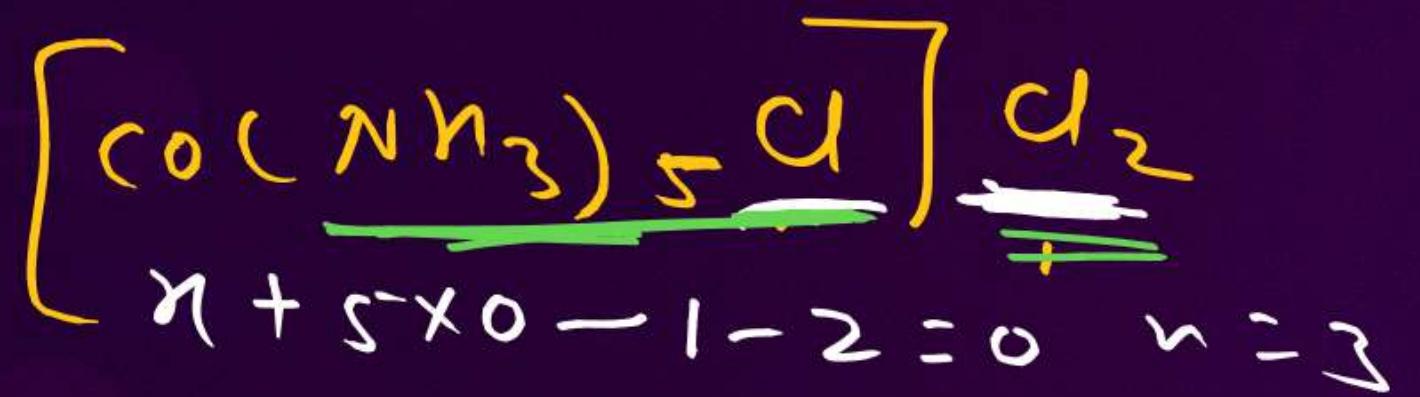
$$\underline{\underline{CN=6}}$$

$$\text{PV} = \text{oN} = 3.$$

$$\text{SV} = \underline{\underline{CN=6}}$$

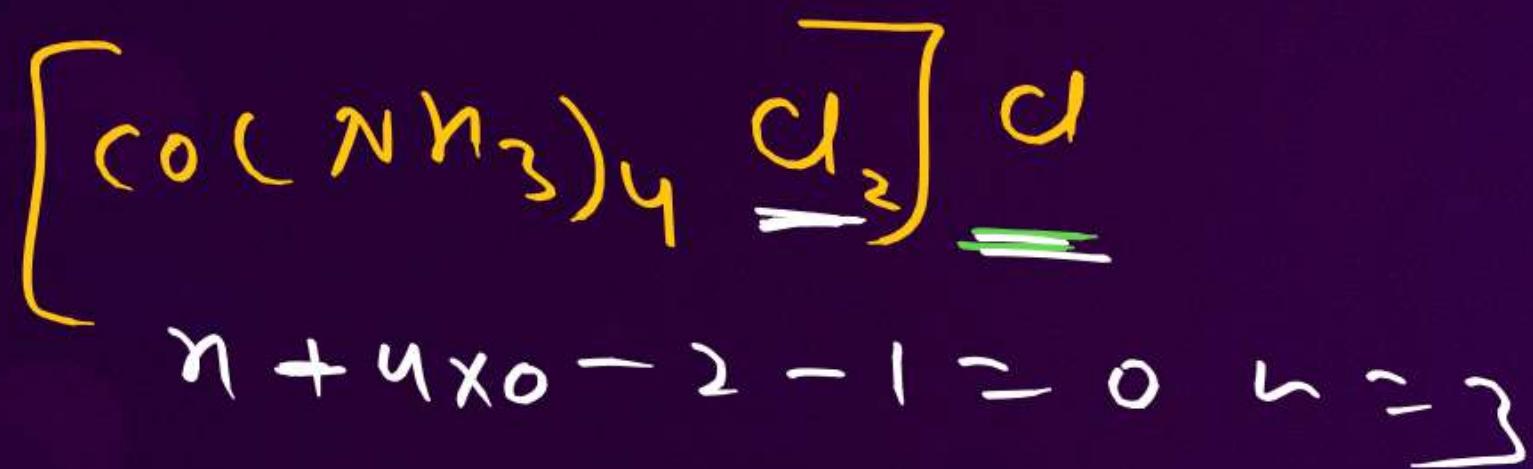
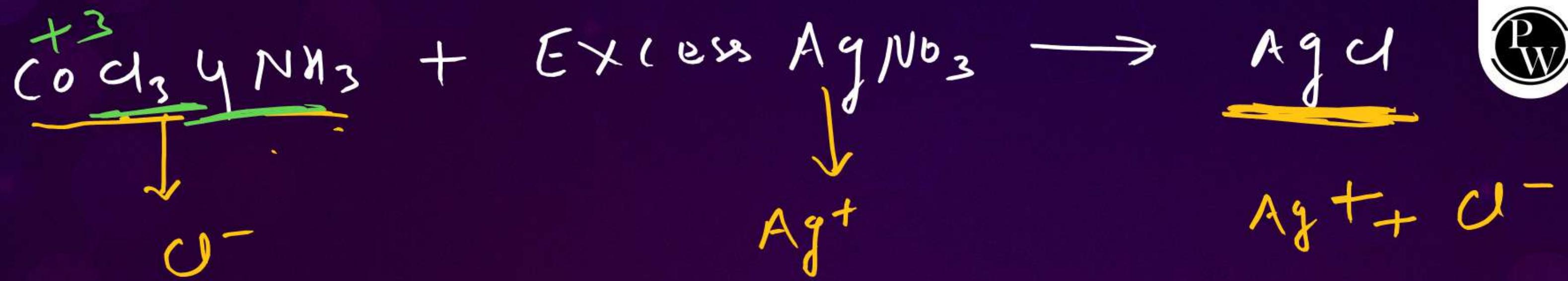
$$\boxed{CN=20N}$$

for 3d-series



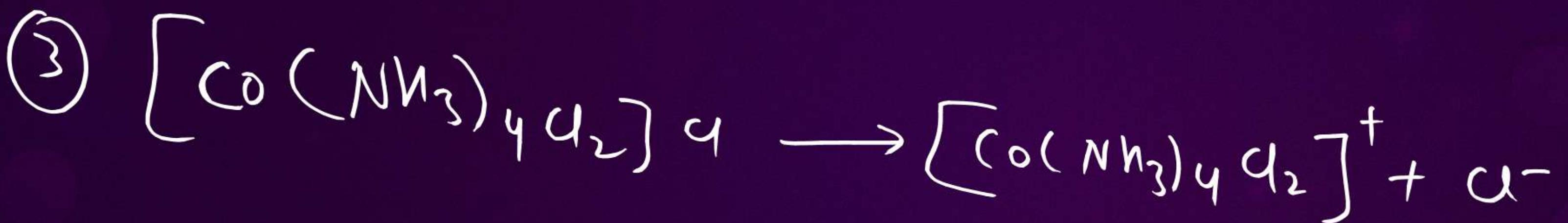
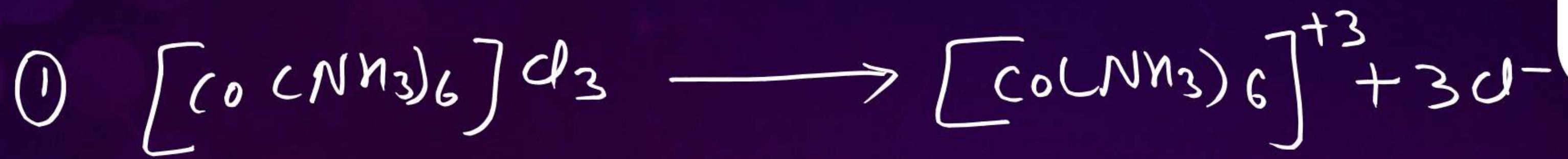
$$CN = 6, PV = \underline{on = 3}$$

$$SV = CN = 6.$$



$$\frac{CN=6}{\equiv} \quad PV = 0N = 3$$

$$\frac{SV = CN = 6}{\equiv}$$





Werner theory of Coordination Compound

Formulation of Cobalt (III) Chloride-Ammonia Complexes

Colour	Formula	Solution conductivity corresponds to
Yellow	a. $[\text{Co}(\text{NH}_3)_6]^{3+} 3\text{Cl}^-$	1:3 electrolyte
Purple	b. $[\text{CoCl}(\text{NH}_3)_5]^{2+} 2\text{Cl}^-$	1:2 electrolyte
Green	c. $[\text{CoCl}_2(\text{NH}_3)_4]^+ \text{Cl}^-$	1:1 electrolyte
Violet	d. $[\text{CoCl}_2(\text{NH}_3)_4]^+ \text{Cl}^-$	1:1 electrolyte

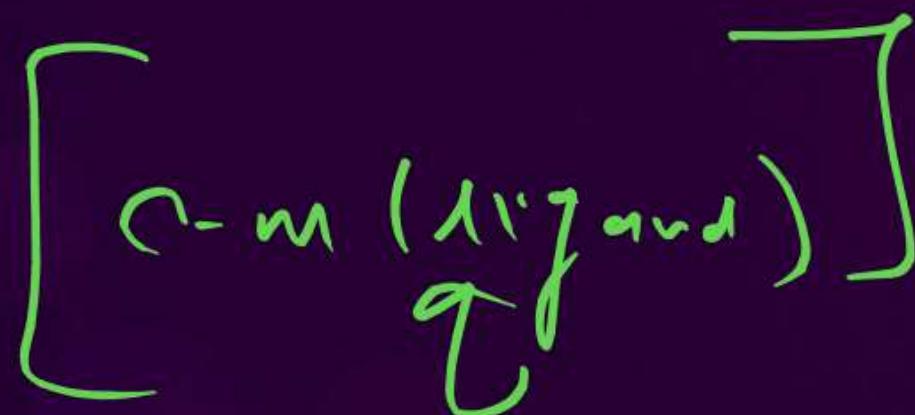
(a) Primary valency (Ionisable valency) (oxidation no.)

- (i) The primary valences are normally ionisable and are satisfied by negative ions.
- (ii) It is referred to as oxidation state.
- (iii) It is represented by dotted lines while writing the structure of complex.

(b) Secondary valency (non ionisable valency)

- (i) It is satisfied by anions or neutral molecules or rarely with cations.
- (ii) The groups satisfying secondary valencies are called ligands. ✓
- (iii) The number of secondary valencies is called coordination number. ✓
- (iv) It is represented by solid lines while writing the structure of the complex.

In some complexes, the same groups satisfies both primary and secondary valencies.



$$CN = \text{No. of Ligands} \times \text{Dentrity}$$

Drawbacks

Does not explain the cause of various properties like

- 1. Color,
- 2. Geometry and
- 3. Magnetic properties



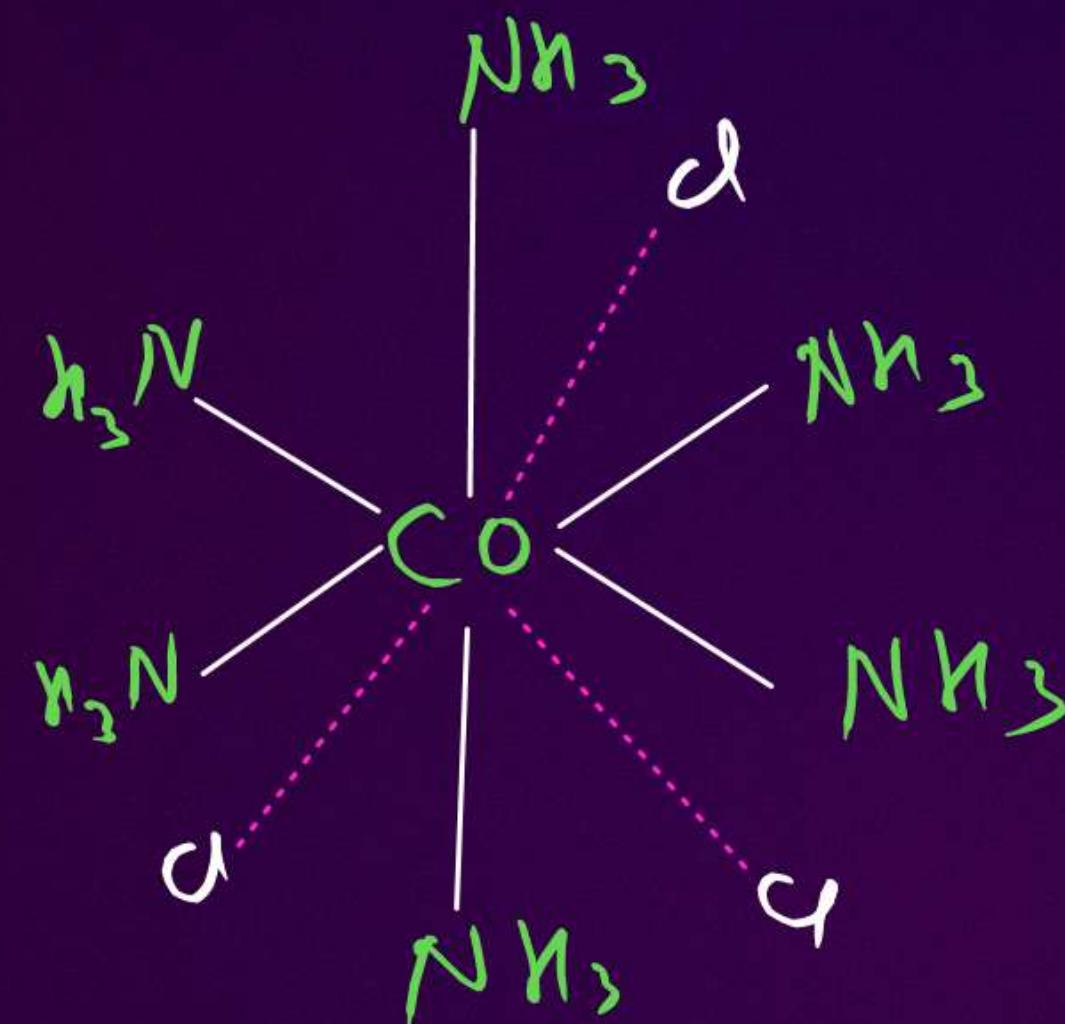
$$n + 6 \times 0 - 3 = 0 \quad n = 3$$

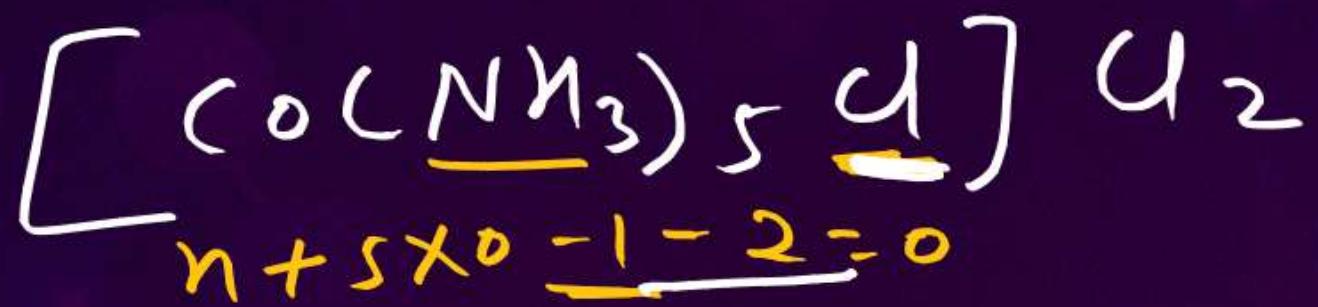
PV = ON

SV = CN = 6 \times 1 = 6.

PV = dotted line

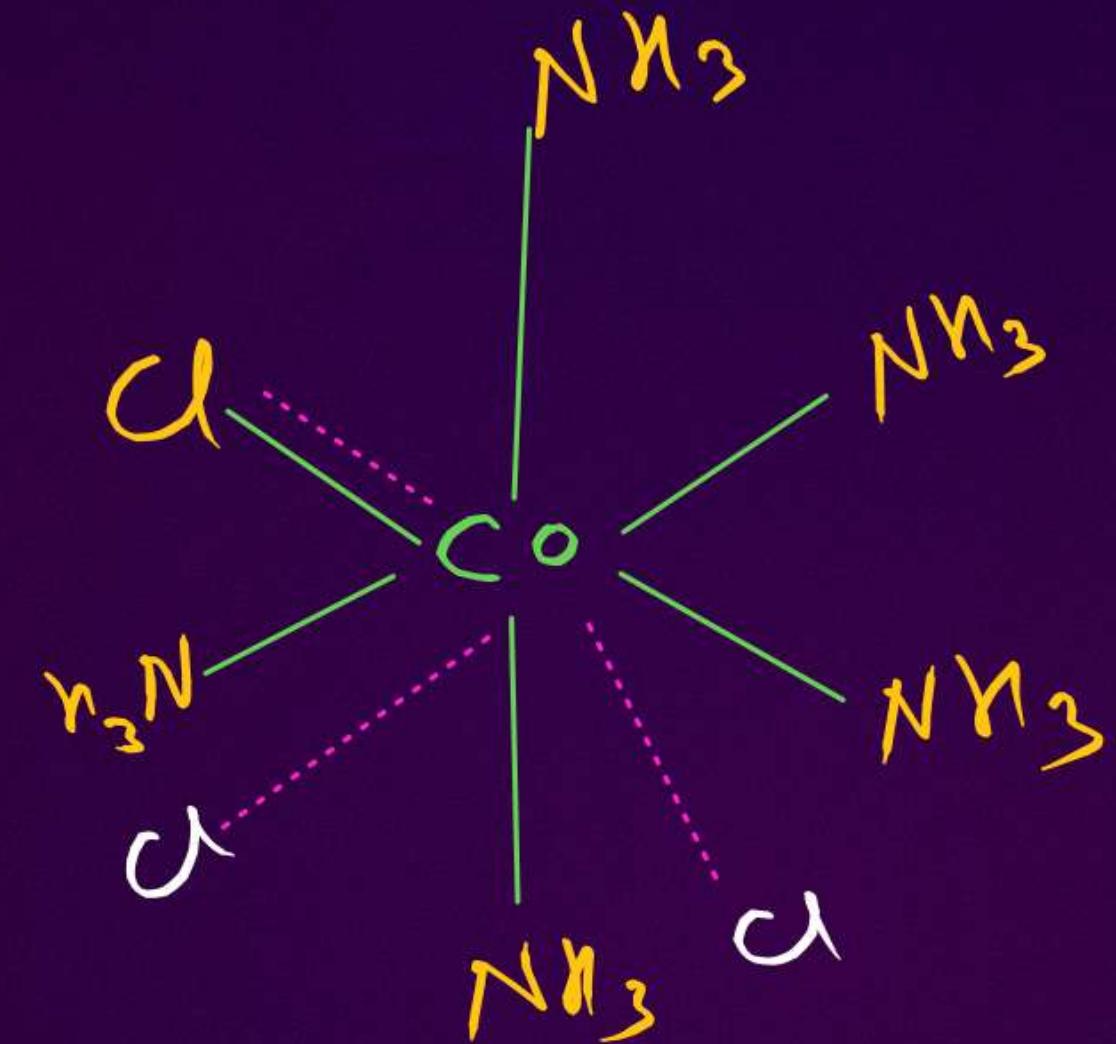
SV = Solid line.

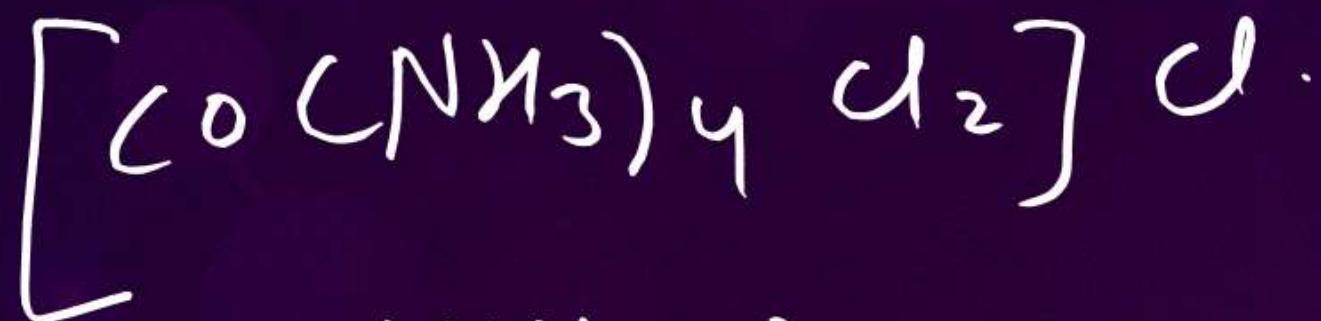




$$PV = 0N = 3$$

$$\underline{SV = CN = 1 \times 5 + 1 \times 1} \\ = 6.$$

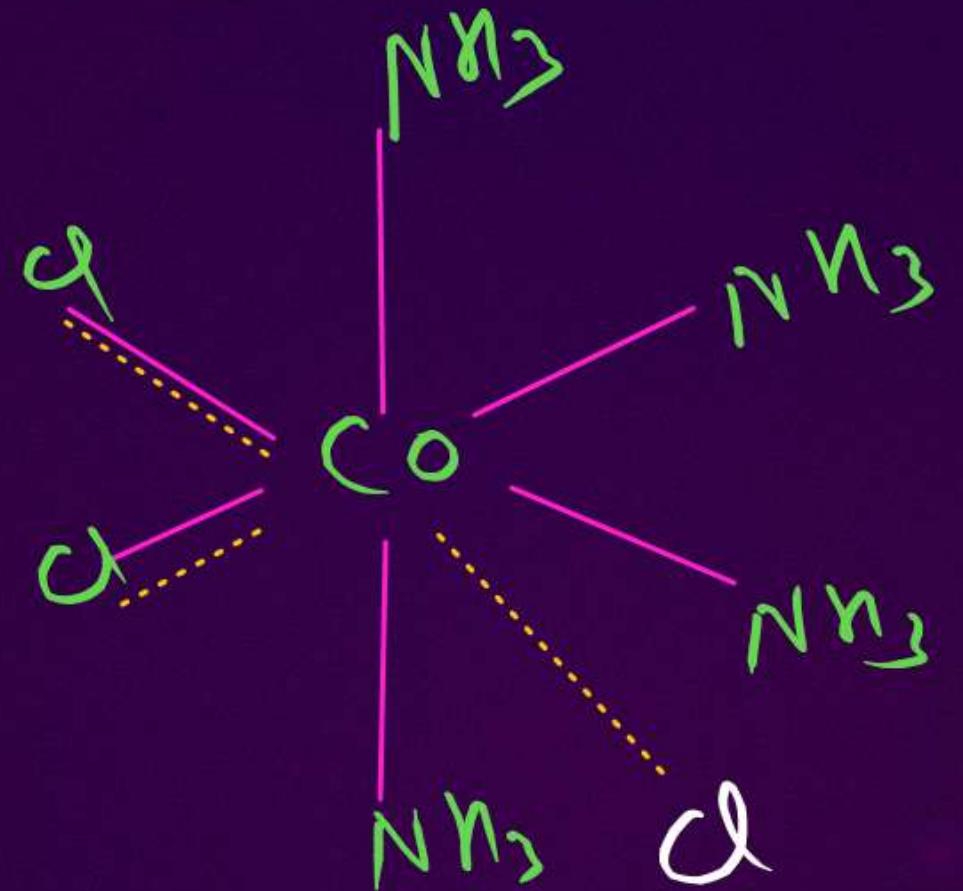




$$n + 4 \times 0 - 2 - 1 = 0 \quad n = 3$$

$$PV = 0N = 3$$

$$SV = CN = 4 \times 1 + 2 \times 1 \\ = 6.$$



Question

The number of chloride ions which would be precipitated, when $\text{CrCl}_3 \cdot 4\text{NH}_3$ is treated with silver nitrate solution.

- A 3
- B 2
- C 1
- D 0



$$n - 3 + 4 \times 0 = 0$$

$$n = 3$$

$$4N = 6$$



Question

According to Werner's theory



- A Primary valency can be ionized
- B Secondary valency can be ionized
- C Primary and secondary valencies both cannot be ionized
- D Only primary valency cannot be ionized



Question

Which of the following will not give a precipitate with AgNO_3 ?

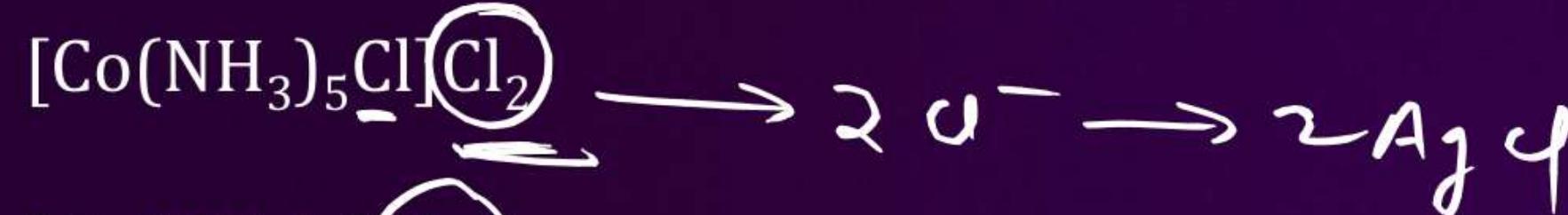
A



B



C



D



[] ↑]

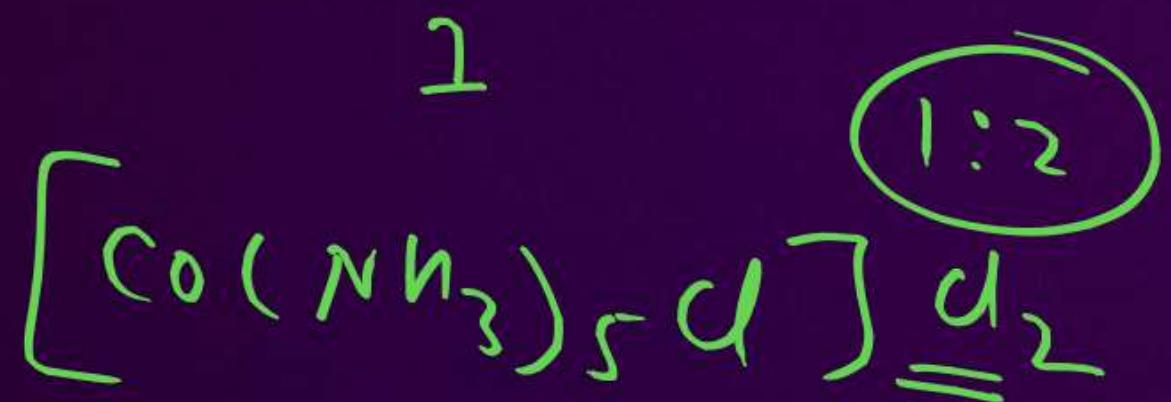
Question

Which of the following has the highest molar conductivity in solution?

- A [Pt(NH₃)₆]Cl₄
- B [Pt(NH₃)₅Cl]Cl₃
- C [Pt(NH₃)₄Cl₂]Cl₂
- D [Pt(NH₃)₃Cl₂]Cl

When 0.1 mol $\text{CoCl}_3(\text{NH}_3)_5$ is treated with excess of AgNO_3 , 0.2 mol of AgCl are obtained. The conductivity of solution will correspond to

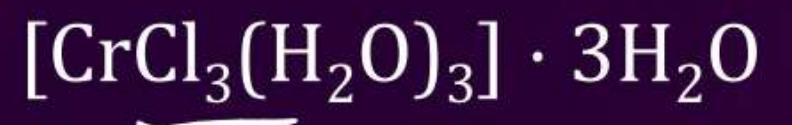
- A** 1:3 electrolyte
- B** 1:2 electrolyte
- C** 1:1 electrolyte
- D** 3:1 electrolyte



NCERT Exemplar

When 1 mol $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ is treated with excess of AgNO_3 , 3 mol of AgCl are obtained. The formula of the complex is :

A



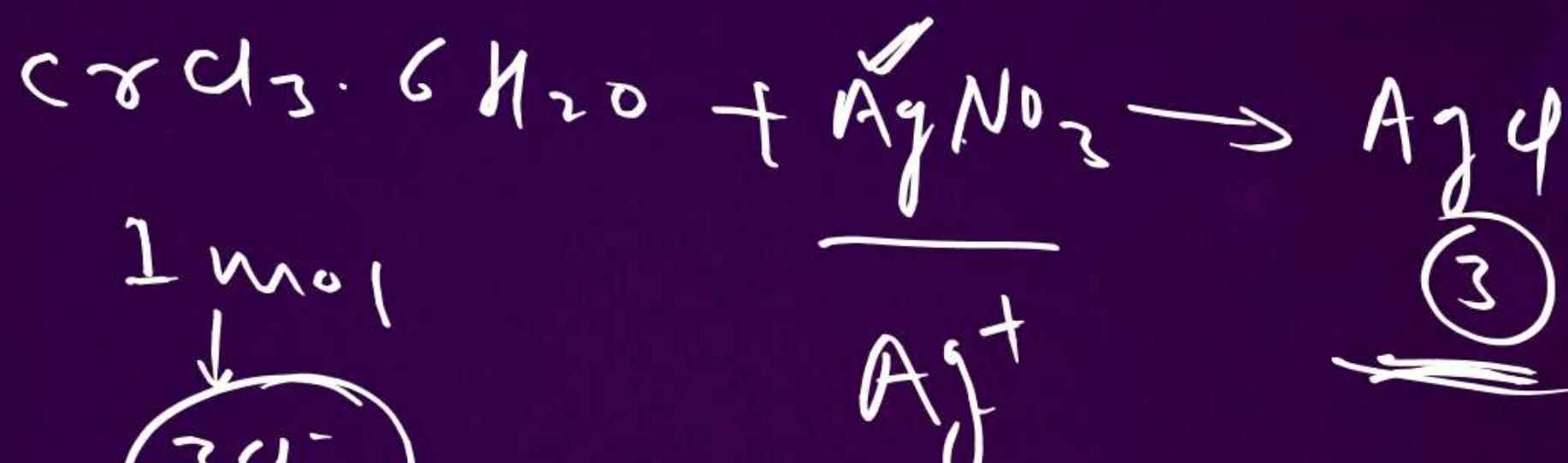
B



C



D





EAN Rule & Sidgwick theory

$$\text{EAN} = Z - \text{O.N} + 2 \times \text{C.N}$$

$$\text{EAN} = Z - \text{O.N} + 2 \times \text{C.N}$$



Oxidation Number = 0 (Electrons lost = 0)

Coordination Number = 6

Electrons gained = $6 \times 2 = 12$

$$\text{EAN} = 24 - 0 + 12 = 36$$

$\equiv \equiv$

$Z = \text{atomic no.}$
if $\text{EAN} = \text{atomic no. of}$
Invert gas.
 \downarrow
stable

EAN

Effective atomic

No.

$\equiv \equiv$



$$n + 6 \times 0 = 0$$

$$n = 0$$

$$N = 0$$

$$CN = \text{No. of ligands} \times \text{Denticity}$$
$$= 6 \times 1 = 6.$$





EAN Rule & Sidgwick theory

$$\text{EAN} = \underline{\underline{Z - O.N + 2 \times C.N}}$$

$$n + 3 \times 0 = +3 \quad n = 3$$

$$[\text{Co}(\text{en})_3]^{+3} : \quad C.N = 3 \times 2 = 6$$

$$\underline{\underline{Z = 27}}$$

$$\text{Oxidation Number} = 3$$

Coordination Number = 6 (en is bidentate ligand)

$$\text{EAN} = 27 - 3 + 12 = 36$$

en \rightarrow Denticity = ?

$$C.N = C \times 1 = 6$$

$$n - 6 = -2 \quad n = 4$$

$$[\text{Pt}(\text{Cl})_6]^{-2} : -$$

$$\underline{\underline{Z = 78}}$$

$$\text{Oxidation Number} = 4$$

Coordination Number = 6

$$\text{EAN} = 78 - 4 + 12 = 86$$

Question

The effective atomic number of Cr (at no. 24) in $\underline{[\text{Cr}(\text{NH}_3)_6]} \text{Cl}_3$ is

A 35

B 27

C 33

D 36

$$n + 6 \times 0 - 3 = 0$$

$$n = 3$$

$$cN = \frac{6}{2}$$

$$EAN = 2 - 0N + 2 \times cN$$

$$= 24 - 3 + 6 \times 2$$

$$= 21 + 12$$

$$= 33.$$

Home Work

→ DPP

PARISHRAM



2026

Coordination Compound

CHEMISTRY LECTURE-07

BY – BIJENDRA SIR (Biju Bhaiya)



Topic Covered

VBT



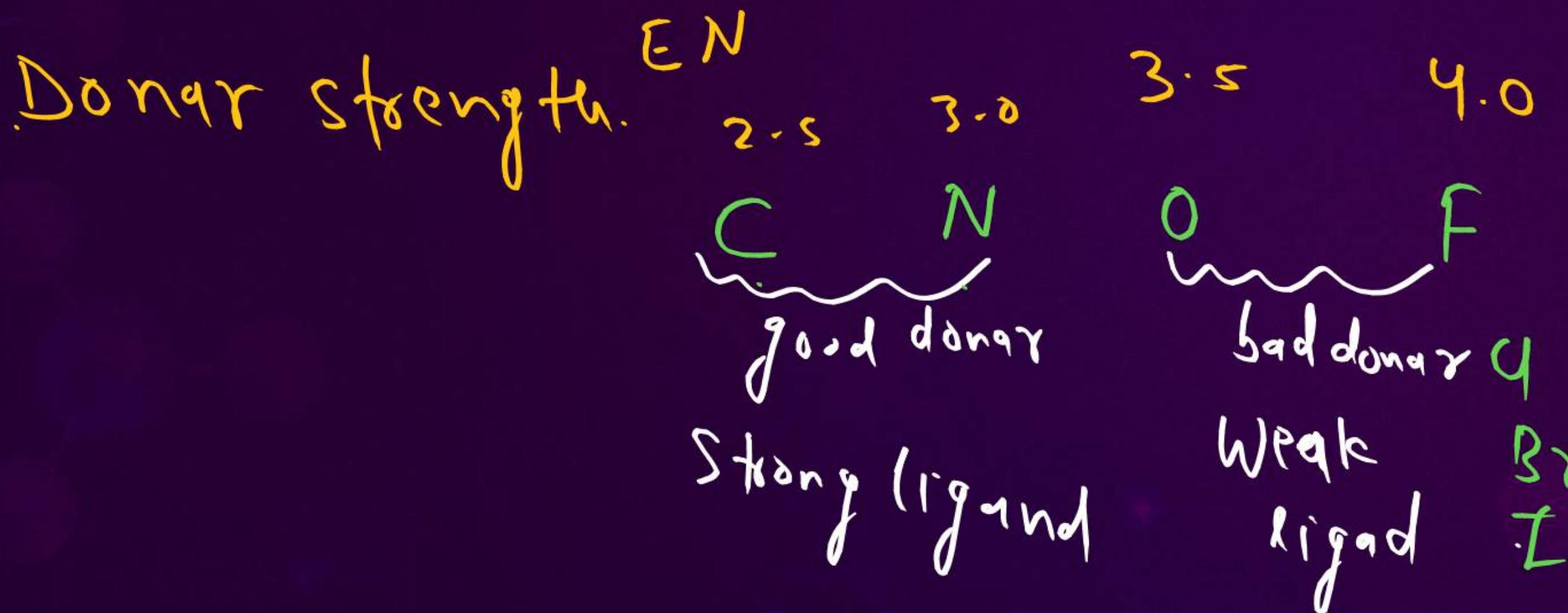
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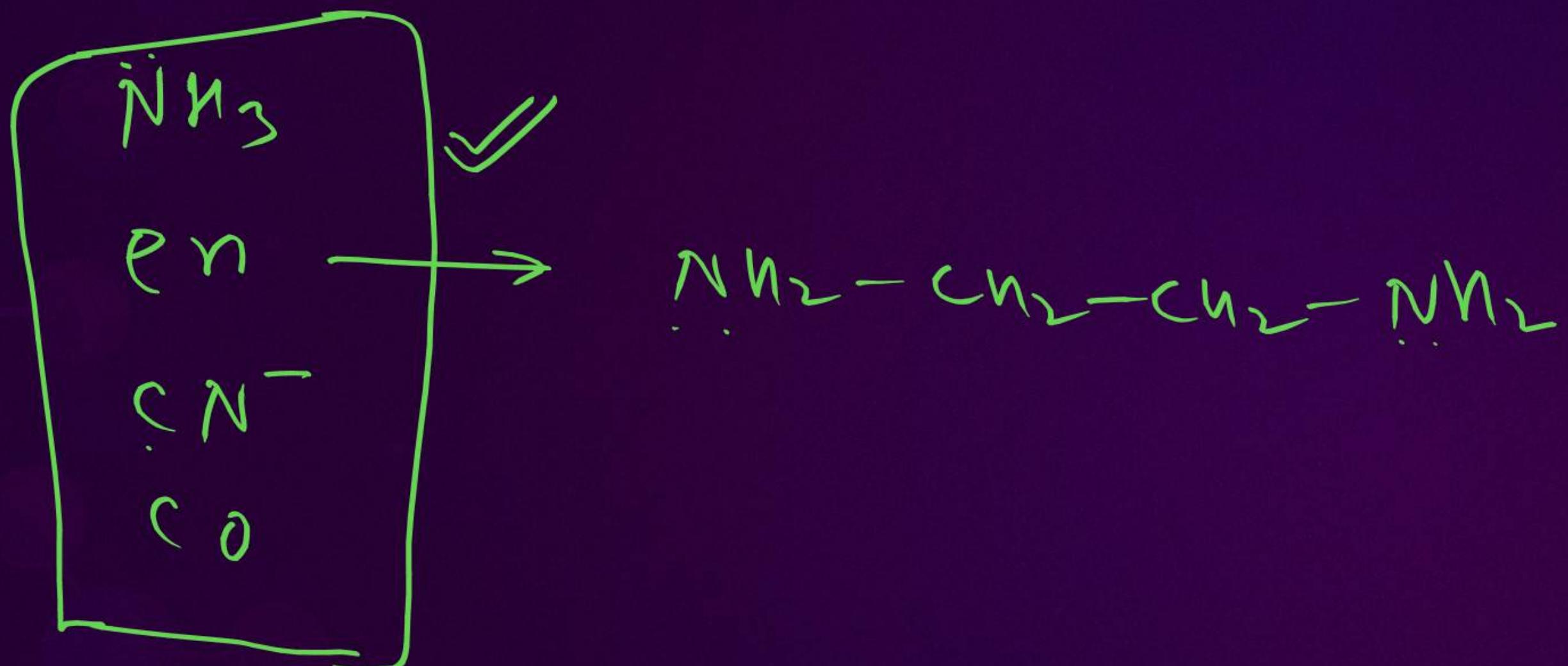


weak ligand → strong ligand
EK bar Sarita college se faraz and uska bani se yad *
 $I^- < Br^- < SCN^- < Cl^- < S^{2-} < F^- < OH^- < C_2O_4^{2-} < H_2O < NCS^- < edta^{4-}$
 $< NH_3 < en < CN^- < CO$

Neha en Canada colombo

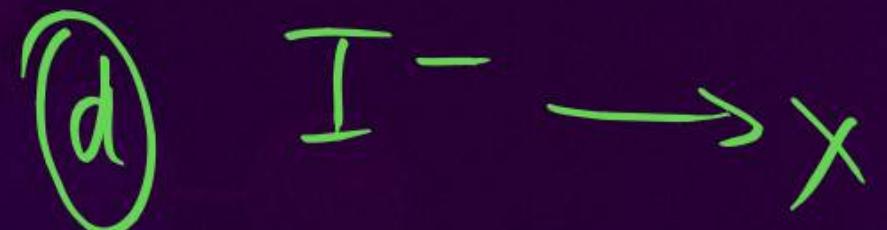


Strong ligand.



Q w o F

is strong ligand?



W_oF is weak ligand?

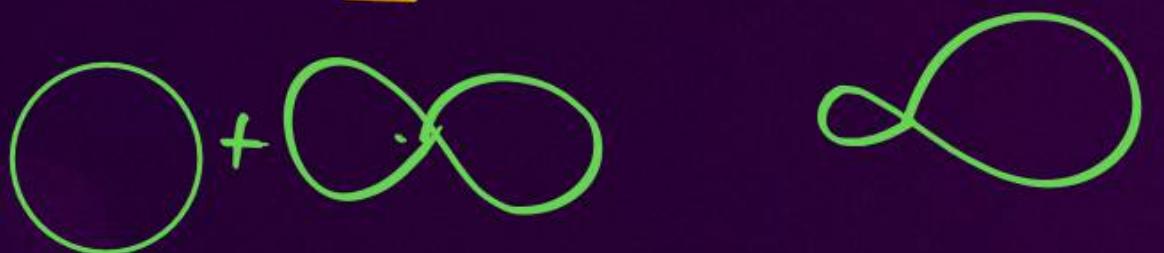
a) CO ✓

b) NH₃ ✓

c) H₂O ~~✓~~

d) en ✓

Hybridization → Intermixing of Atomic Orbitals.



No. of Atomic Orbitals = No. of Hybridized Orbitals



$$n - 6 = -4, n = +2$$

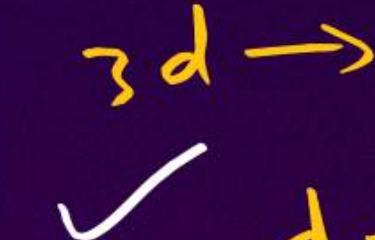
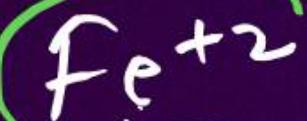
$$\boxed{\text{CN} = 6} \rightarrow \begin{cases} s \rightarrow 1 \\ p \rightarrow 3 \\ d \rightarrow 2 \end{cases}$$

six coordinate bonds.

⑥

- * maxⁿ no. of e in an orbitals.
- * we need vacant orbitals.

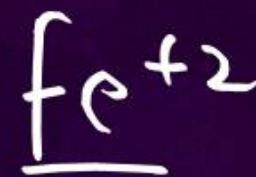
TL



$$\begin{array}{c} \checkmark \\ \underline{d} + \underline{d} + \boxed{s + p + p + p} \\ = d^2 s p^3 \end{array}$$

$$\checkmark u d \rightarrow s + p + p + d + d$$

$$= \boxed{s p^3 d^2}$$



2	1	1	1	1

✓

✓	✓	✓

✓	✓		



~~A → B~~

A → B ($A \rightarrow B$)



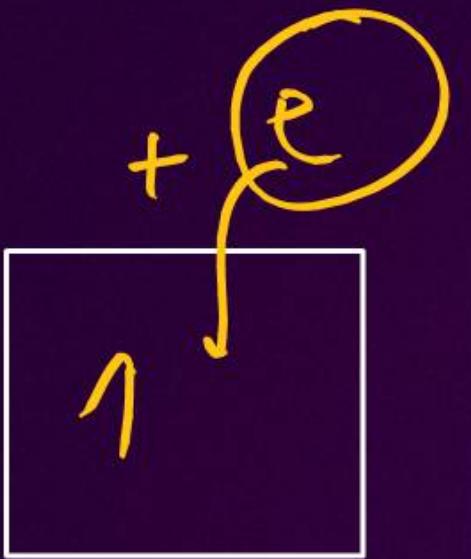
Valence Bond Theory

Number of Orbitals and Types of Hybridisations

Coordination number	Type of hybridisation	Distribution of hybrid orbitals of space
4	sp^3	Tetrahedral
4	dsp^2	Square planar
5	sp^3d	Trigonal bipyramidal
6	sp^3d^2	Octahedral
6	d^2sp^3	Octahedral

Pairing

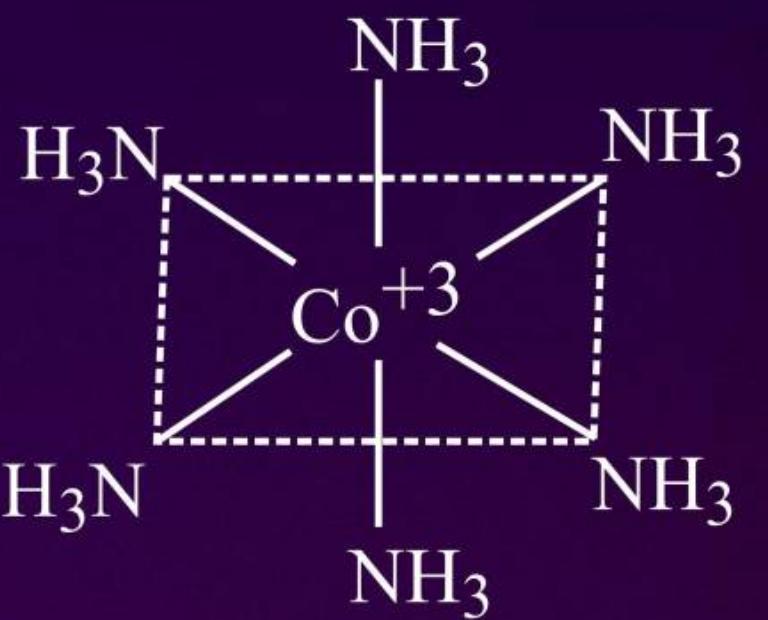
↑
12



- * strong ligand \rightarrow pairing hogya.
- * weak pairing \rightarrow pairing Nhi hogya.

Octahedral Complexes

Inner-Orbital Complexes



Octahedral shape of
 $[\text{Co}(\text{NH}_3)_6]^{3+}$



Orbitals of Co^{3+} ion

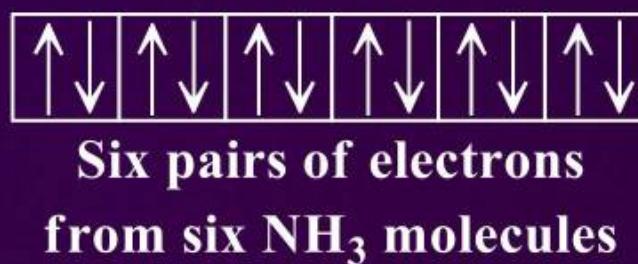
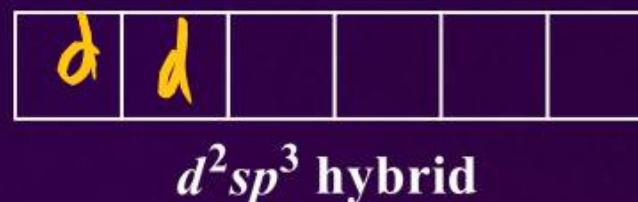
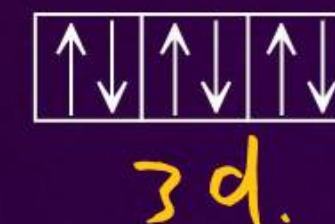
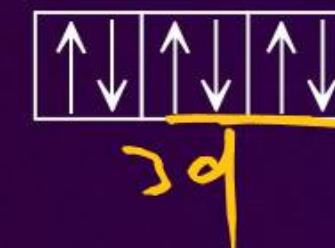
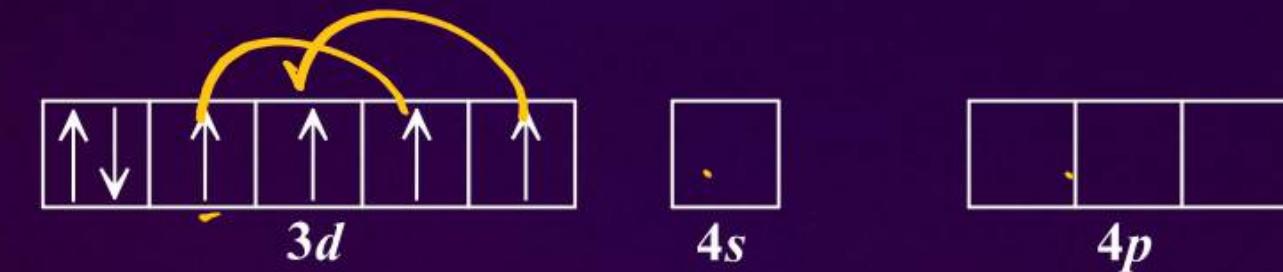


d^2sp^3 hybridized orbitals of Co^{3+}



$[\text{Co}(\text{NH}_3)_6]^{3+}$ (inner orbital or low spin complex)

up spin \leftarrow $1L$ \rightarrow down spin



In the formation of this complex, since the inner d orbital (3d) is used in hybridisation, the complex, $[\text{Co}(\text{NH}_3)_6]^{3+}$ is called an inner orbital or low spin or spin paired complex



$$n + c_{x_0} = +3$$

Ligand $\rightarrow \text{NH}_3$

pairing hoga.

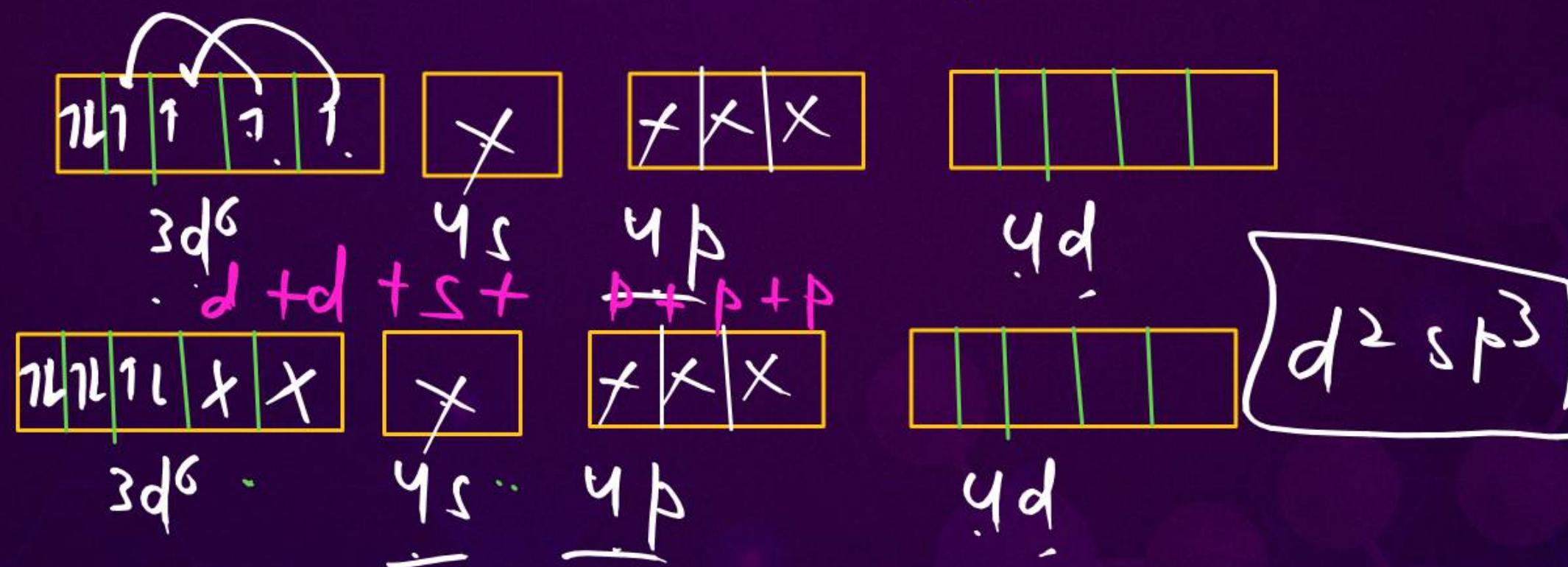
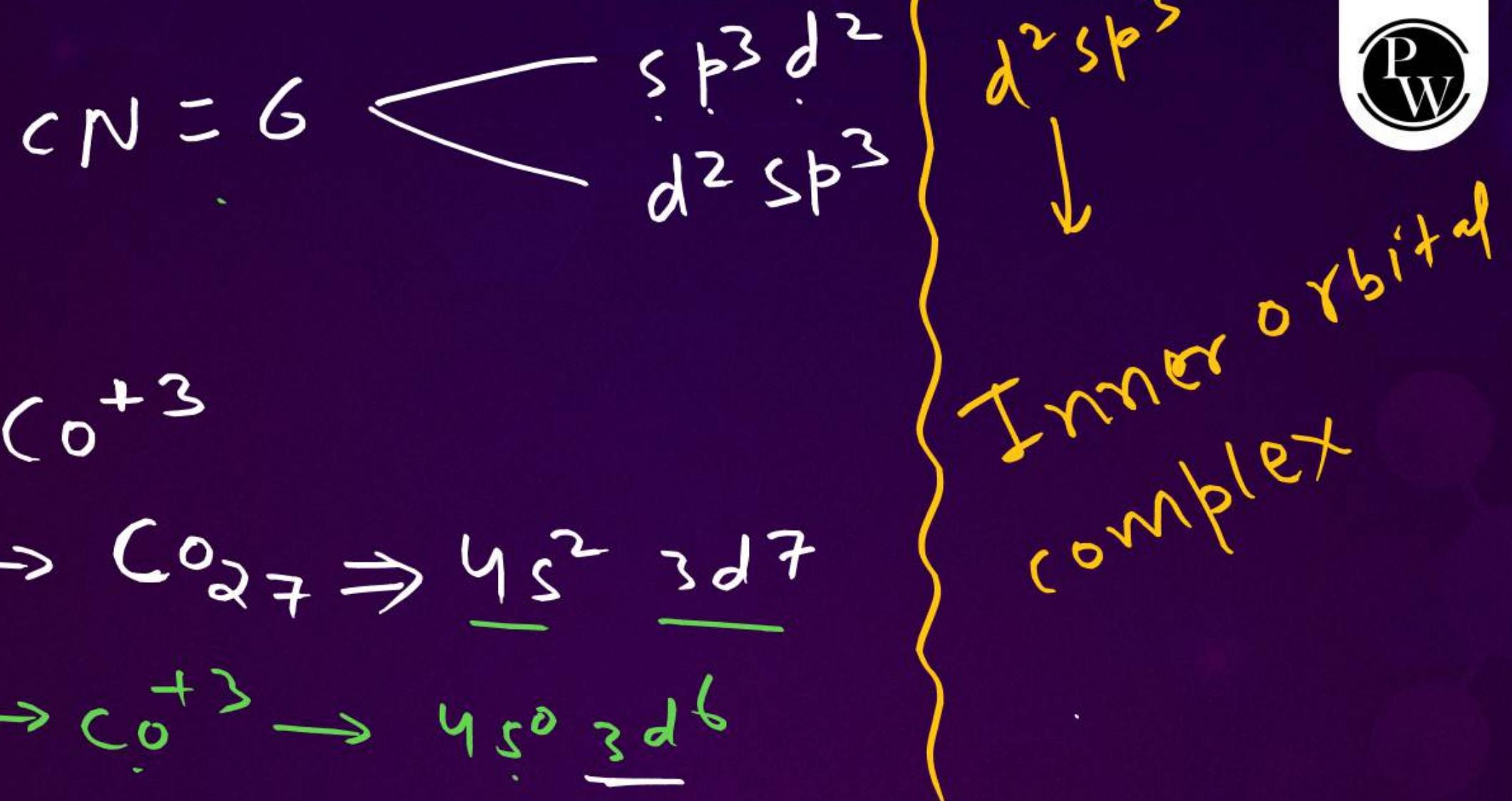
Nature \rightarrow Strong

Oxidation no = +3

CN = No. of ligands

\times Denticity.

$$CN = 6 \times 1 = 6$$





Orbitals of Co^{3+} ion

	$3d$	$4s$	$4p$	$4d$
--	------	------	------	------

sp^3d^3 hybridized
orbitals of Co^{3+}

	$3d$	sp^3d^3 hybrid	$4d$
--	------	------------------	------

$[\text{CoF}_6]^{3-}$
(outer orbital or
high spin complex)

	$3d$		$4d$
--	------	--	------

Six pairs of electrons
from six F^- ion

The paramagnetic octahedral complex, $[\text{CoF}_6]^{3-}$ uses outer orbital (4d) in hybridisation (sp^3d^2). It is thus called outer orbital or high spin or spin free complex

d^2sp^3

sp^3d^2

→ octahedral

→ octahedral.

→ CN = 6

→ CN = 6

→ $d+d+s+p+p+p=d^2sp^3$ → $s+p+p+p+d+d$

→ 3d 1s used

→ 4d 1s used.

→ Inner orbital complex

→ outer orbital complex

→ Low spin

→ high spin

→ Spins paired

→ spin free



$$\left[\text{O}_f g \right]^{-3}$$

$$n-6 = -3, n = 3$$

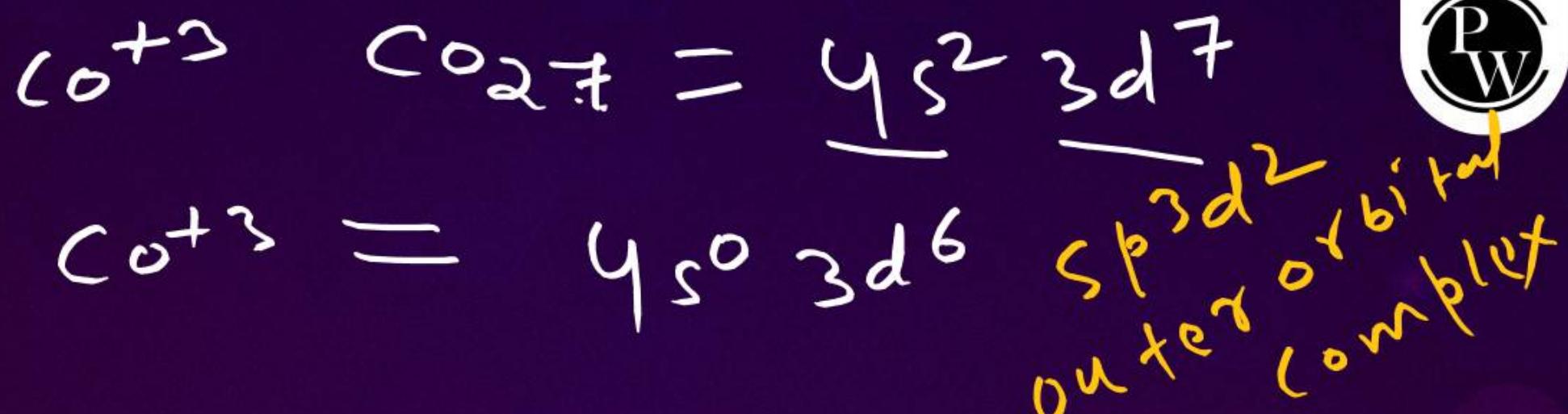
→ ligand = F⁻

→ Nature → weak

parring Nhi
hoga.

\rightarrow oxidation no = +3

$$\rightarrow CN = 6x = 6.$$



$3d^6$

4s 4p 4d
s + p + p + p + d + d

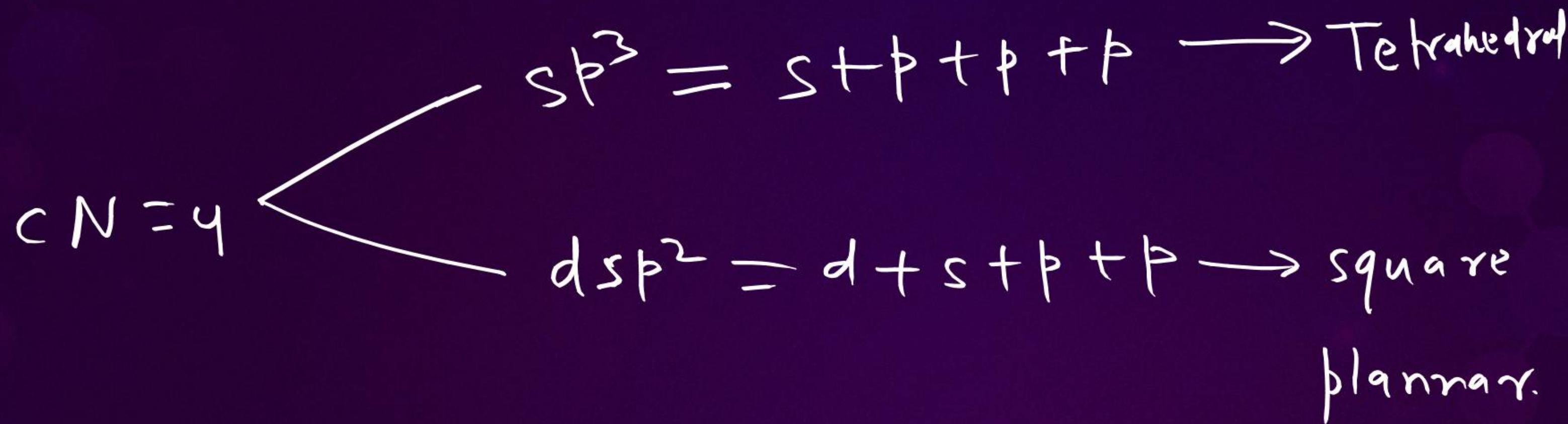
$$= \zeta b^3 d^2$$

$$CN=6 \rightarrow sp^3d^2 = s + p + p + p + d + d$$

$$CN=6 \rightarrow sp^3d^2 = s + p + p + p + d + d$$

$$CN=6 \rightarrow sp^3d^2 = s + p + p + p + d + d$$

$$CN=6 \rightarrow sp^3d^2 = s + p + p + p + d + d$$

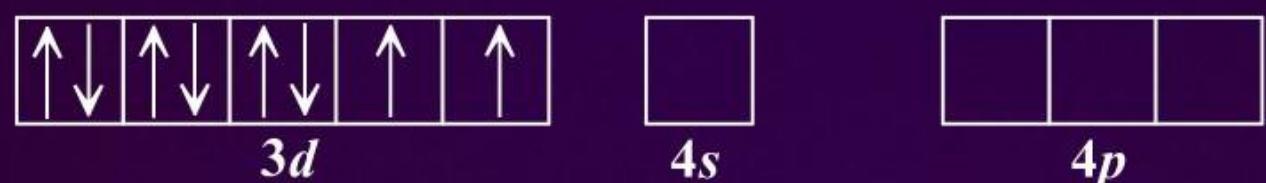


Tetrahedral Complexes

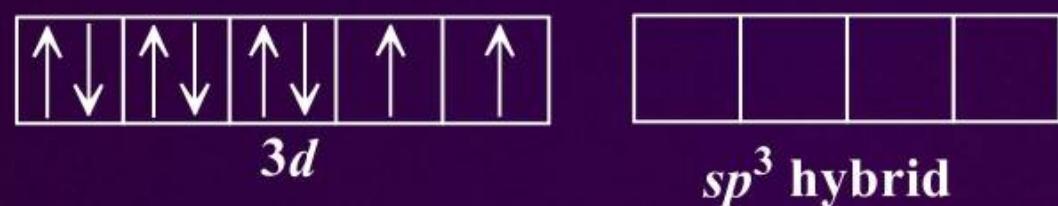
In tetrahedral complexes one s and three p orbitals are hybridized to form four equivalent orbitals oriented tetrahedrally.



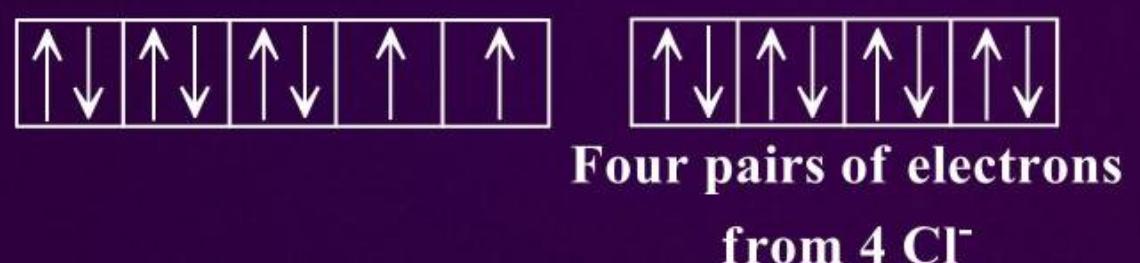
Orbitals of Ni^{2+} ion

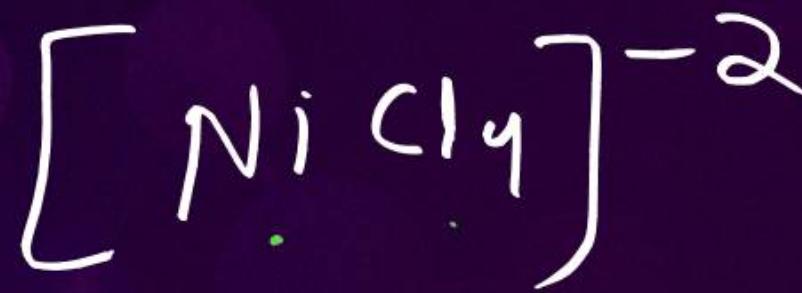


sp^3 hybridized
orbitals of Ni^{2+}



$[\text{NiCl}_4]^{2-}$
(high spin complex)





$$n-4 = -2$$

$$n=2$$

Ligand \rightarrow Cl⁻

Nature \rightarrow weak



pairing
Nhi hogga

$$\rightarrow O.N = +2$$

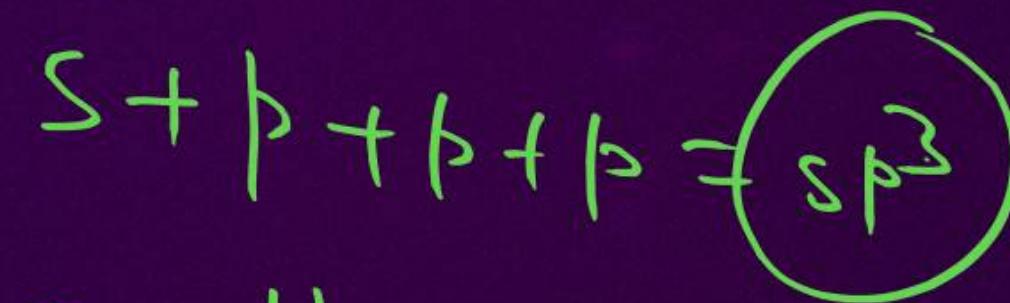
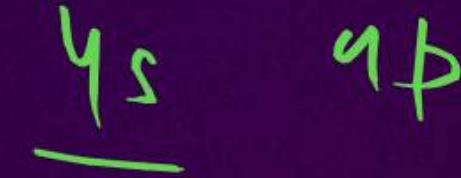
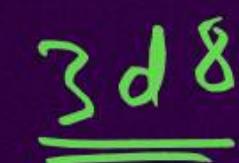
$$\rightarrow CN = 4 \times 1 \\ = 4.$$



1L	1L	1L	1
.	.	.	.

.

✓	✓	✓
---	---	---

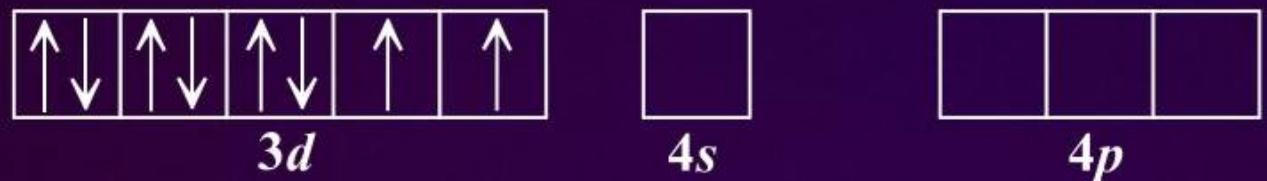


High spin complex Tetrahedral.

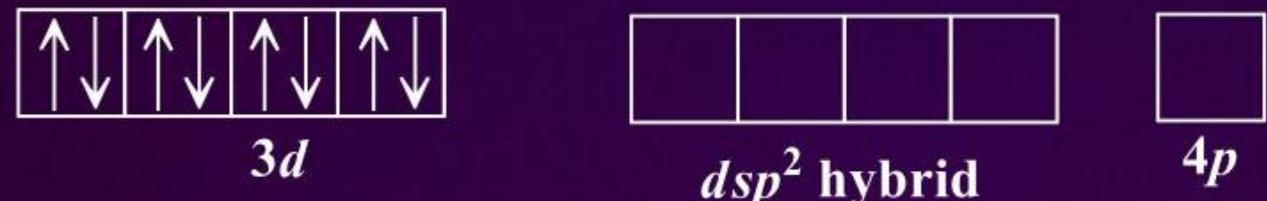
Square Planer Complexes



Orbitals of Ni^{2+} ion



dsp^2 hybridized
orbitals of Ni^{2+}



$[\text{Ni}(\text{CN})_4]^{2-}$
(low spin complex)



$$[Ni(N)_4]^{-2}$$

$$n - 4 = -2$$

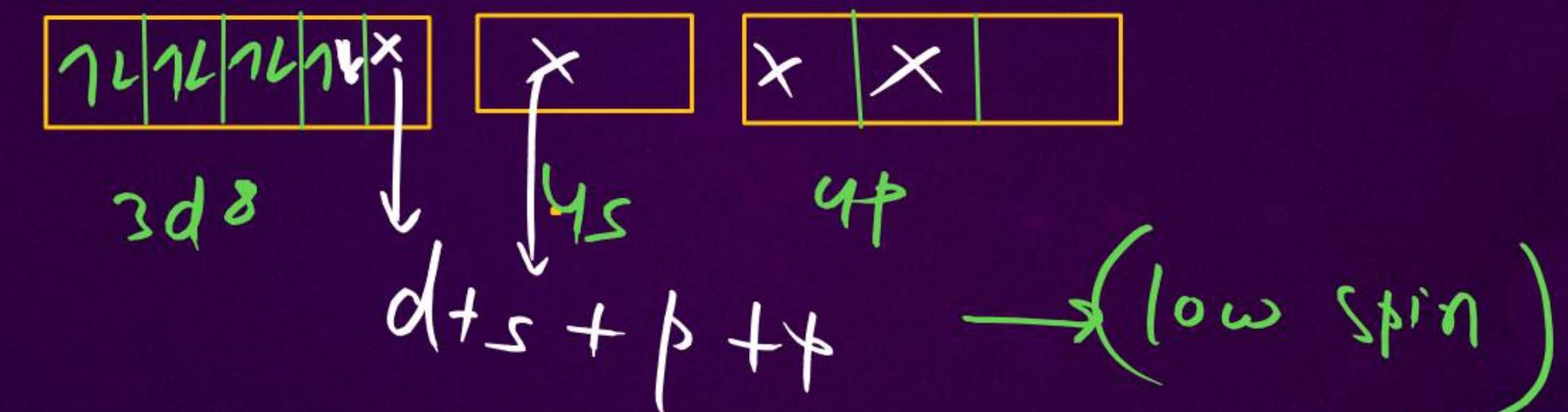
$$\rightarrow \text{Ligand} = CN^-$$

\rightarrow Nature = Strong
 ↓
 pairing hoga

$$\rightarrow ON = +2$$



$$Ni^{+2} = 4s^0 3d^8$$



\rightarrow (low spin)

$= dsp^2 \rightarrow$ 89498 planar.

Bk T

C.N = 4

1. Zn, Cd, Hg always tetrahedral

2. Pt, Pd always sq. planer

sp^3

\downarrow
 $d\overline{sp^2}$

Question

The hybridization of Fe in $K_3[Fe(CN)_6]$ is:

- A sp^3
- B dsp^3
- C sp^3d^2
- D d^2sp^3



Home Work

→ No DPP

→ Class notes.



PARISHRAM



2026

Coordination Compound

CHEMISTRY LECTURE-08

BY – BIJENDRA SIR (Biju Bhaiya)



Topic Covered

VBT – Part 2 ✓



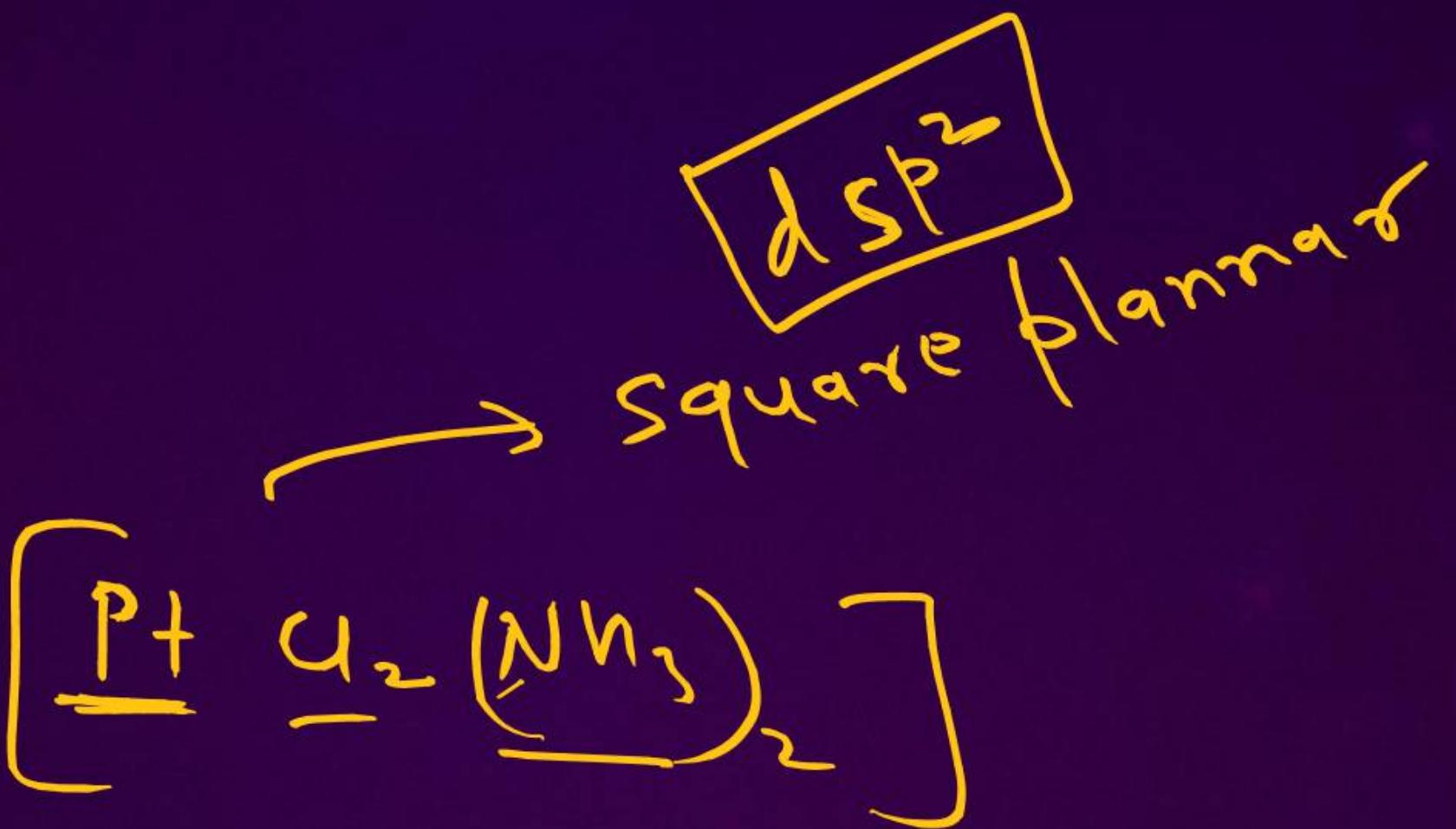
BIJENDRA SIR

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

1. Zn, Cd, Hg always tetrahedral
2. Pt, Pd always sq. planer



$$\begin{aligned}\text{CN} &= 2 + 2 \\ &= 4\end{aligned}$$



Magnetic Properties of Coordination Compounds

The magnetic moment of coordination compounds can be measured by the magnetic susceptibility experiments

$$\underline{\mu} = \sqrt{n(n+2)} B.M$$

(n = number of unpaired electrons)

$$BkT$$

$$n=1 \quad \mu = \sqrt{3} = 1.73$$

$$n=2 \quad M = 2 \dots$$

$$n=3 \quad M = 3 \dots$$

$$n=4 \quad M = 4 \dots$$

if no. of unpaired electrons

$n > 0$ Diamagnetic

$n \neq 0$ Paramagnetic.



Magnetic Properties of Coordination Compounds

- ✓ $[\text{Mn}(\text{CN})_6]^{3-}$ has magnetic moment of two unpaired electrons while $[\text{MnCl}_6]^{3-}$ has a paramagnetic moment of four unpaired electrons
- $[\text{Fe}(\text{CN})_6]^{3-}$ has magnetic moment of a single unpaired electron while $[\text{FeF}_6]^{3-}$ has a paramagnetic moment of five unpaired electrons



$$n - 6 = -3 \quad n = 3$$

→ Ligand = CN^-

→ Weak or strong
↓
Strong } pairing
hoga.

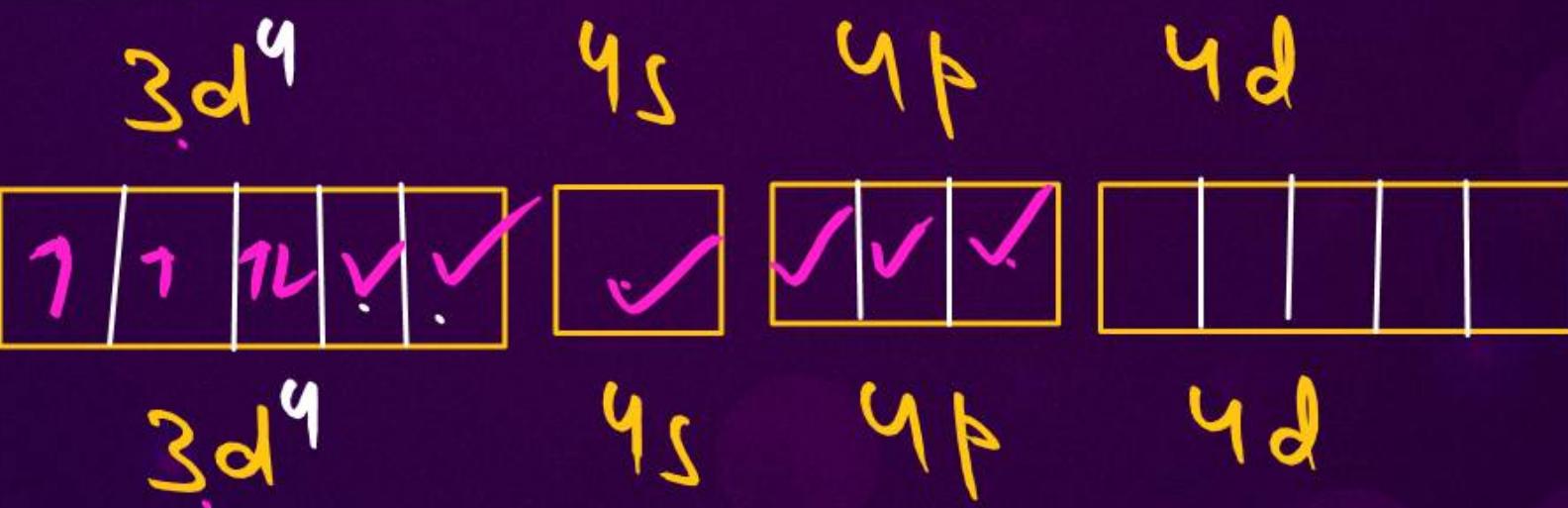
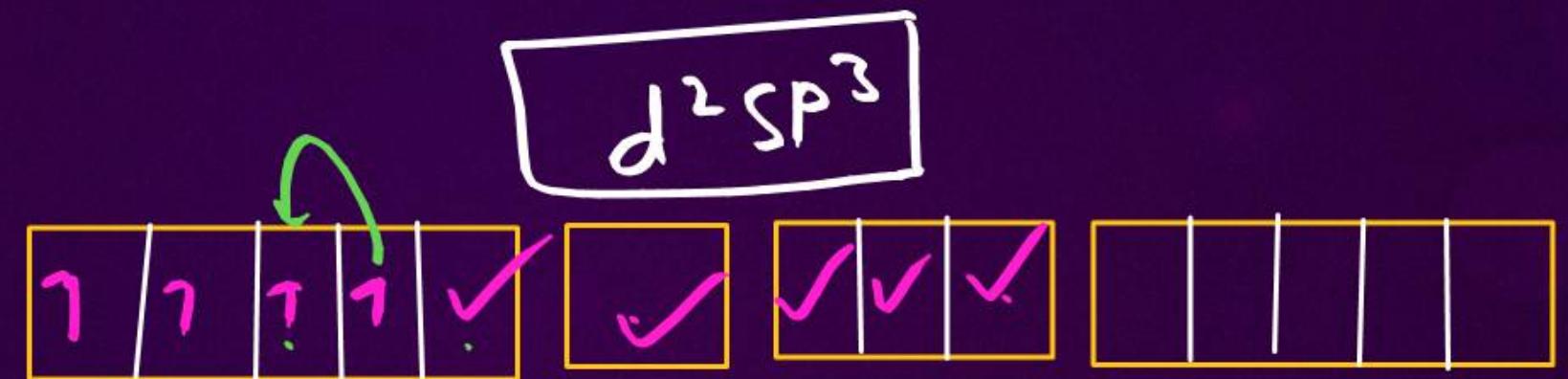
$$\rightarrow \sigma N = 3$$

$$\rightarrow CN = 6 \quad \begin{matrix} d^2sp^3 \\ sp^3d^2 \end{matrix}$$

$$M_{n+3} \quad \text{no. of unpainted edges} \\ e^{n=2}.$$

$$Mn_{2.5} = 4s^2 \ 3d^5$$

$$Mn^{+3} = 4s^0 \ 3d^4$$



$$\left[\frac{m_n}{a_6} \right]^{-3} \quad \text{no. of unpaired electrons.}$$



a) 2

~~b)~~ 4

c) 5

d) none

1	1	1	1	
—	—	—	—	

d- weak
 \downarrow
 no pairing

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

$$n - 6 = -3$$

$$n = 3$$

$$\rightarrow \text{Fe}^{+3}$$

$$\rightarrow \text{ligand} = \text{CN}^-$$

\rightarrow strong \rightarrow pairing
 \rightarrow $\text{CN} = 6$ $n_{\text{hsgq}} = 1$



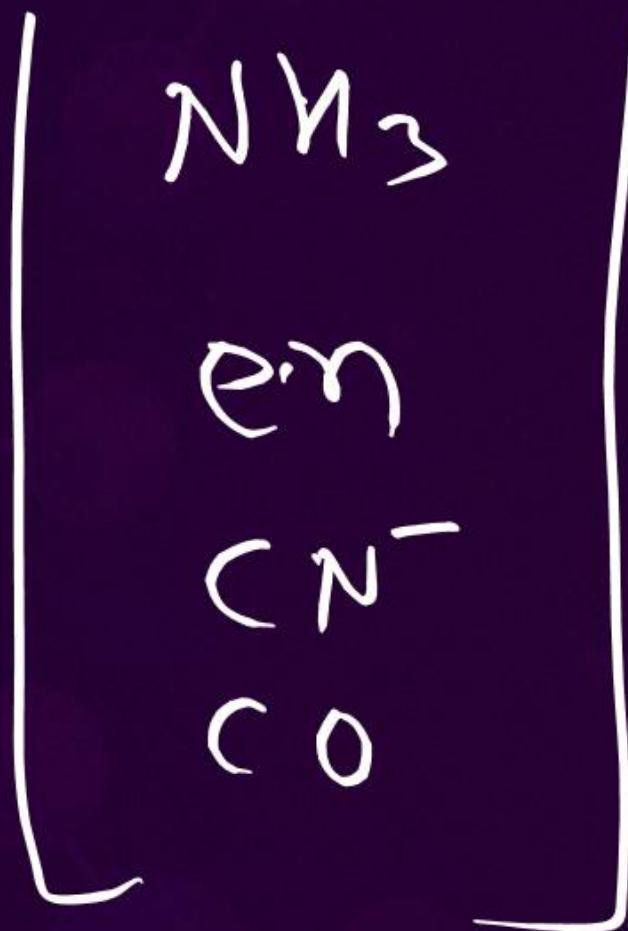
3d⁵ 4s 4p



3d⁵ 4s 4p

$n = 1$

strong ligand.



$[FeF_6]^{3-}$ no. of unpaired electrons?



- (a) 4
- (b) 5
- (c) 3
- (d) none.

↓ weak

no pairing.

$n=5$



Limitations of Valence Bond Theory

- It involves a number of assumptions.
- It does not explain the colour exhibited by coordination compounds.
- It does not give a quantitative interpretation of the thermodynamic or kinetic stabilities of coordination compounds.
- It does not make exact predictions regarding the tetrahedral and square planar structures of 4-coordinate complexes.
- It does not distinguish between weak and strong ligands.



1. d^1, d^2, d^3

$\xrightarrow{CN=6 S.F.L/W.F.L}$
Hybridization - d^2sp^3

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

2. d^8, d^9, d^{10}

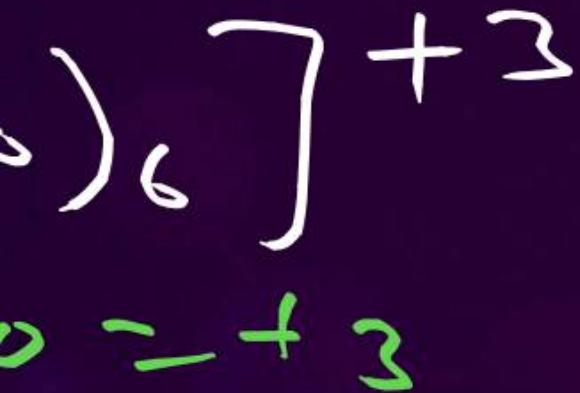
$\xrightarrow{CN=6 S.F.L/W.F.L}$
Hybridization - sp^3d^2

Ex. - $[N(NH_3)_6]^{2+}$

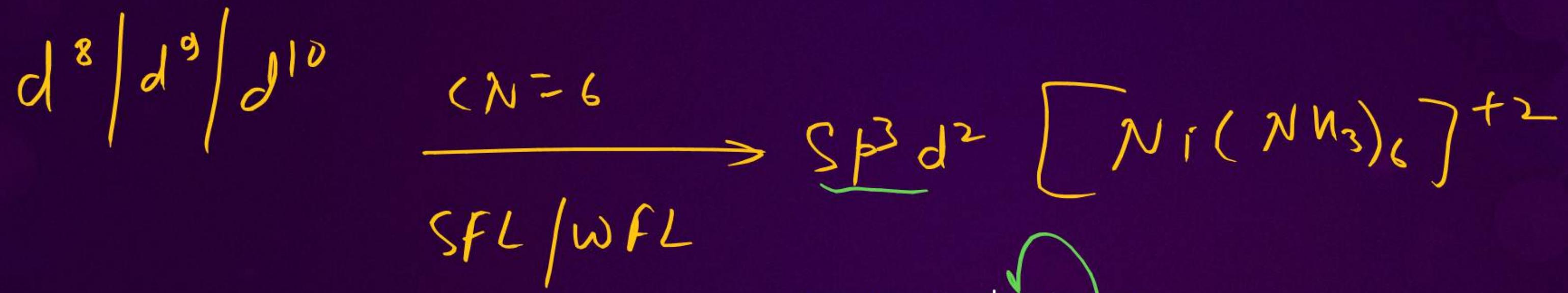
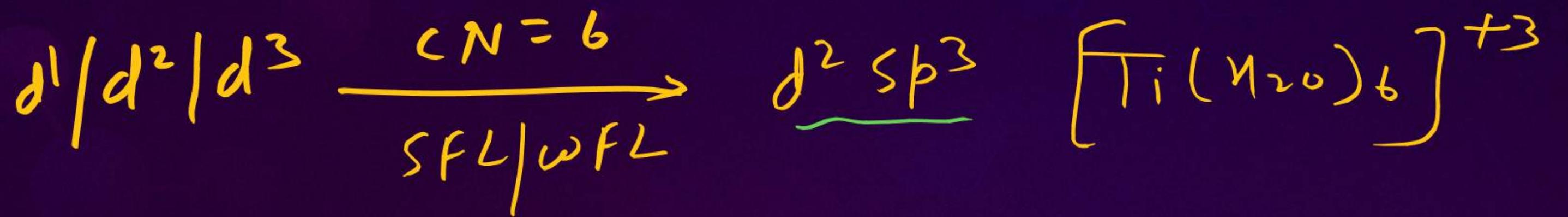


$\rightarrow NH_3 \rightarrow$ Strong

$Ni^{+2} \rightarrow 4s^0 3d^8$

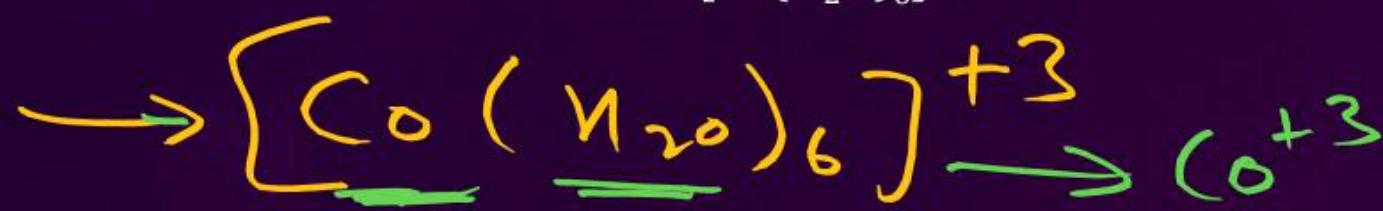


1L	1L	1L	1	1
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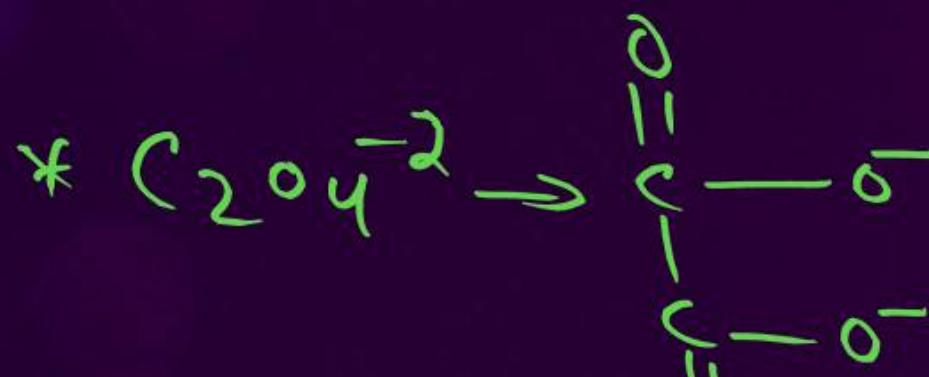


3. Co^{3+} Ligand Nature :-(O)donor
Ex. {OX}; {H₂O}

Ex. - [Co(OX)₃]³⁻

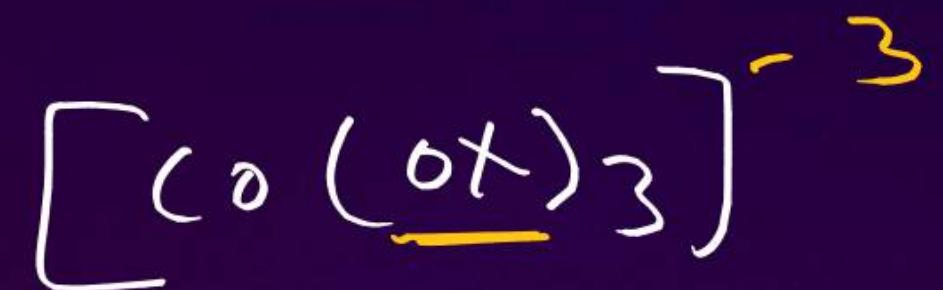


$\therefore \text{H}_2\text{O} \rightarrow \text{weak}$



* oxygen donor

\downarrow
weak ligand.



$$\gamma + 3(-2) = -3$$

$$\gamma - 6 = -3 \quad \gamma = 3$$

only with Co^{+3}

Strong.

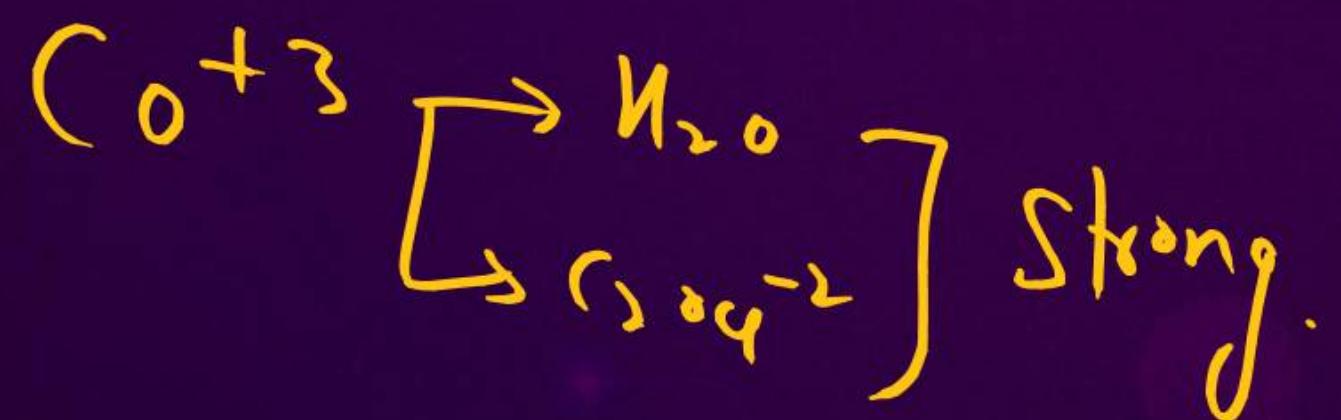
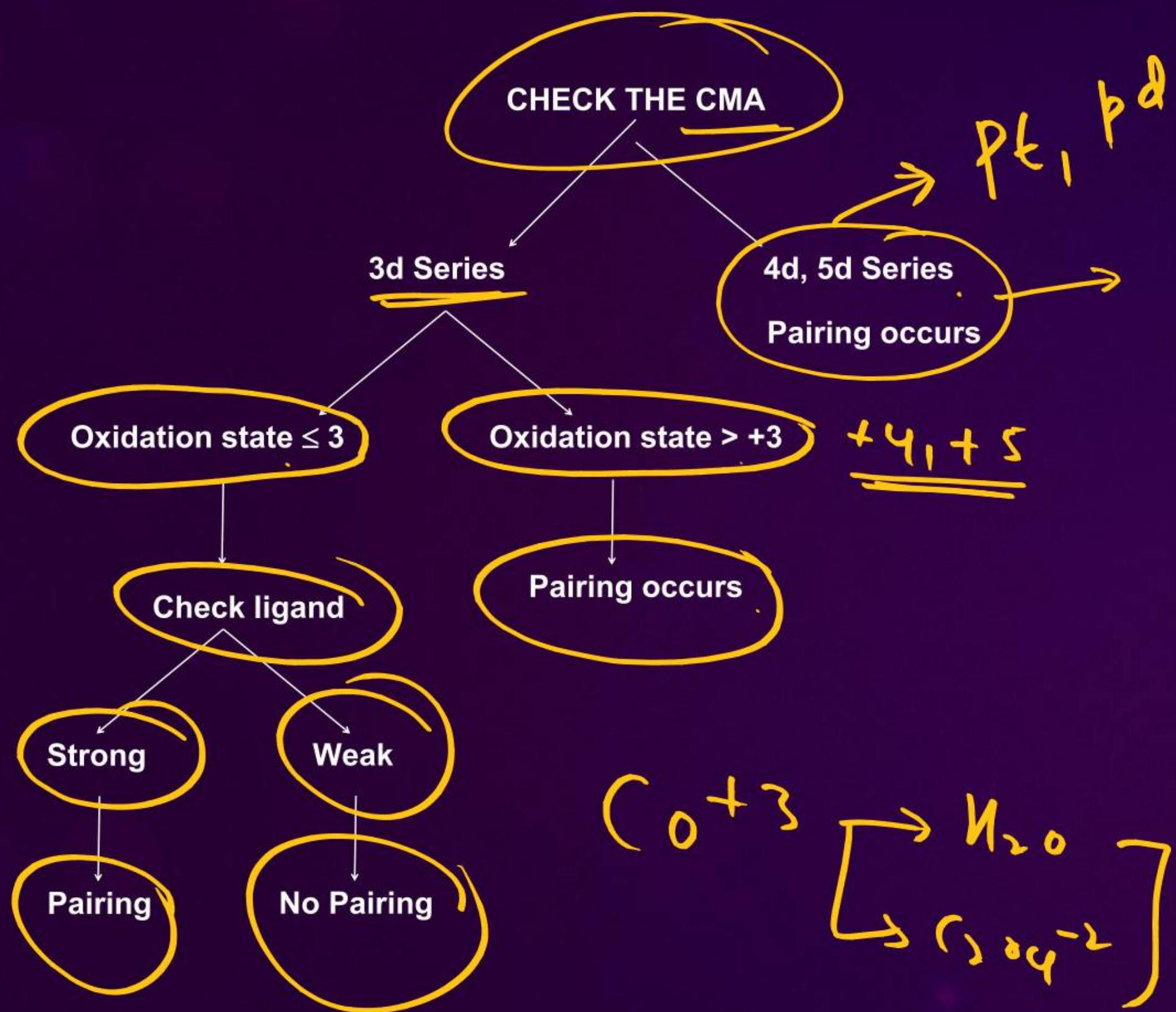


1L	1L	1L		
----	----	----	--	--

3d XX

$d^2 f^1 s^1 p^1$
 $d^2 S p^3$





Question

Which of the following species will be diamagnetic?

A



B

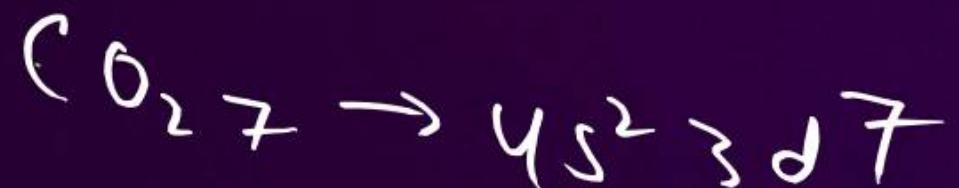
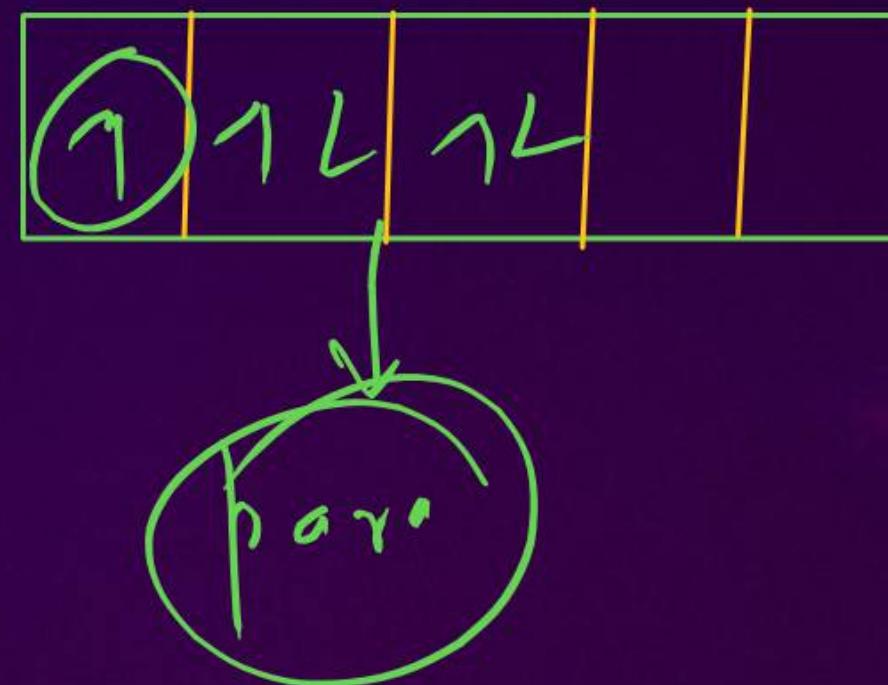


C



D

None of the above





$$n + 4 \times 0 = 0$$

$$n = 0$$

\rightarrow ligand = CO

\rightarrow strong

\rightarrow pairing hole

\rightarrow CN = 4

$\begin{array}{c} \text{SP}^3 \\ \diagdown \quad \diagup \\ \text{d.SP}^2 \end{array}$

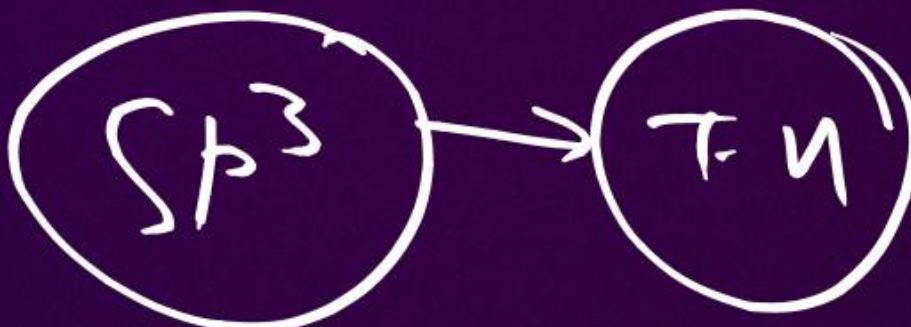


$3d^{10}$

$4s^0$

$4p$

S + P + P + P



Question

$s\bar{p}^2$ $d\bar{s}\bar{p}^2$ $\overline{sp^3}$

Among $[Ni(CO)_4]$, $[Ni(CN)_4]^{2-}$, $[NiCl_4]^{2-}$ species, the hybridization states at the Ni atom are, respectively



- A** sp^3, sp^3, dsp^2
- B** dsp^2, sp^3, sp^3
- C** sp^3, dsp^2, dsp^2
- D** ~~sp^3, dsp^2, sp^3~~



Home Work

DPP

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2026

Coordination Compound

CHEMISTRY LECTURE-09

BY – BIJENDRA SIR (Biju Bhaiya)



Topic Covered

CFT

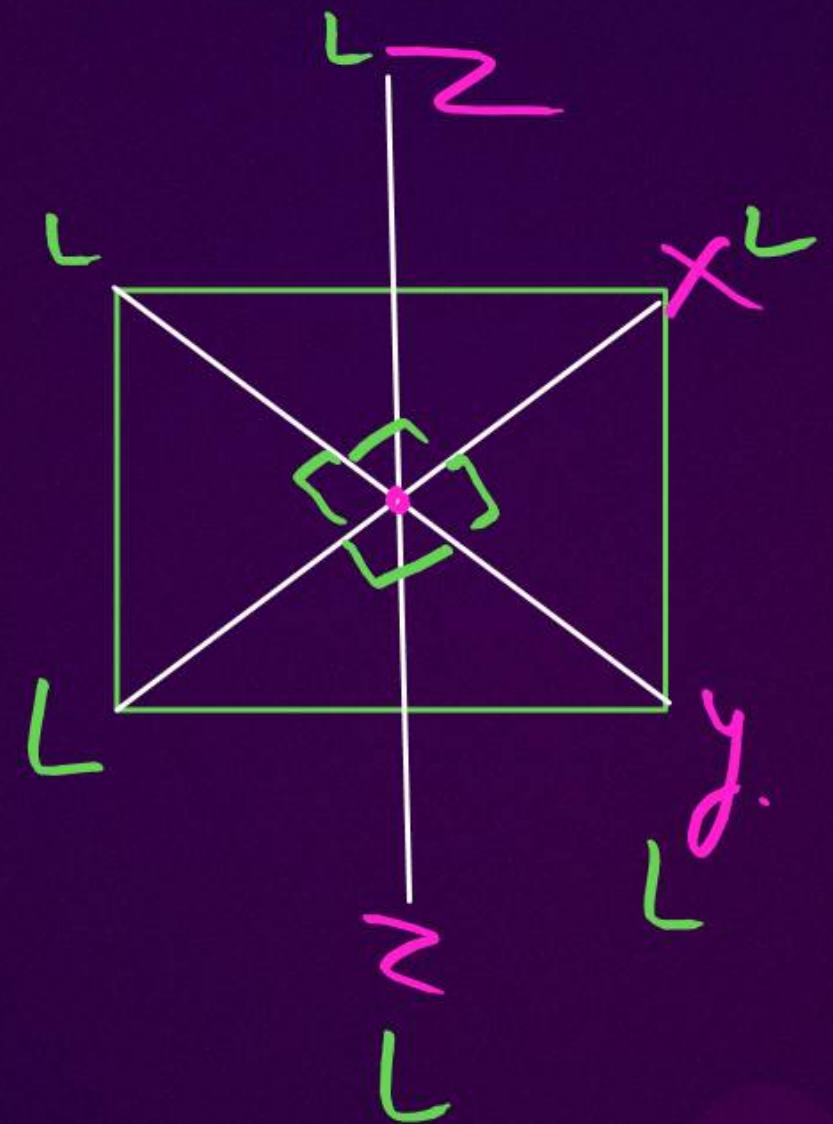
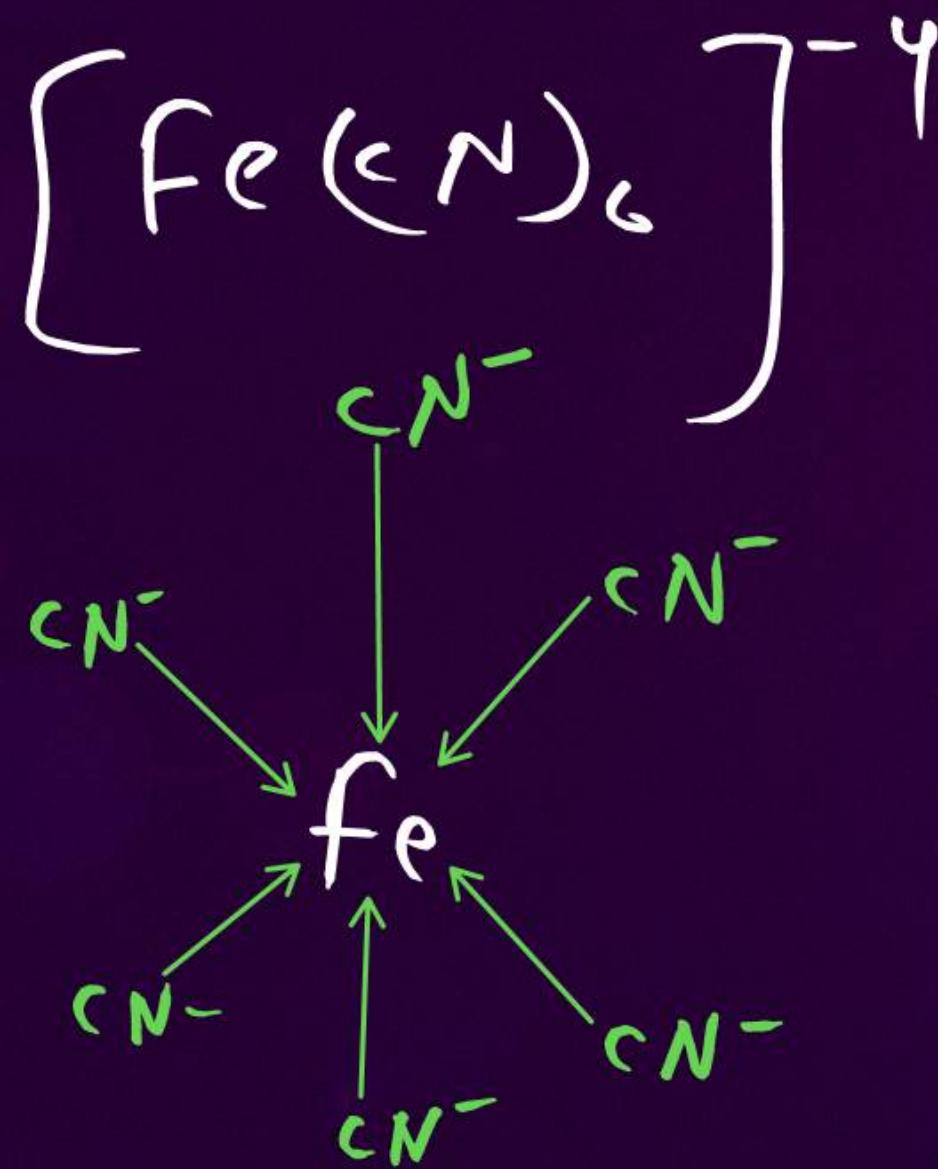


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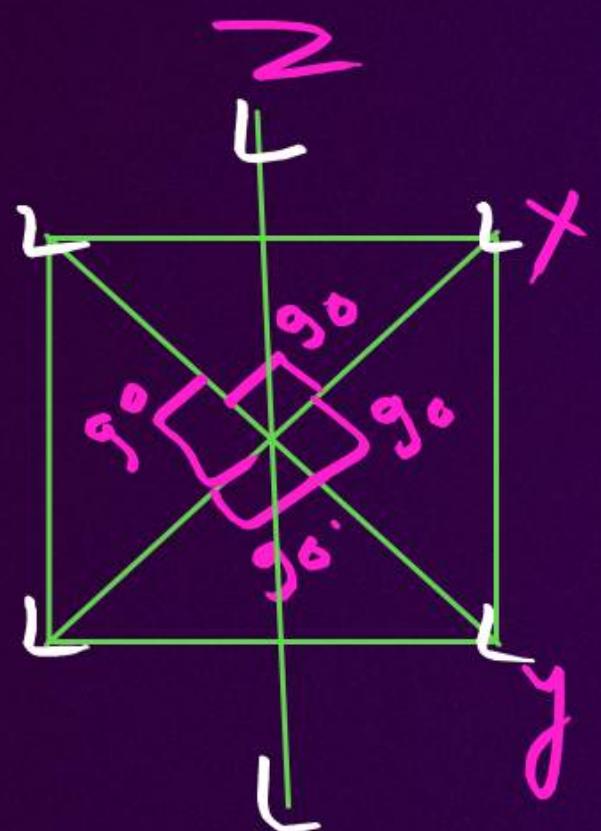
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$CN = 6$ $\xrightarrow{sp^3 d^2}$ $d^2 sp^3$ \rightarrow octahedral.

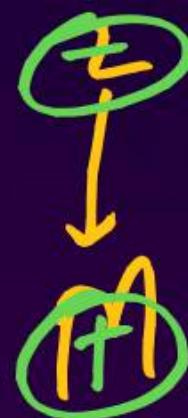


AU ligands
are on the
axis in
octahedral.





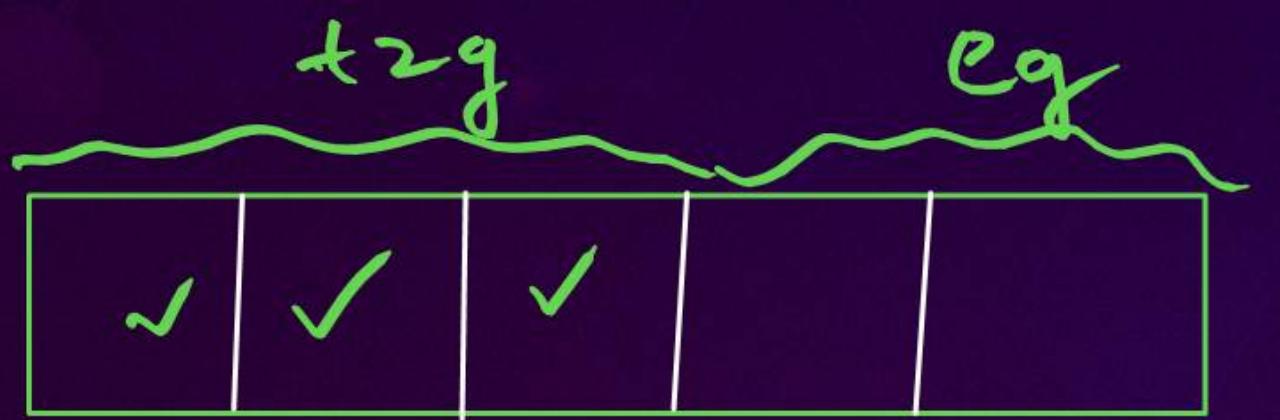
Crystal Field Theory



- The crystal field theory (CFT) is an electrostatic model which considers the metal-ligand bond to be ionic arising purely from electrostatic interactions between the metal ion and the ligand.
- Ligands are treated as point charges in case of anions or point dipoles in case of neutral molecules.
- ✓ Metal Ion is treated as +ve charge
- ✓ The five d orbitals in an isolated gaseous metal atom/ion have same energy, i.e., they are degenerate (same energy)
- This degeneracy is maintained if a spherically symmetrical field of negative charges surrounds the metal atom/ion
- ✓ However, when this negative field is due to ligands in a complex, it becomes asymmetrical and the degeneracy of the d orbitals is lifted. It results in splitting of the d orbitals

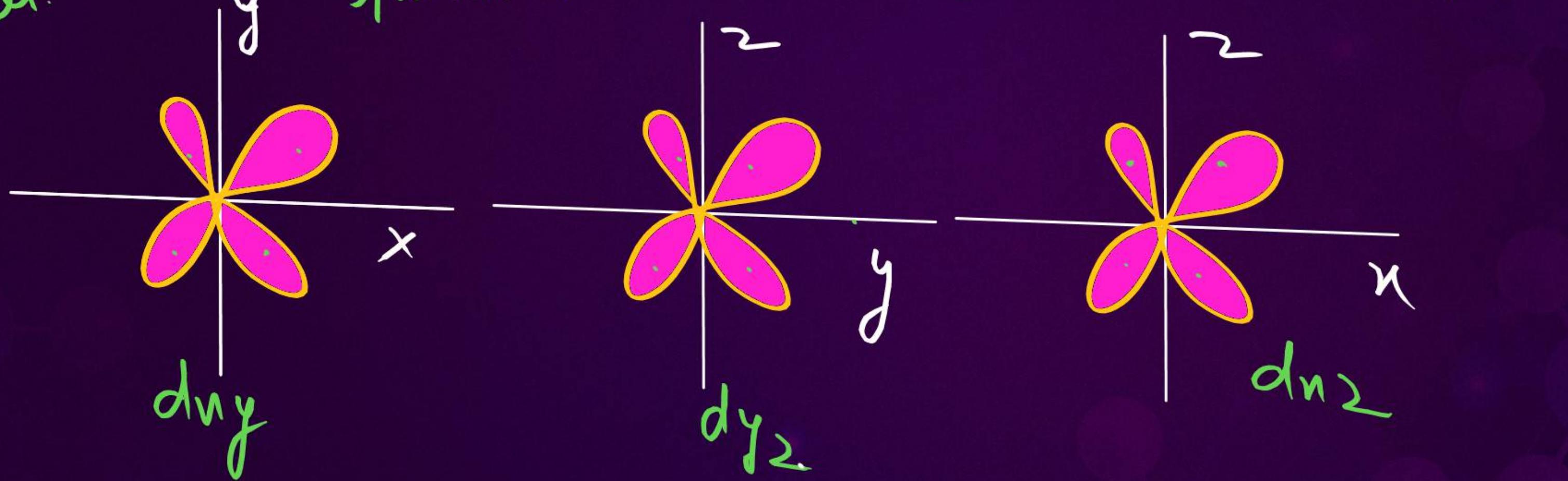
$d \rightarrow$ orbitals
is

double dumbell.



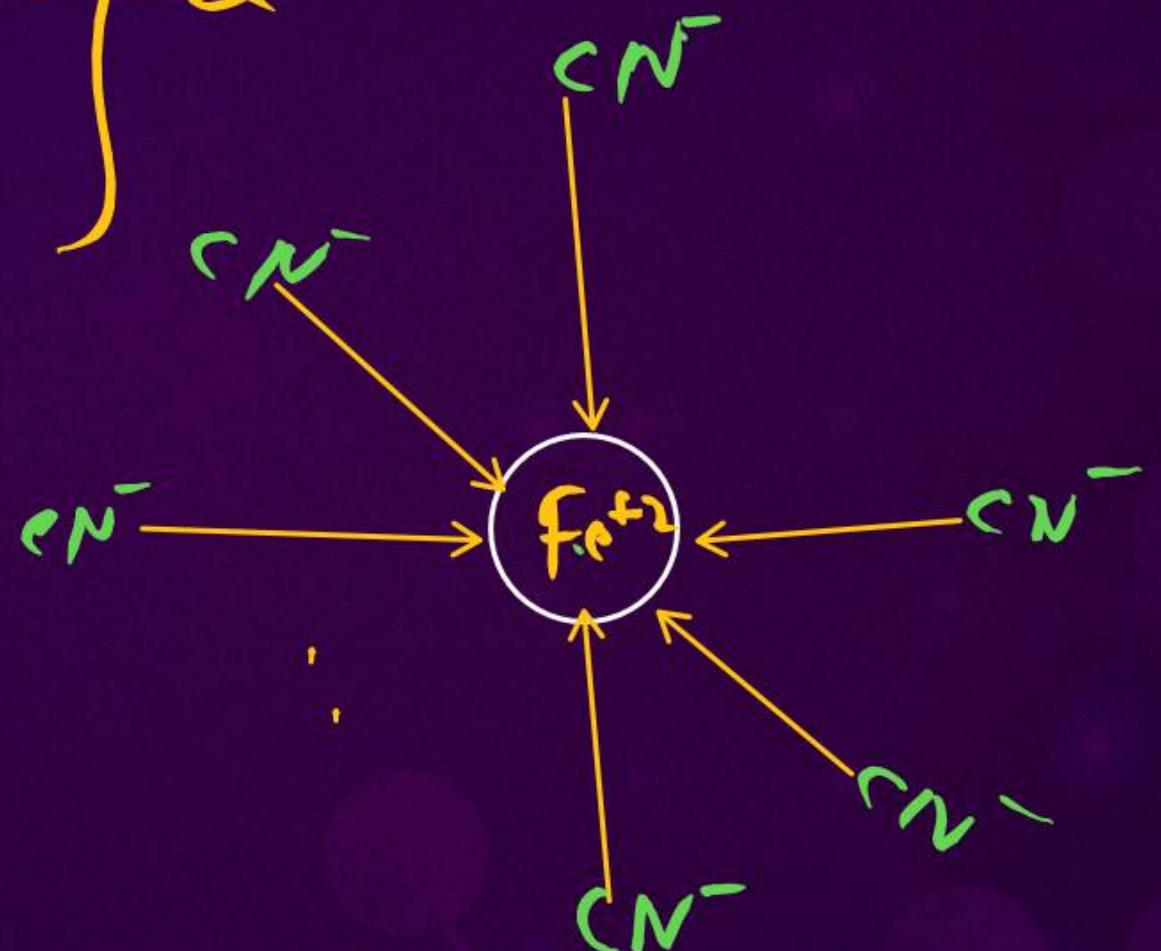
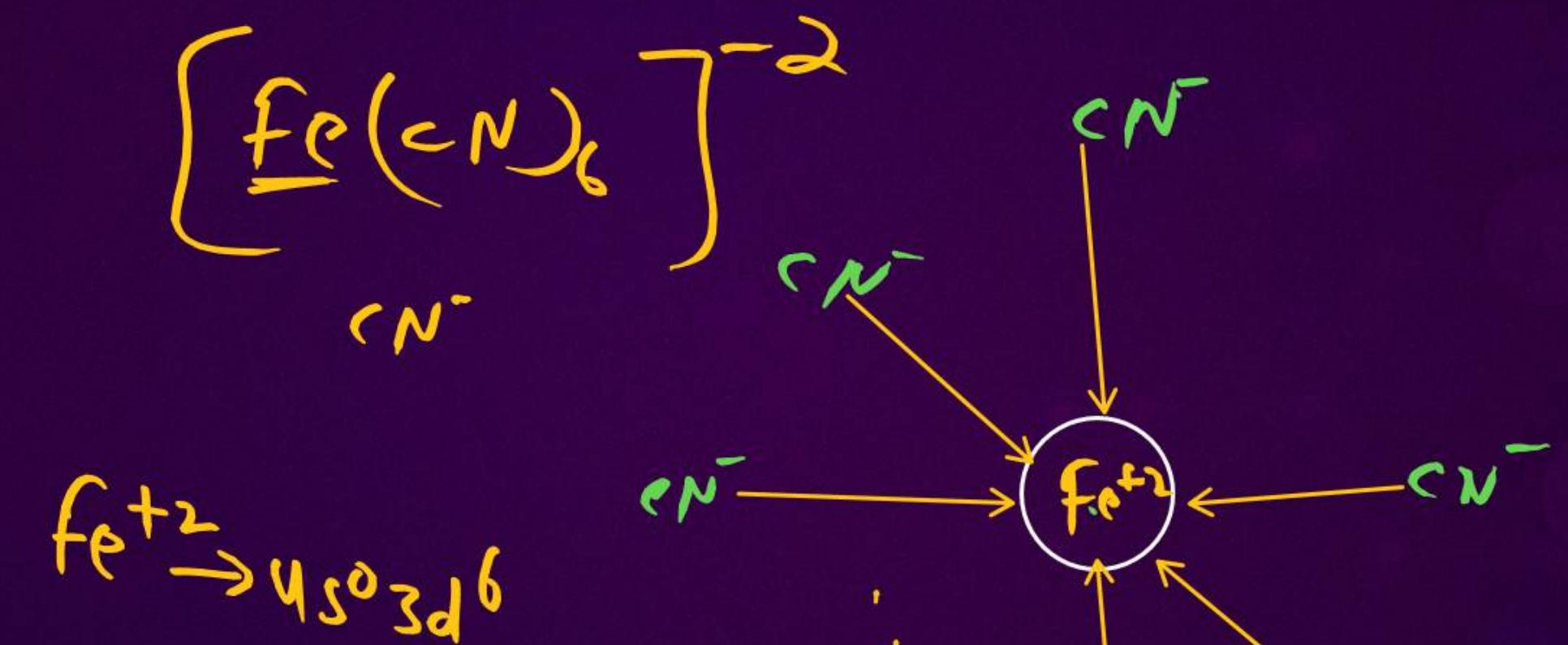
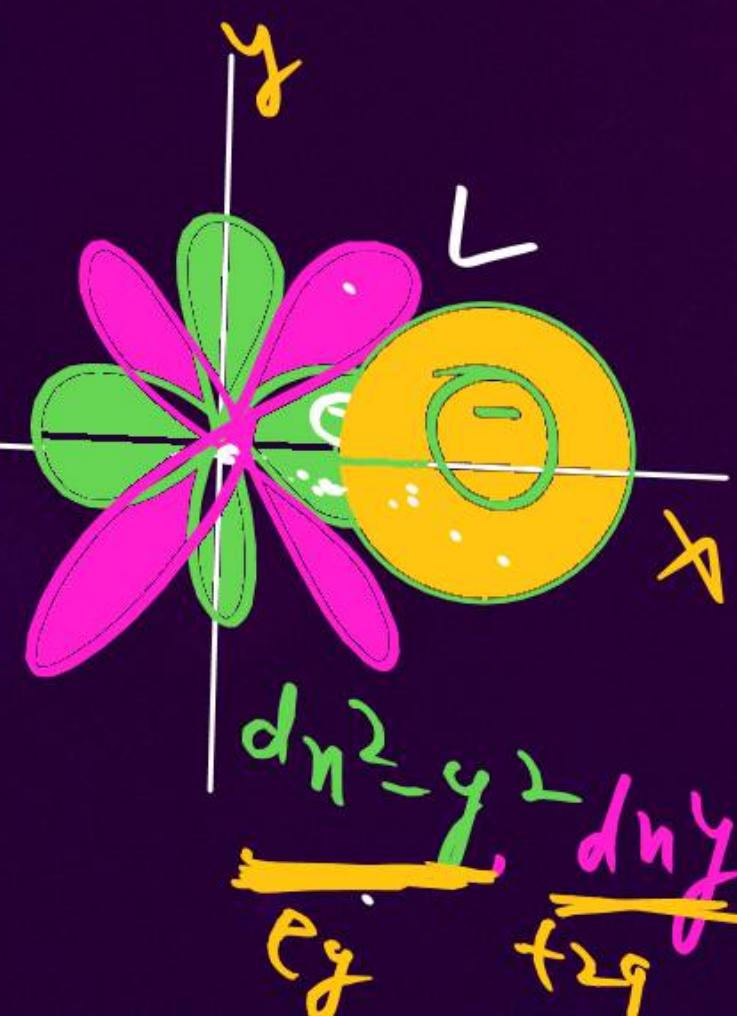
d_{xy} d_{yz} d_{zx} $d_{x^2-y^2}$ d_{z^2}

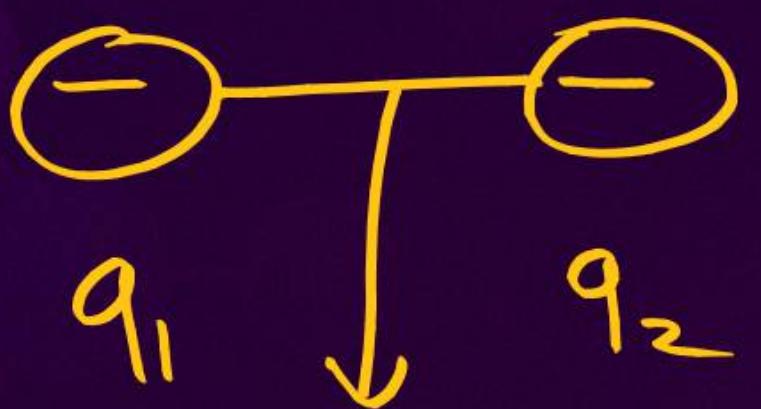
b/w the axis on the axis



$t_{2g} \rightarrow d_{xy}, d_{yz}, d_{zx} \rightarrow b/a$ the axis.

Eg $\rightarrow d_{z^2} - y^2$ d_{z^2} \rightarrow on the axis.

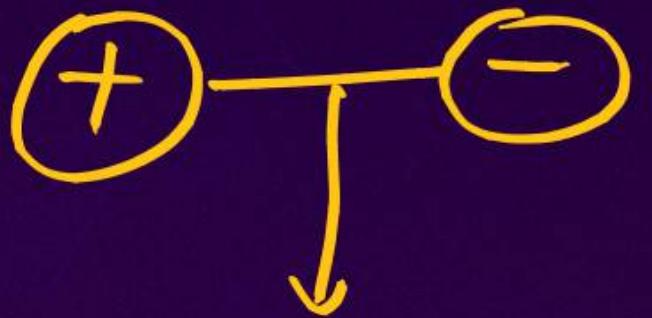




Repulsive force



Energy increases



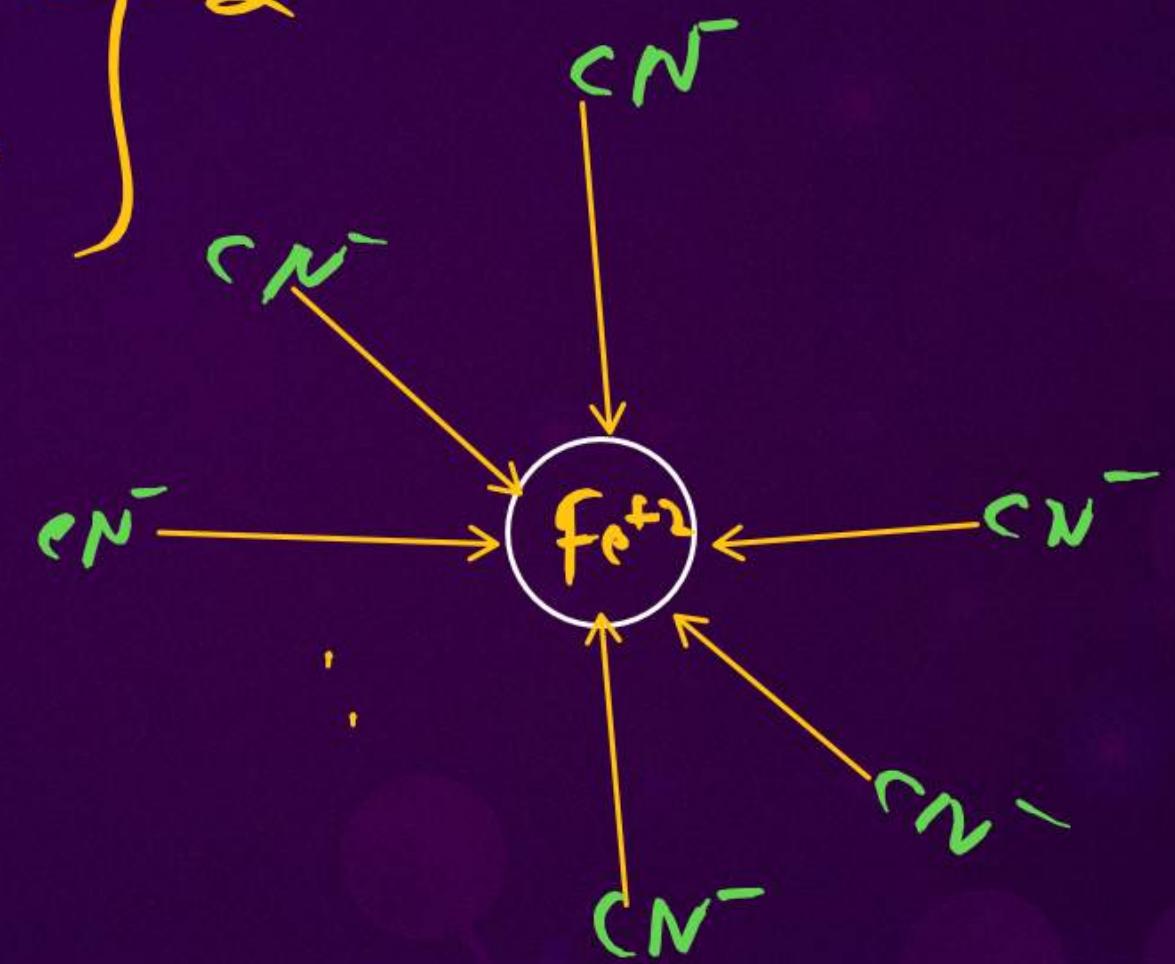
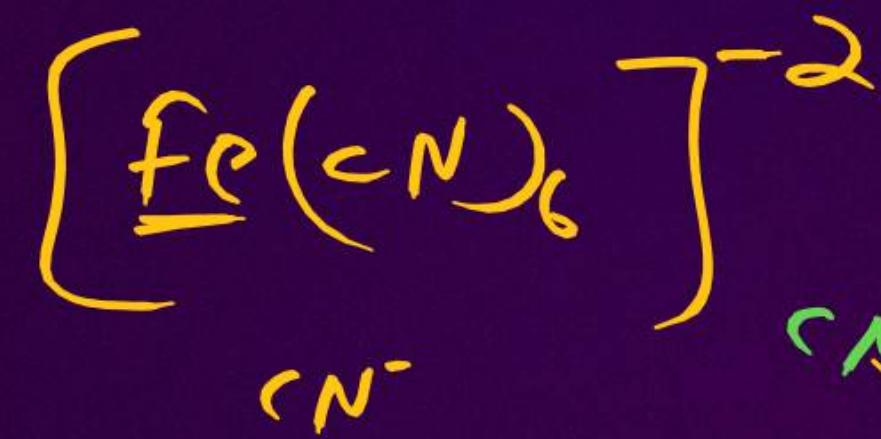
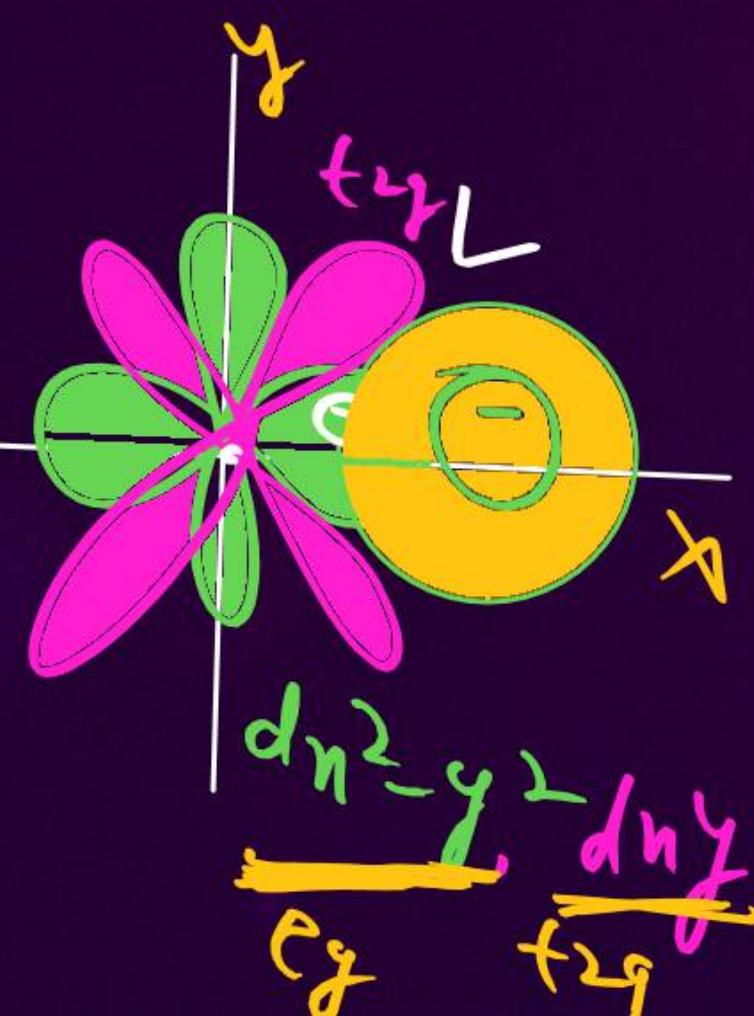
Attractive force



Energy decreases.

Repulsive force \rightarrow

d orbitals of Fe^{+2} and (ve) charge of ligand.

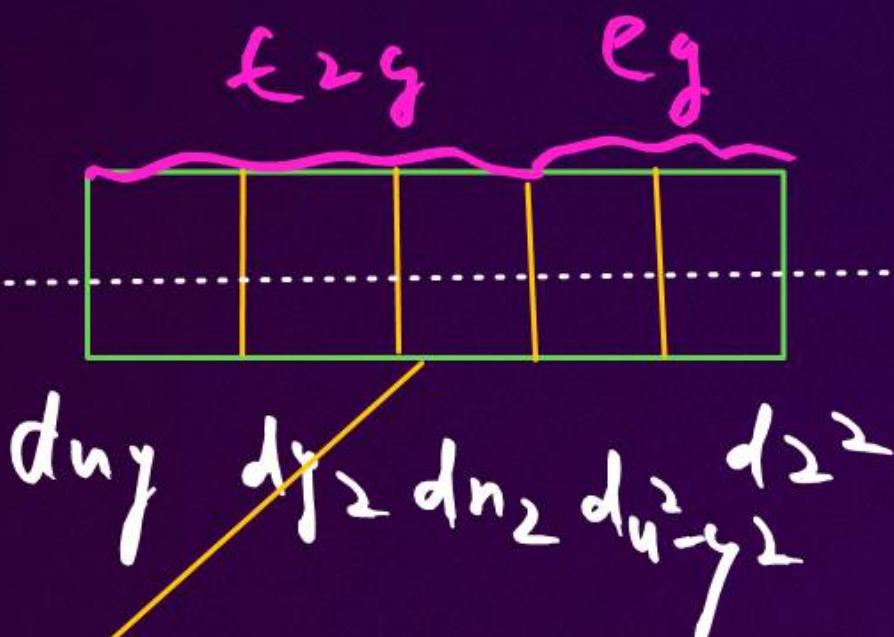


splitting of d orbitals.
crystal field splitting in octahedral.

same energy.
↑
degenerated.



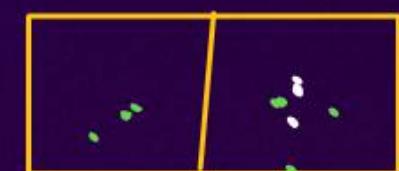
d_{xy} d_{z^2} d_{n_2} $d_{x^2-y^2}$



d_{xy} d_{z^2} d_{n_2} $d_{x^2-y^2}$

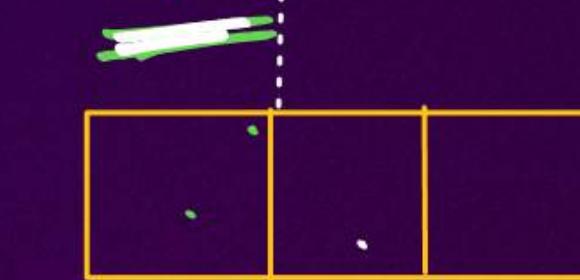
Δ_{00} repulsion

Δ_{00} strong field.



$+0.6\Delta_0$

Δ_0



$-0.4\Delta_0$

berry
centre.

eg

t2g

D₀ order.

NH₃, H₂O, CN⁻

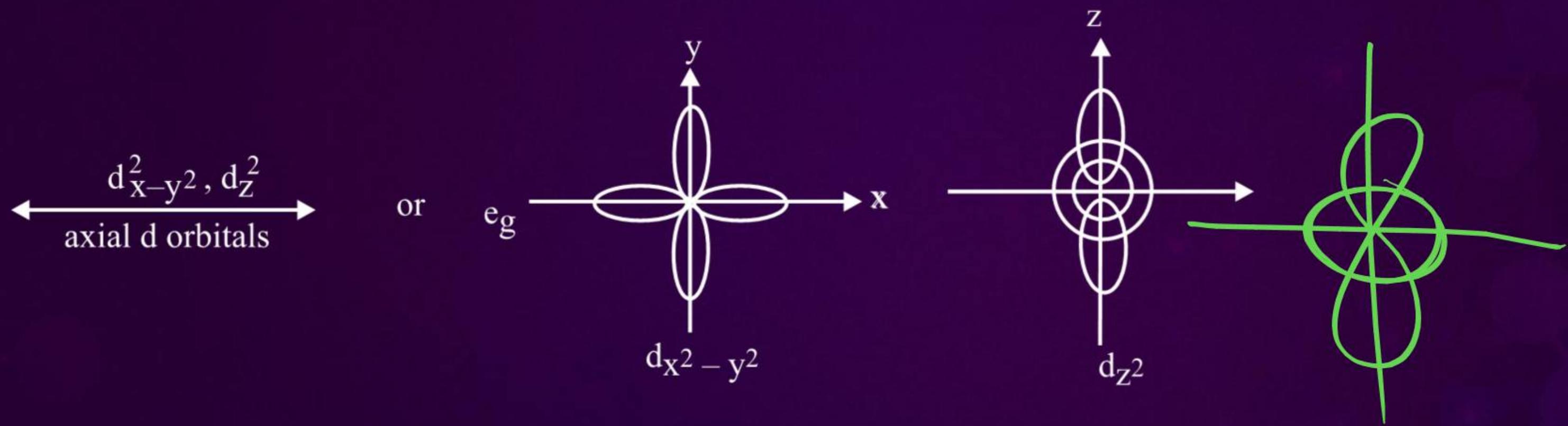
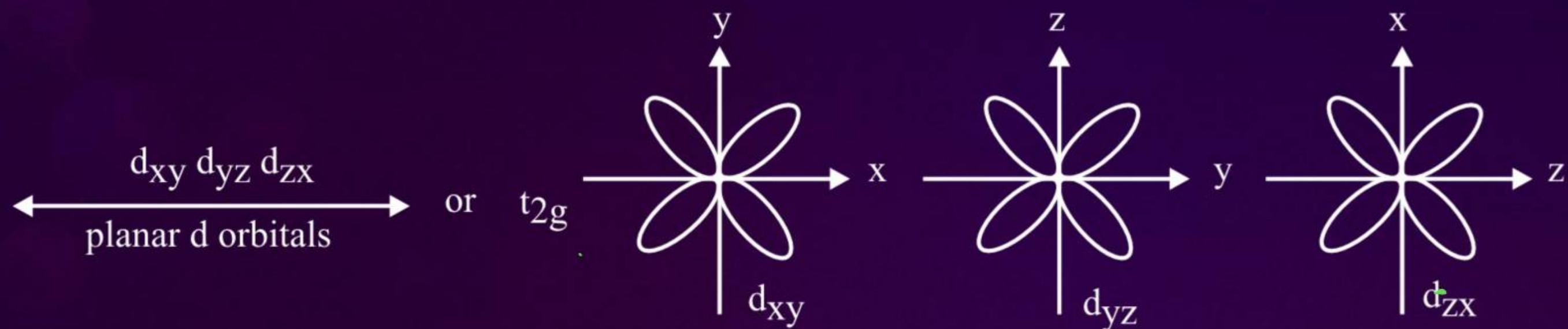
H₂O < NH₃ < CN⁻

* C⁻, I⁻, SCN⁻, OH

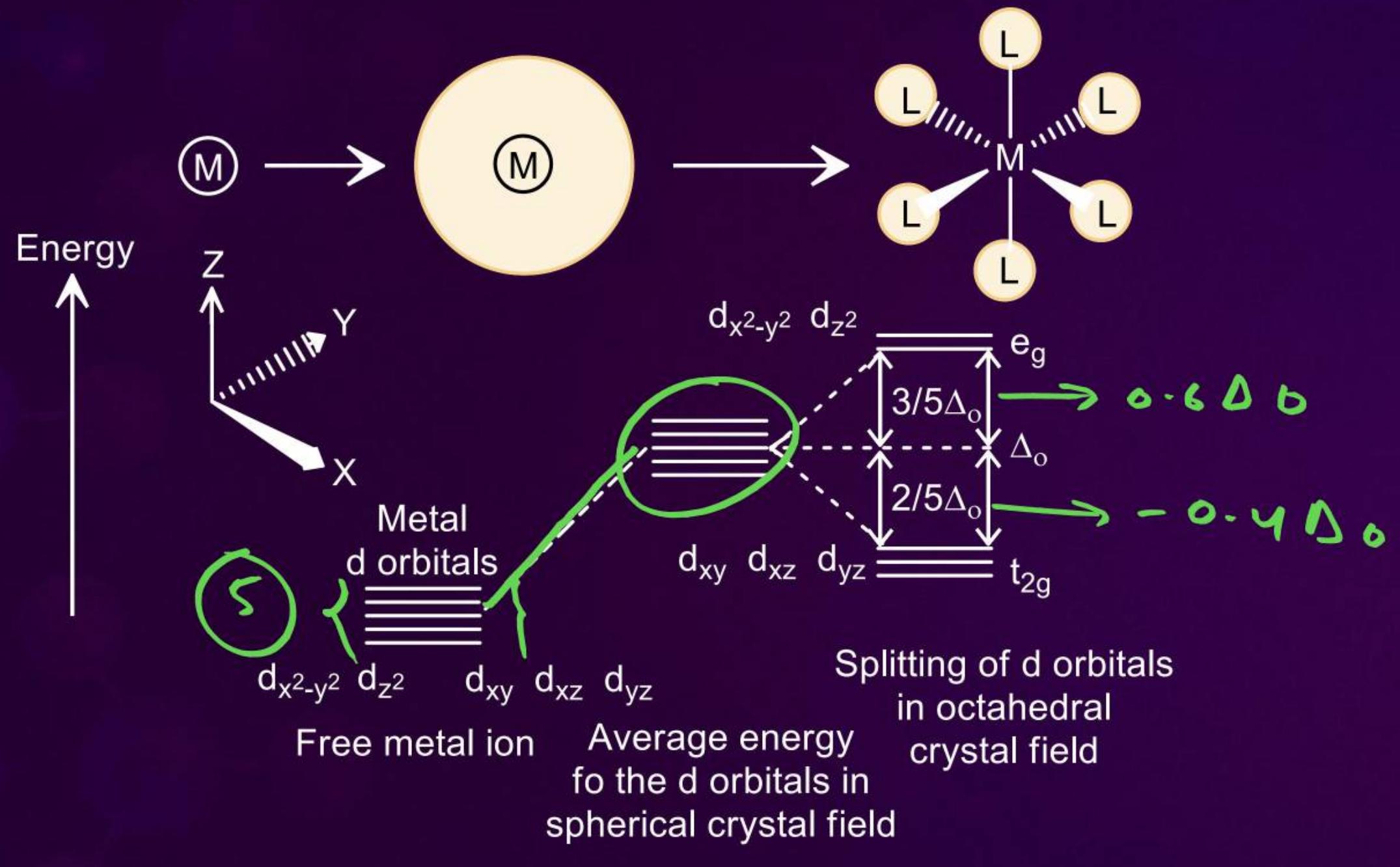
I⁻ < SCN⁻ < C⁻ < OH

* H₂O, NH₃, CO, C⁻

C⁻ < H₂O < NH₃ < CO



Crystal field splitting in octahedral coordination entities



d orbital splitting in an octahedral crystal field

Crystal field splitting in octahedral coordination entities

- $d_{x^2-y^2}$ and d_{z^2} orbitals which point towards the axes along the direction of the ligand will experience more repulsion and will be raised in energy. ✓
 - d_{xy} , d_{yz} and d_{xz} orbitals which are directed between the axes will be lowered in energy relative to the average energy in the spherical crystal field
- ✓ This splitting of the degenerate levels due to the presence of ligands in a definite geometry is termed as crystal field splitting and the energy separation is denoted by Δ_o
- the energy of the two e_g orbitals will increase by $(3/5) \Delta_o$ and that of the three t_{2g} will decrease by $(2/5)\Delta_o$

Factors affecting Δ_o repulsion

- Depends upon the field produced by the ligand

Spectrochemical series

Δ^o

$I^- < Br^- < SCN^- < Cl^- < S^{2-} < F^- < OH^- < C_2O_4^{2-} < H_2O < NCS^- < edta^{4-} < NH_3 < en < CN^- < CO$

Charge on the metal ion

$K_4[FeCN_6] < K_3[Fe(CN)_6]$

Fe^{+2} Fe^{+3} $\rightarrow \Delta_o$

$$F = \frac{k q_1 q_2}{r^2}$$

Home Work

→ $N^o DPP$

PARISHRAM



2026

Coordination Compound

CHEMISTRY **LECTURE-10**

BY – BIJENDRA SIR (Biju Bhaiya)



Topic Covered

CFT ✓ (Part - 02)

Color of Coordination Compound

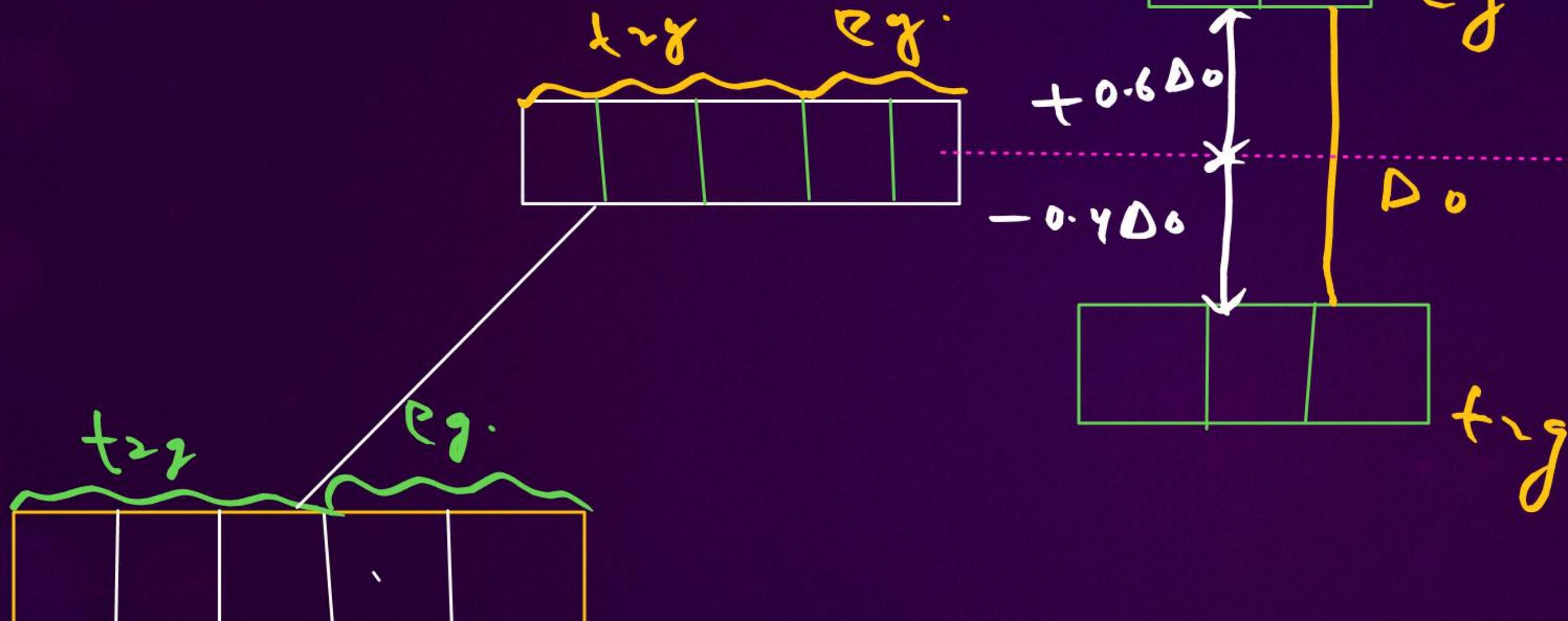


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Crystal Field Splitting in octahedral



$d_{xy} d_{yz} d_{zx} d_{x^2-y^2} d_{z^2}$

Q. Following is correct order of Do.

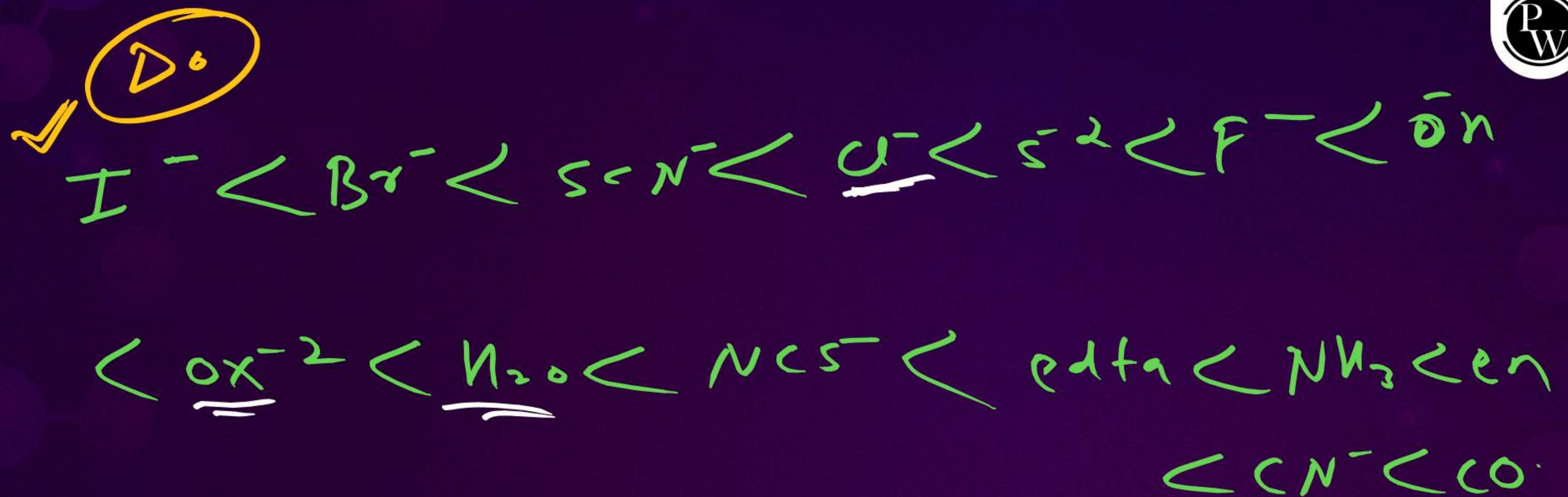


a) $\underline{N} \underline{Y_3} > \underline{\text{en}}^- X$

b) $\underline{\text{co}} < \underline{N} \underline{Y_3} X$



d) $\underline{Y_{2,0}} > \underline{\text{en}}^- X$

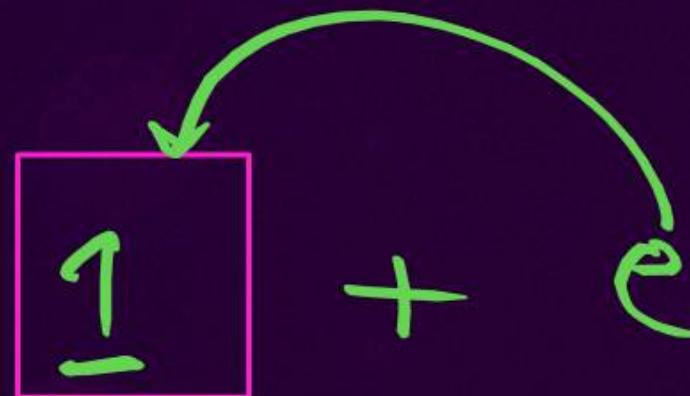


w of F is

correct order of Δf

- a) $\text{NH}_3 < \underline{\text{CO}} < \underline{\text{CN}^-} \times$
- b) $\text{NH}_3 > \text{H}_{20} > (\text{Zn}^{+2}) > \text{O}^- \checkmark$
- c) $\text{NH}_3 > \text{H}_{20} > \text{SCN}^- > \text{CO} \times$
- d) $\text{Cl}^- > \text{Br}^- > \text{I}^- > \text{S}^{+2} \times$

Pairing Energy $\rightarrow P$


$$1V$$

$(e - e) \rightarrow$ repulsive force.

1	1	1	\times
---	---	---	----------

Energy required
for pairing
is called pairing
energy.

Weak ligand.

$$P > D_0$$

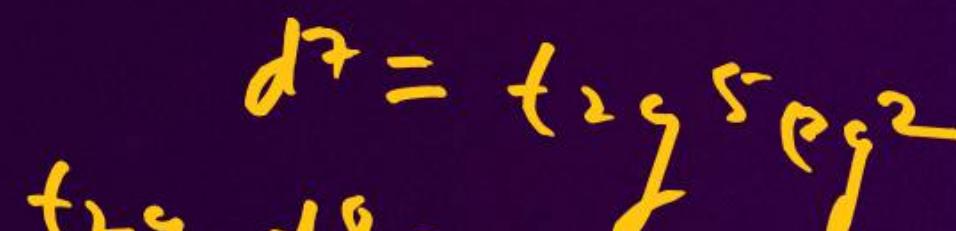
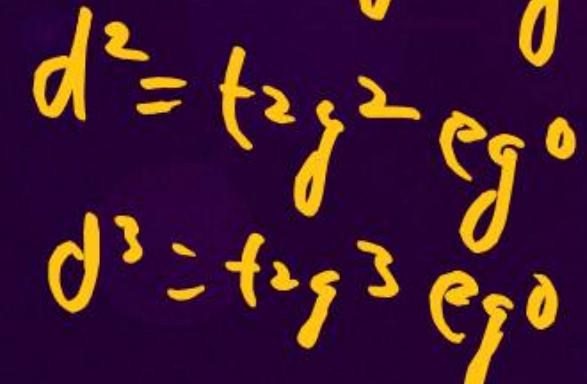
1L	1L
----	----

eg



$$D_0$$

1L	1L	1L
----	----	----



No pairing

eg

1L	1L	1L	1L	1L
----	----	----	----	----

pairing
hoga. \curvearrowleft Strong ligand

$$P < D_0$$

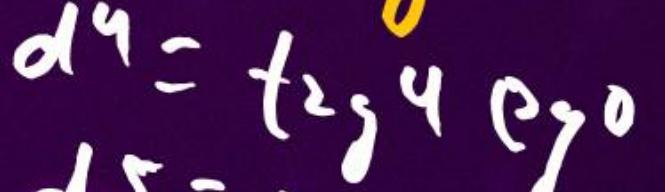
1L	1L
----	----

eg

$$D_0$$



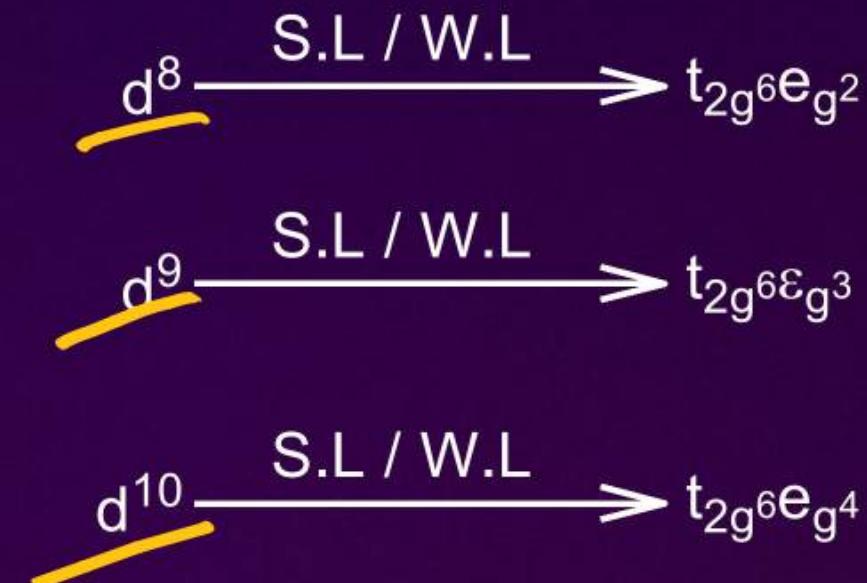
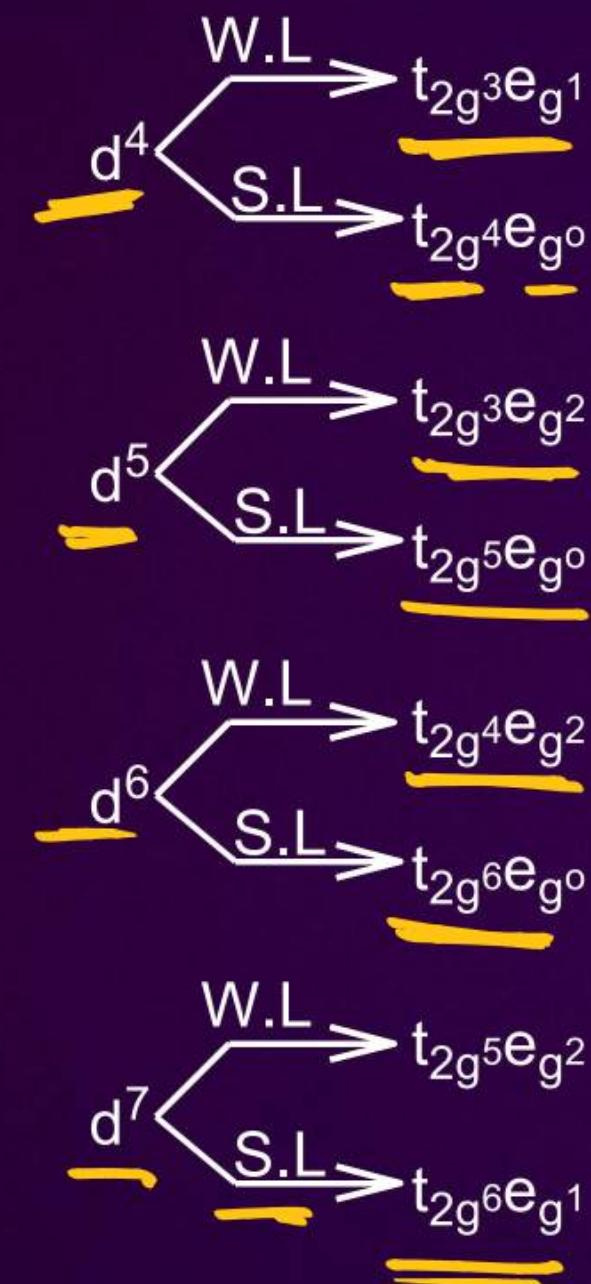
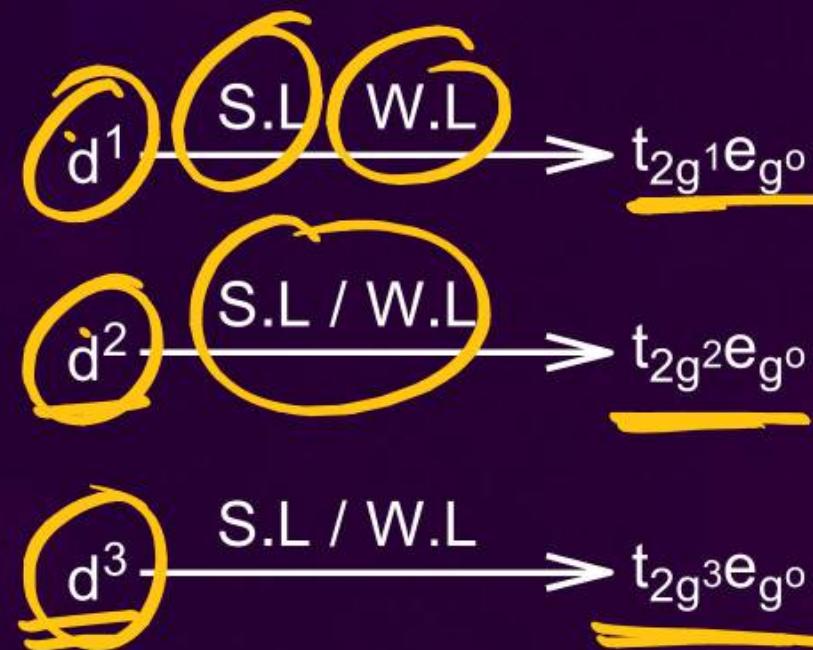
1L	1L	1L
----	----	----



Electron filling in Octahedral

- In d^1 d^2 and d^3 coordination entities, the d electrons occupy the t_{2g} orbitals singly in accordance with the Hund's rule.
 - i) If $\Delta_o < P$, the fourth electron enters one of the eg orbitals giving the configuration $t_{2g}^3 e_g^1$. Ligands for which $\Delta_o < P$ are known as weak field ligands and form high spin complexes.
 - ii) If $\Delta_o > P$, it becomes more energetically favorable for the fourth electron to occupy a t_{2g} orbital with configuration $t_{2g}^4 e_g^0$.

Electron filling in Octahedral



d^4 strong ligand.

a) $t_{2g}^3 e_g^1$

b) $t_{2g}^2 e_g^2$

c) $t_{2g}^4 e_g^0$

d) none.



e_g



t_{2g}

d^5

weak ligand.



1	1
---	---

 e_g 

1	1	1
---	---	---

 t_{2g} 

d^9 $\Delta_o < P$ weak ligand

① $t_{2g}^6 e_g^3$

1L	1L
----	----

e_g

⑤ $t_{2g}^7 e_g^2$

1L	1L	1L
----	----	----

e_g

③ $t_{2g}^5 e_g^2$

④ $t_{2g}^4 e_g^5$

d^7 strong ligand.

a) $t_{2g}^4 e_g^3$



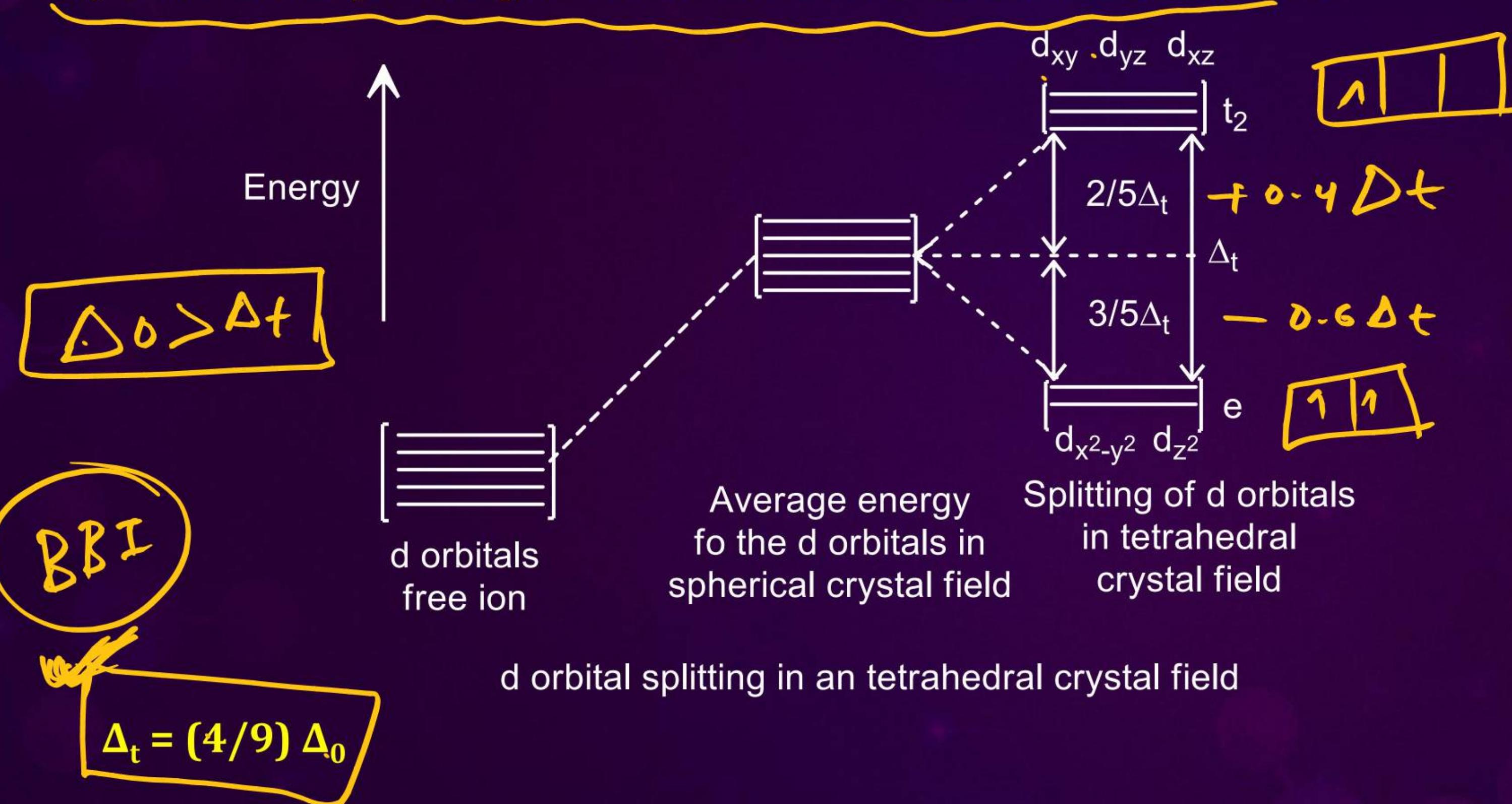
b) ~~$t_{2g}^6 e_g^1$~~



c) $t_{2g}^5 e_g^2$

d) none.

Crystal field splitting in tetrahedral coordination entities



Electron filling in Tetrahedral

The orbital splitting energies are not sufficiently large for forcing pairing and, therefore, low spin configurations are rarely observed.

The CFSE for octahedral $[\text{CoCl}_6]^{4-}$ is 18,000 cm^{-1} . The CFSE for tetrahedral $[\text{CoCl}_4]^{2-}$ will be

- A 18,000 cm^{-1}
- B 16,000 cm^{-1}
- C 8,000 cm^{-1}
- D 20,000 cm^{-1}

$$D_t = \frac{4}{9} D_o$$

$$\begin{aligned} D_t &= \frac{4}{9} \times 18000 \\ &= \underline{\underline{8000}} \end{aligned}$$

Question

The number of unpaired electrons in d^6 , low spin, octahedral complex is:

- A 4
- B 2
- C 1
- D 0

pairing hoga.



$$n = 0$$

Question



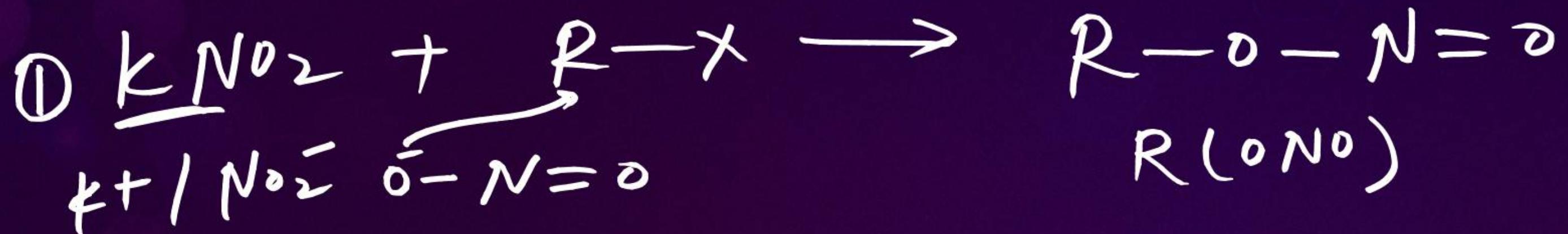
Which of the following will not give a precipitate with AgNO_3 ?

A ~~$[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$~~

B $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$

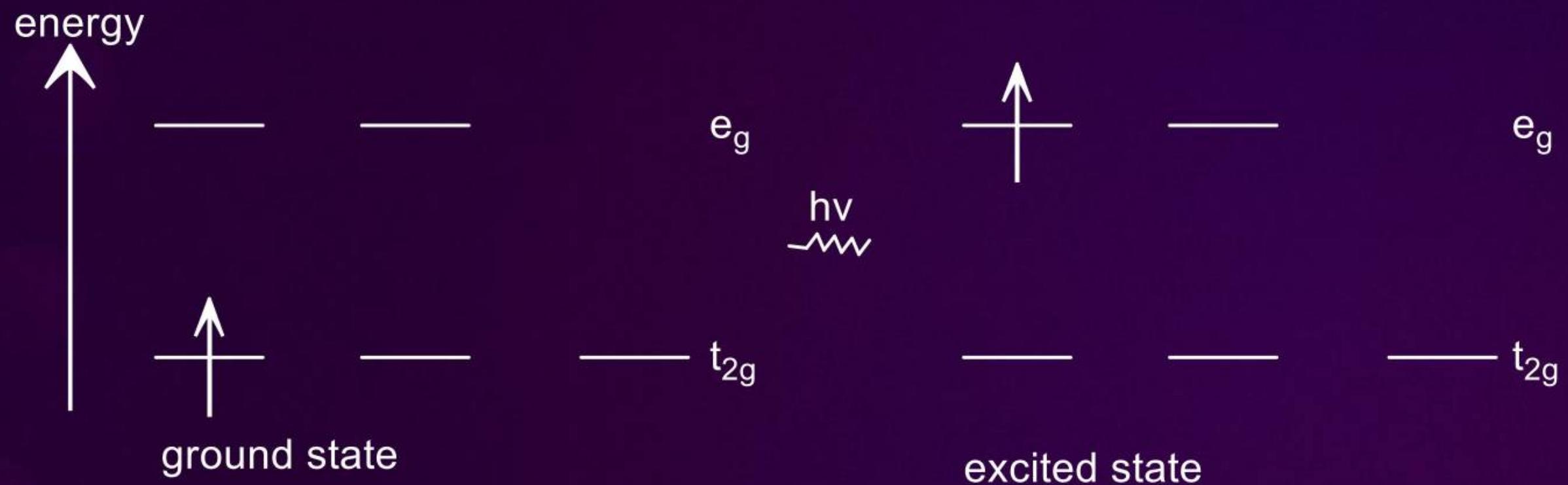
C $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$

D $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$





Colour in Coordination Compounds



Transition of an electron in $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$

White
light



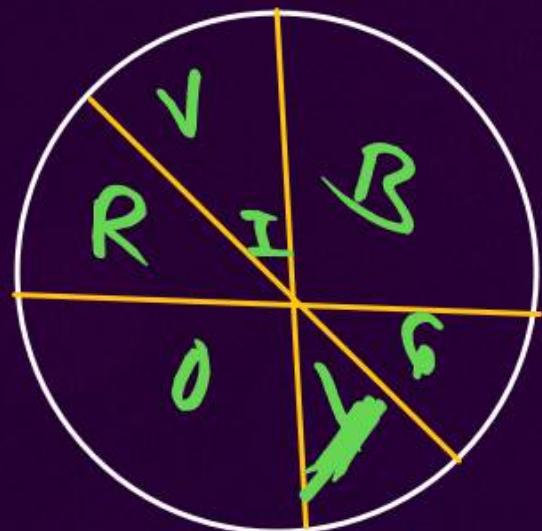
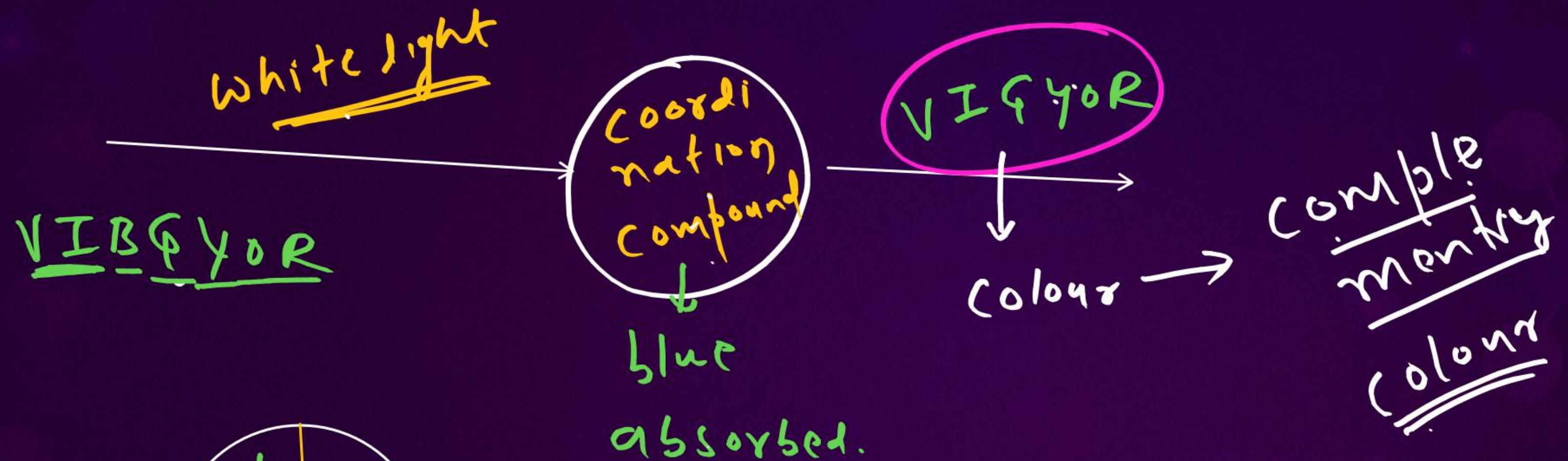
VIBGYOR



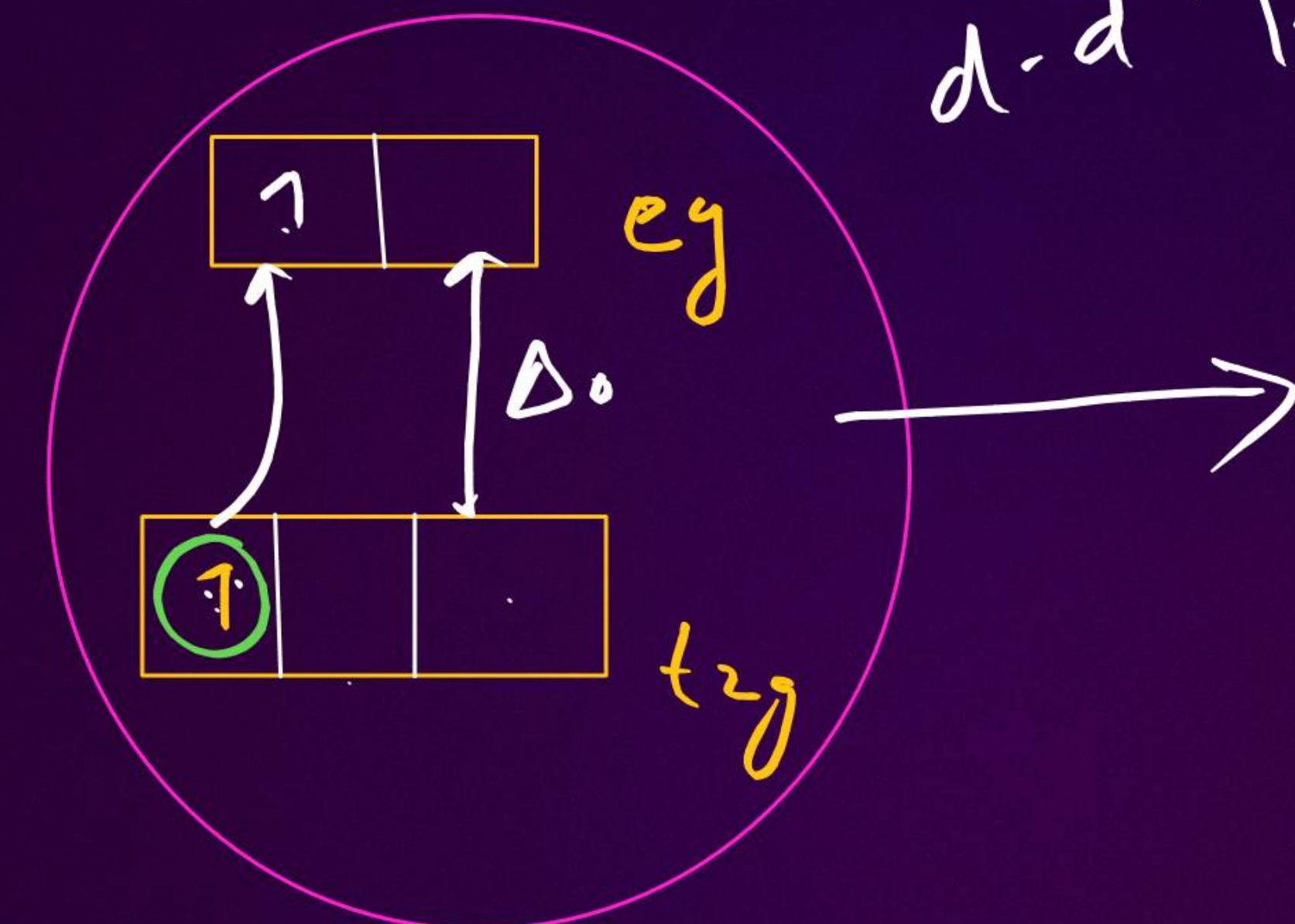
color \rightarrow wavelength $\rightarrow \lambda$

$$E = \frac{hc}{\lambda} \quad c = \text{speed of light.}$$

$$E \propto \frac{1}{\lambda}$$



d-d Transition.



white light

VIB & YOR

$$E = \frac{hc}{\lambda}$$

$$E_a = \Delta_0$$

$$\frac{hc}{\lambda_a} = \Delta_0$$

$$\Delta_0 \propto \frac{1}{n_a}$$

Relationship between the wavelength of Light absorbed and the Colour observed in some Coordination Entities

<u>Coordination entity</u>	<u>Wavelength of light absorbed (nm)</u>	<u>Colour of light absorbed</u>	<u>Colour of coordination entity</u>
$[\text{CoCl}(\text{NH}_3)_5]^{2+}$	535	Yellow	Violet
$[\text{Co}(\text{NH}_3)_5(\text{H}_2\text{O})]^{3+}$	500	Blue Green	Red
$[\text{Co}(\text{NH}_3)_6]^{3+}$	475	Blue	Yellow Orange
$[\text{Co}(\text{CN})_6]^{3-}$	310	Ultraviolet	Not in visible region
$[\text{Cu}(\text{H}_2\text{O})_4]^{2+}$	600	Red	Pale Yellow
$[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$	498	Blue Green	Violet

Complexometry

$$\Delta_o > \Delta_f$$





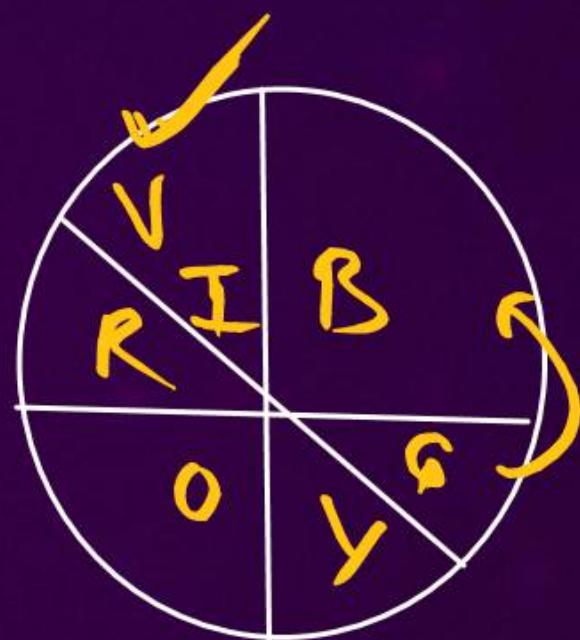
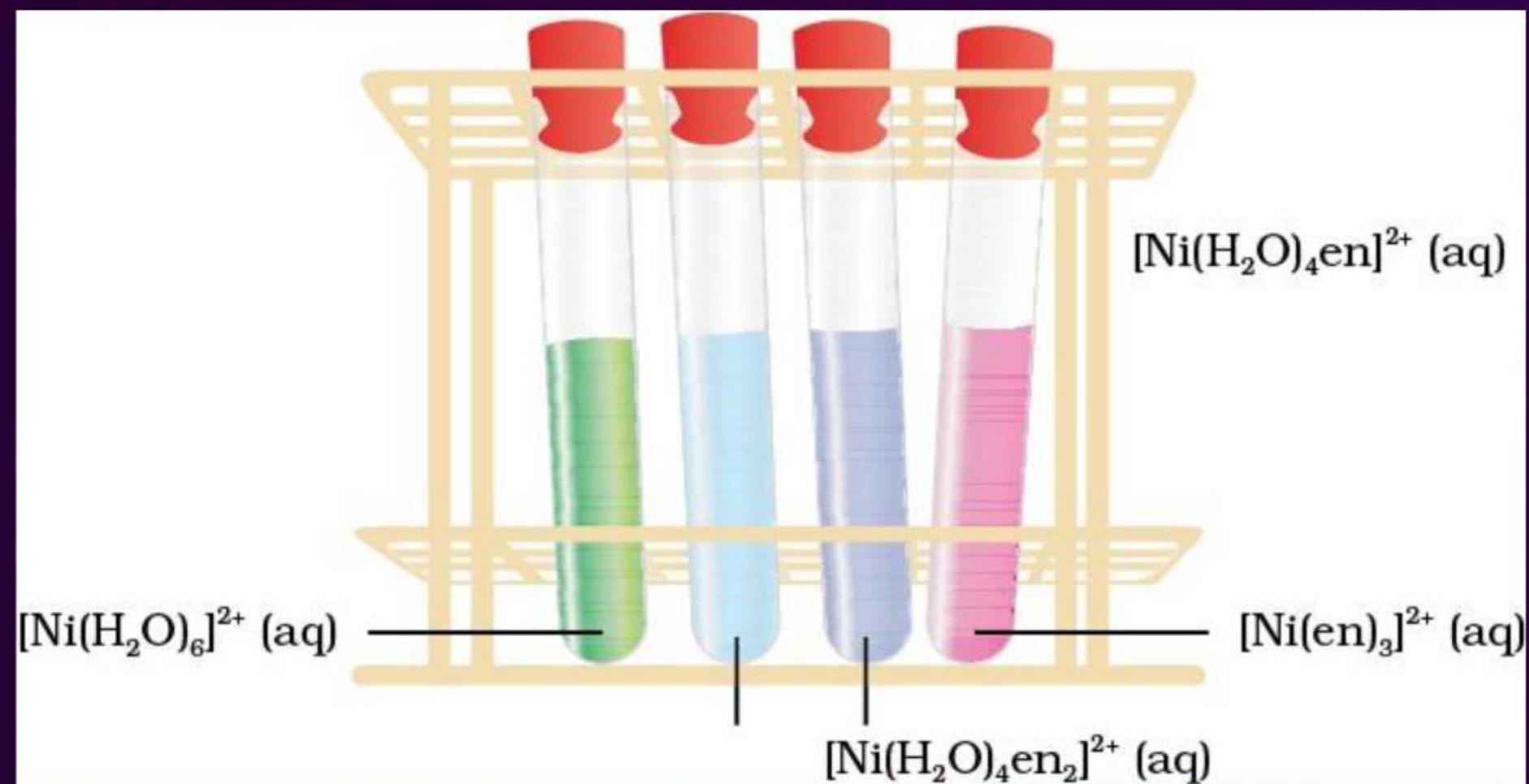
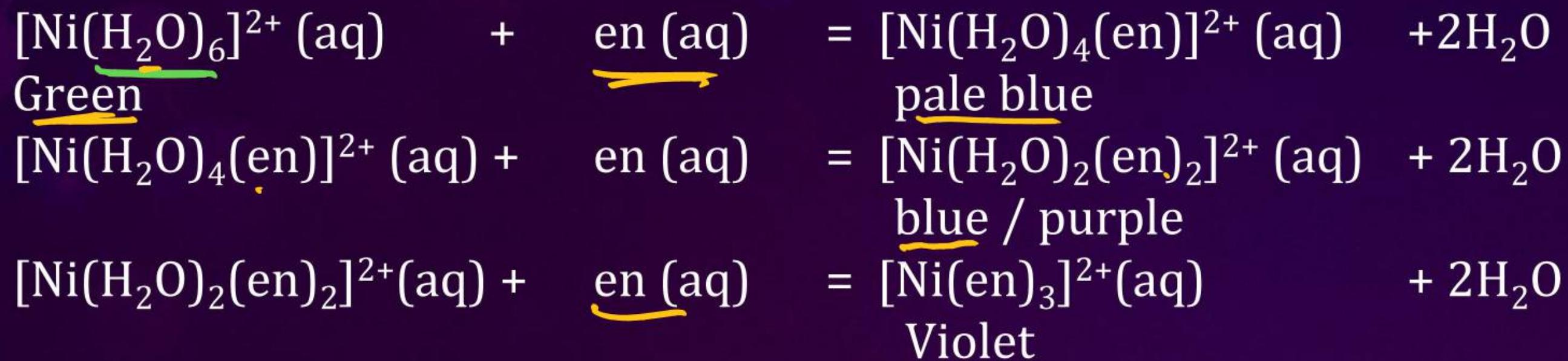
Colour in Coordination Compounds

- ✓ The colour of the complex is complementary to that which is absorbed.
 - The complementary colour is the colour generated from the wavelength left over.
 - if green light is absorbed by the complex, it appears red.
- ✓ It is important to note that in the absence of ligand, crystal field splitting does not occur and hence the substance is colourless. For example, removal of water from $[\text{Ti}(\text{H}_2\text{O})_6]\text{Cl}_3$ on heating renders it colourless



- Anhydrous CuSO_4 is white, but $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ is blue in colour $[\text{Cu}(\text{H}_2\text{O})_4]\text{SO}_4 \cdot \text{H}_2\text{O}$





en

2625

When ethane-1, 2-diamine is progressively added to aqueous solution of Nickel (II) chloride the sequence of colour change observed will be:

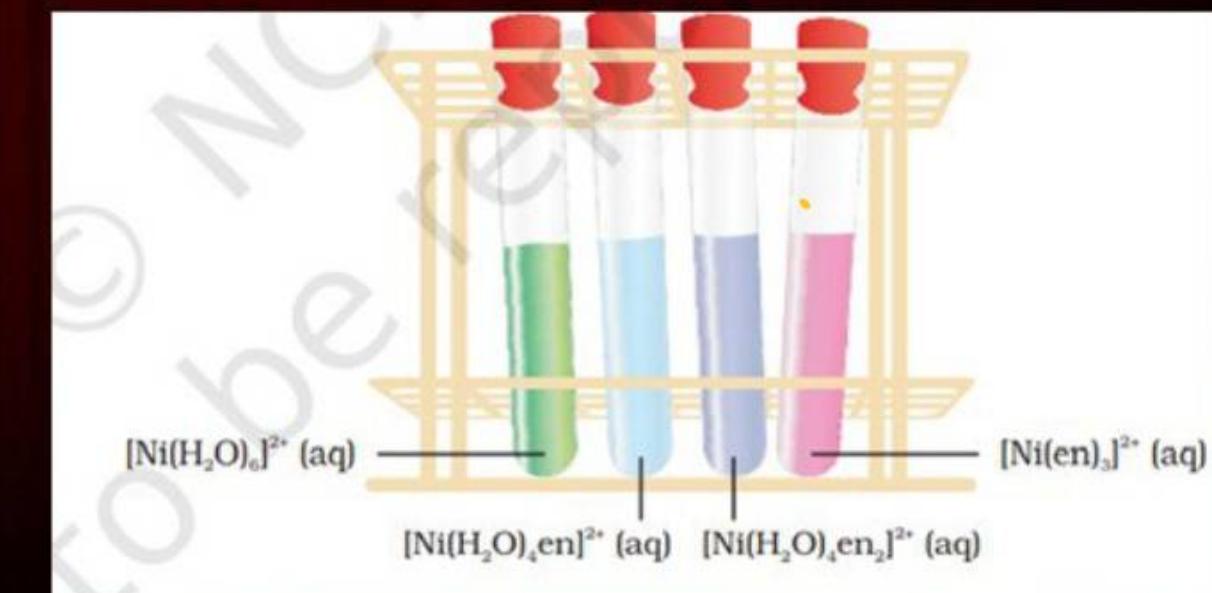
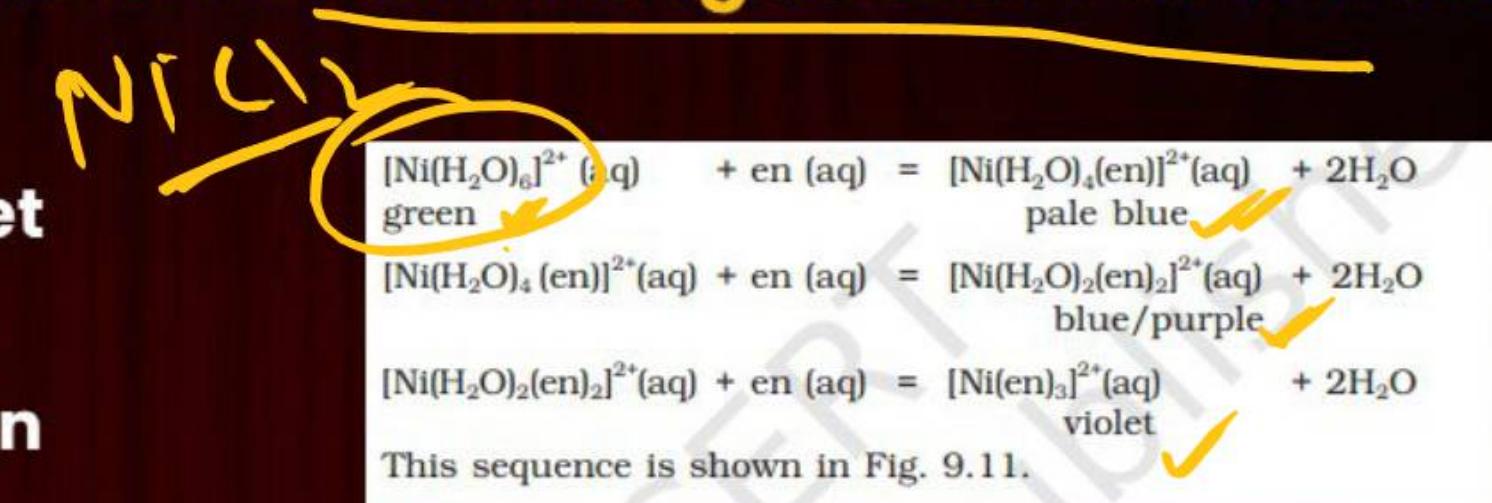


A Pale Blue → Blue → Green → Violet

B Violet → Blue → Pale Blue → Green

C Pale Blue → Blue → Violet → Green

D Green → Pale Blue → Blue → Violet



Question



Which of the following compounds is colourless

A



B



C



D





Home Work

DPP

PARISHRAM



2026

Coordination Compound

CHEMISTRY LECTURE-11

BY – BIJENDRA SIR (Biju Bhaiya)



Topic Covered

Isomerism ✓



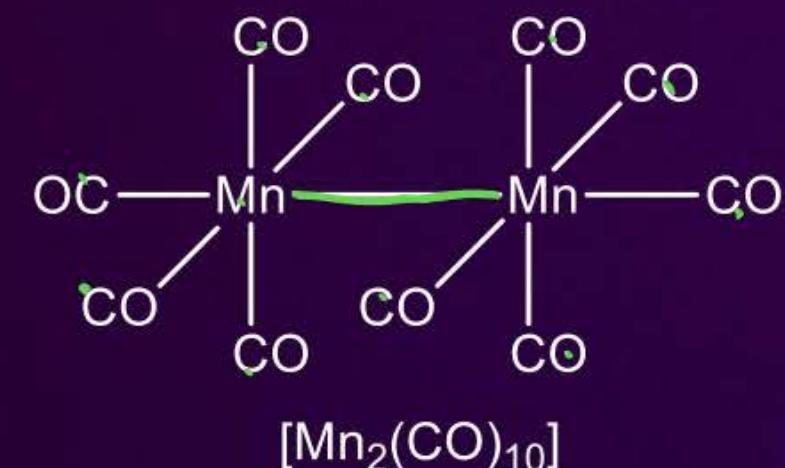
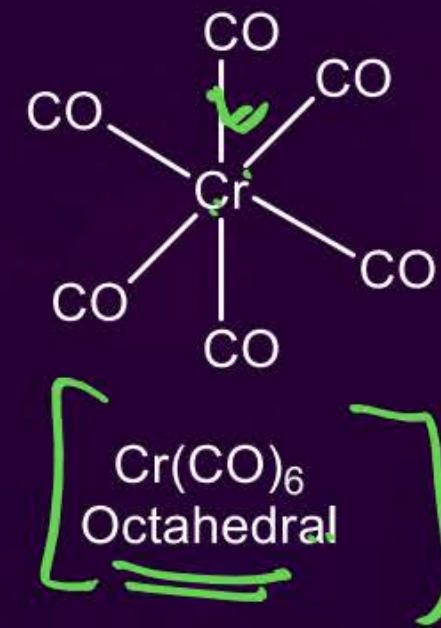
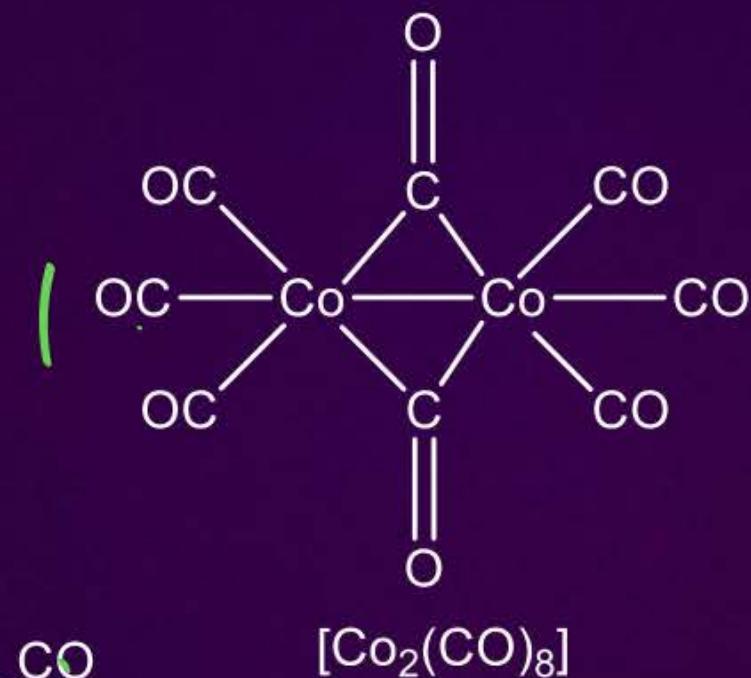
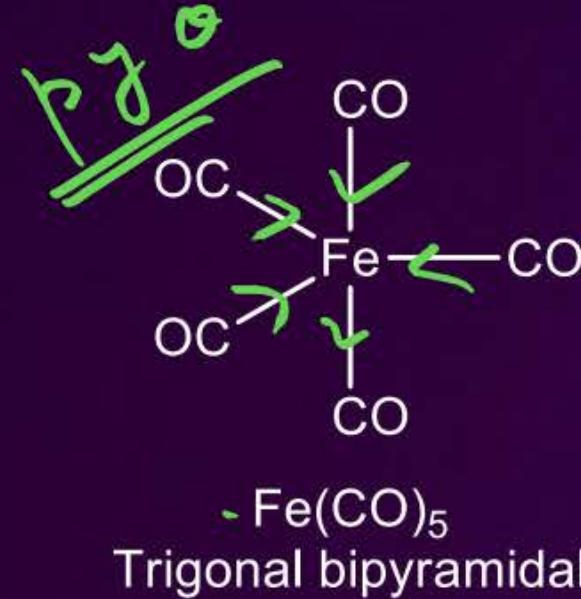
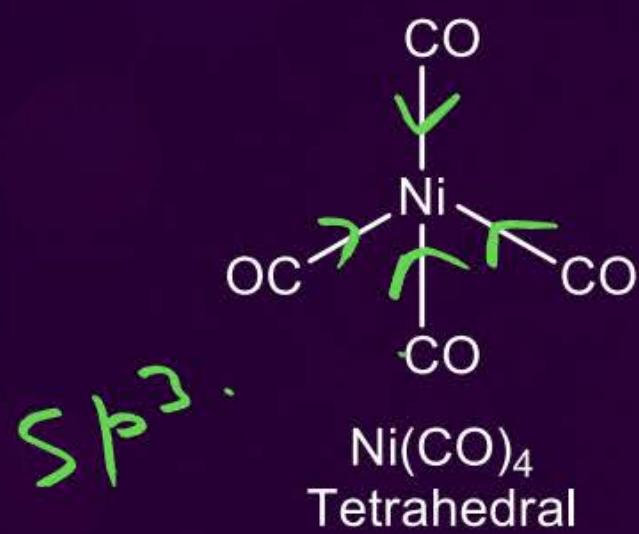
BIJENDRA SIR

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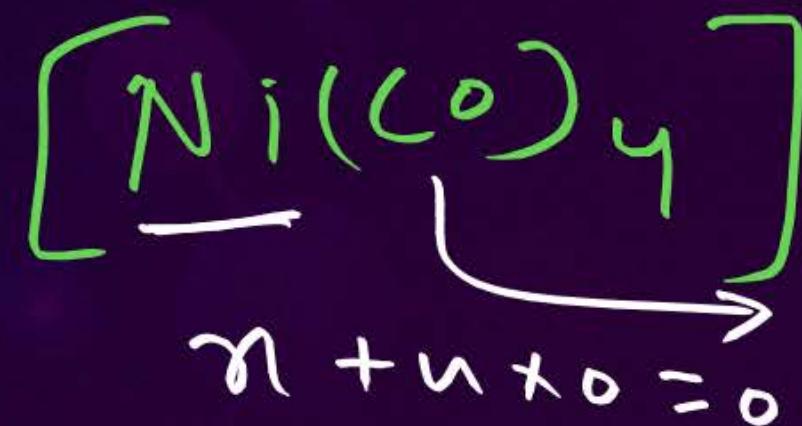




Bonding in Metal Carbonyls



$\text{CO} \rightarrow \text{carbon monoxide}$



$\text{CO} \rightarrow \text{Neutral}$

(a) $s\text{p}^2$

$n = 0$

$$\text{Ni} \rightarrow 4s^2 3d^8$$

(b) ~~$s\text{p}^3$~~

(c) $d\text{s}\text{p}^2$

$\text{CO} \rightarrow$ strong ligand.

$\frac{4s^0}{=} \frac{3d^{10}}{=}$

$s + p + d + f = sp^3$

(d) none.

Synergic bonding

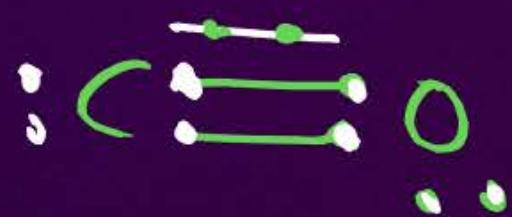


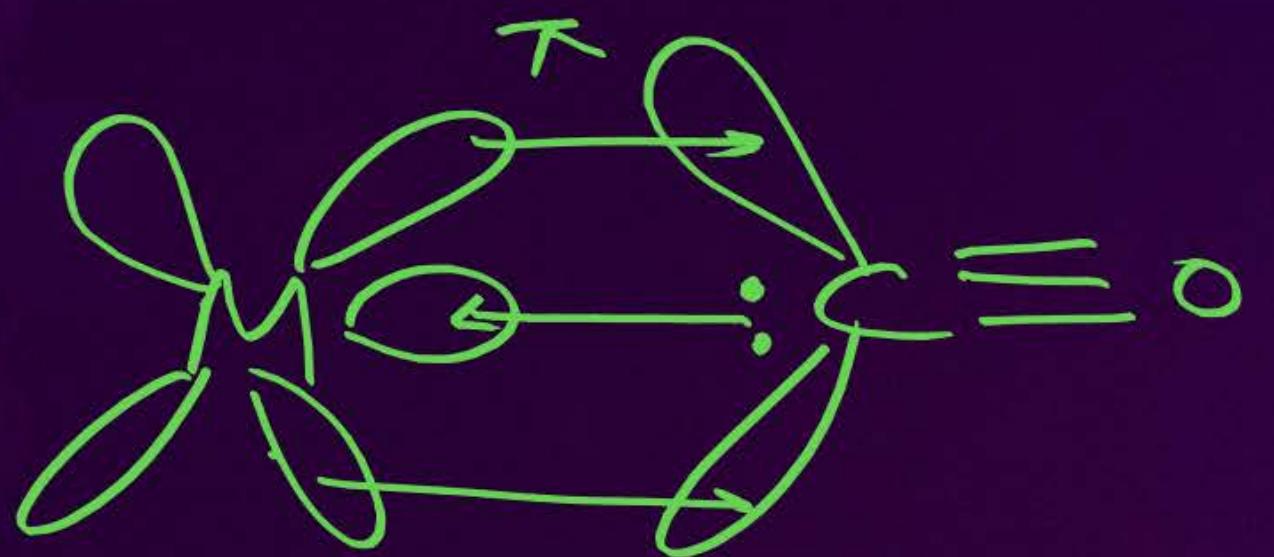
- The metal-carbon bond in metal carbonyls possess both σ and π character.
- ✓ The M-C σ bond is formed by the donation of lone pair of electrons on the carbonyl carbon into a vacant orbital of the metal.
- ✓ The M-C π bond is formed by the donation of a pair of electrons from a filled d orbital of metal into the vacant antibonding π^* orbital of carbon monoxide.
- The metal to ligand bonding creates a synergic effect which strengthens the bond between CO and the metal

*



$$\Rightarrow 6 + 8 = 14$$







Isomerism in Coordination Compound

When complex compounds have same molecular formula but have different structural or spatial arrangement of ligand around central metal atom/ion called as isomers and this phenomenon is known as isomerism.

Co-ordination compounds exhibit isomerism. The isomerism can be divided into two types. They are:

1. Stereoisomerism ✓
2. Structural isomerism ✓

ISOMERS → Molecular formula
Same.

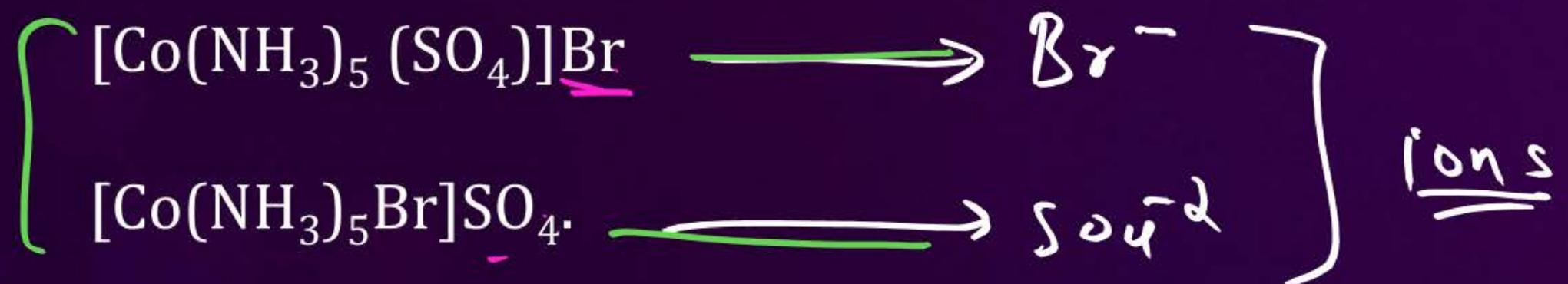
(2) Structural Isomerism

This isomerism arises due to the difference in the structures of complexes.

It is of four types:

Ionisation Isomerism: \rightarrow Ion different

This form of isomerism arises when the counter ion in a complex salt is itself a potential ligand and can displace a ligand which can then become the counter ion.



(V20)

- ✓ (ii) **Hydrate/Solvate Isomerism:** Hydrate isomerism is a special type of ionization isomerism. This type of isomerism arises due to the presence of water molecules in and outside the coordination sphere.

✓ Ex: $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ molecular formula has four possible isomers. They are
 ✓ $[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_3$ - violet coloured;
 ✓ $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}_2 \cdot \text{H}_2\text{O}$ - light green coloured.

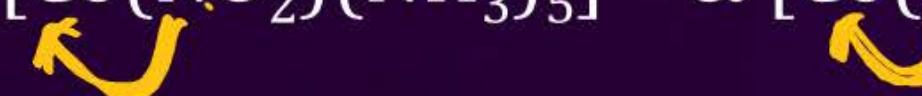
Linkage different

Ambidentate ligand.



- ✓ (iii) **Linkage Isomerism:** Complex consisting ambidentate ligands gives this kind of isomerism. A monodentate ligand with two (or) more donor atoms is called ambidentate ligand.

Ex: $[\text{Co}(\text{NO}_2)(\text{NH}_3)_5]^{+2}$ & $[\text{Co}(\text{ONO})(\text{NH}_3)_5]^{+2}$



(ii) Linkage Isomerism: Complex consisting ambidentate ligands gives this kind of isomerism.



Question

Which of the following compounds exhibits linkage isomerism?

- A $[\text{Co}(\text{en})_3]\text{Cl}_3$ ✓
- B $[\text{Co}(\text{NH}_3)_6][\text{Cr}(\text{en})_3]$ ↗
- C $[\text{Co}(\text{en})_2\text{NO}_2\text{Cl}]\text{Br}$ ✓
- D $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Br}_2$ ↗



(iv) **Coordination Isomerism:** It arises due to the mutual exchange of ligands between anionic and cationic spheres of a different metal ions in a complex.

Ex: $[\text{Co}(\text{NH}_3)_6] [\text{Cr}(\text{CN})_6]$ &

$[\text{Co}(\text{CN})_6][\text{Cr}(\text{NH}_3)_6]$



Question



$[\text{Co}(\text{NH}_3)_5\text{Br}]\text{SO}_4$ and $[\text{Co}(\text{NH}_3)_5\text{SO}_4]\text{Br}$ are related to each other as:

- A ionisation isomers
- B linkage isomers
- C coordination isomers
- D geometrical isomers

1. Stereoisomerism

Isomers which have the same position of atoms (or) groups but differ in the spatial arrangements around the central atom are called stereoisomers and the phenomenon is called stereoisomerism,. It is classified into two types.

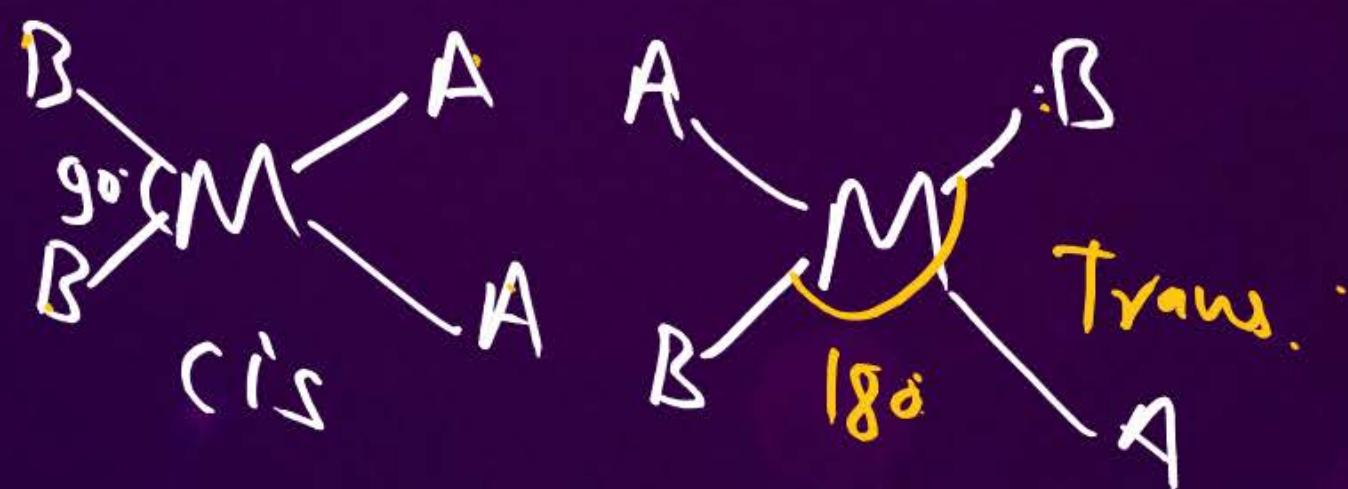
- (i) Geometrical isomerism
- (ii) Optical isomerism

(i) Geometrical isomerism

Compounds have same molecular formula and same connectivity but have different distances and bond angles between their ligands/groups in the structure.

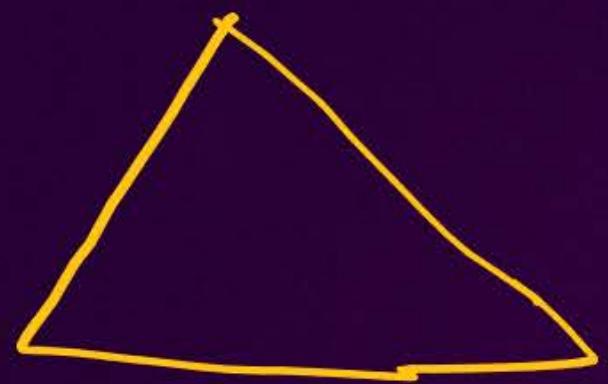
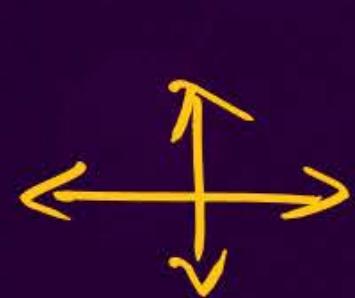
When two identical ligands occupy adjacent positions, the isomer is called cis-isomer. [Bond Angle - 90 degree]

When two identical ligands occupy opposite positions, the isomer is called trans-isomer [Bond Angle - 180 degree]



(ii) Optical Isomerism

- The compounds having same molecular formula but differ in the rotation of plane polarised light are called optical isomers and the phenomenon is called optical isomerism.
- ✓ The isomer which rotates the plane polarised light to the right direction is called dextro (d)-form while the isomer which rotates the plane polarised light to left direction is called laevo (l)-form.
- ✓ A pair of optical isomers which are non superimposable mirror images are called enantiomers.
- An equimolar mixture of d-forms and l-forms is called racemic mixture. Racemic mixtures are optically inactive



Nicol

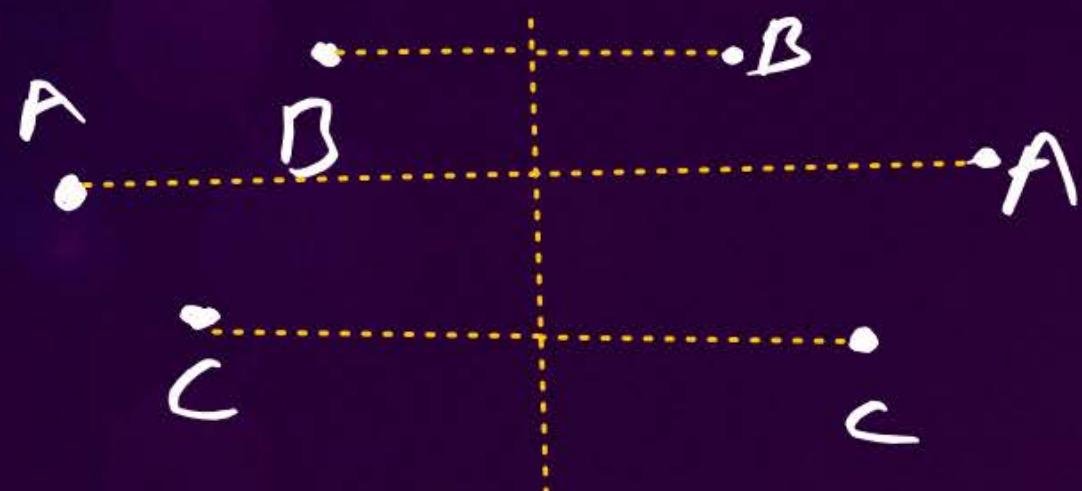
prism.

T ↑
PPL



(ii) Condition for Optical Isomerism ✓

- ✓ A pair of optical isomers which are non superimposable mirror images are optically active & called enantiomers
- ✓ An equimolar mixture of d-forms and l-forms is called racemic mixture. Racemic mixtures are optically inactive
- ✓ If there are any plane of symmetry present in the molecule then compound will be **optically inactive**



Superimposable \rightarrow optically Inactive.

P

^{OP}P

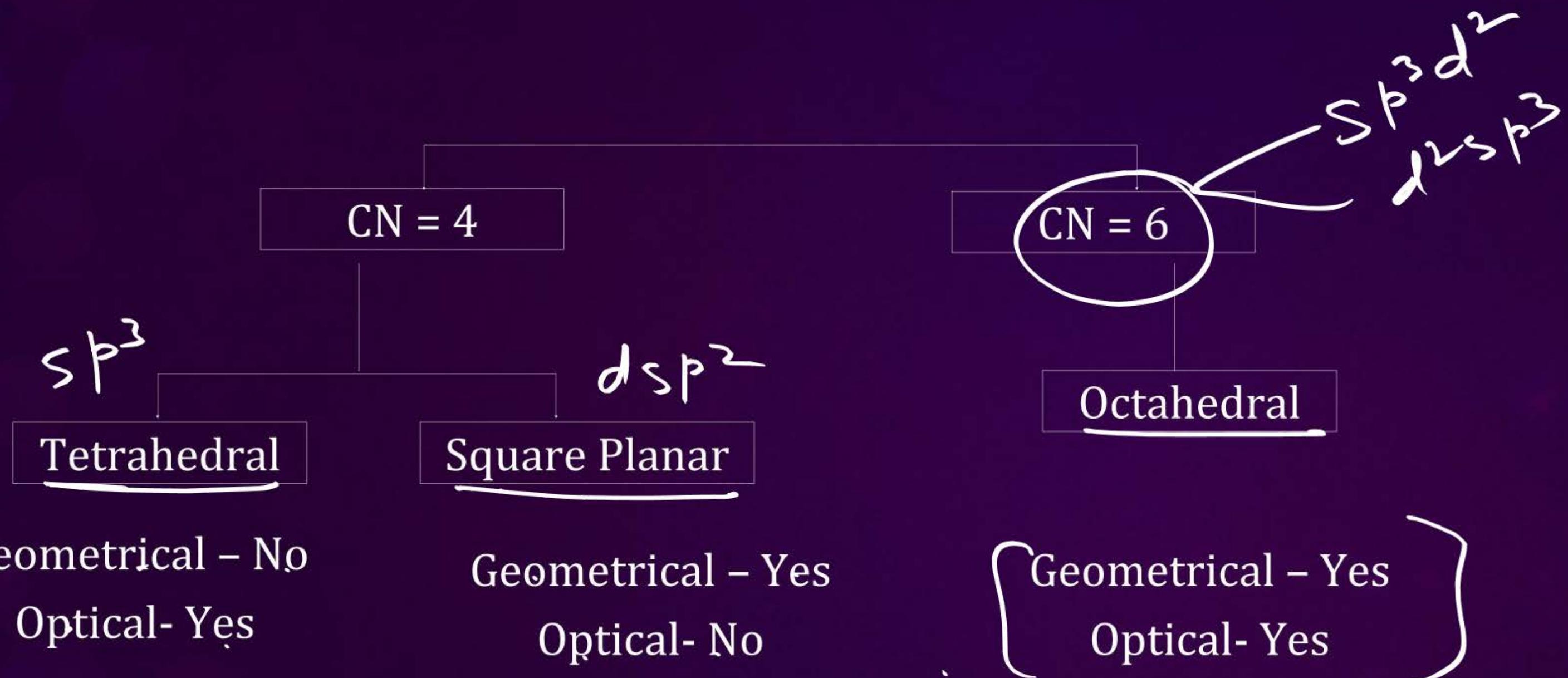
Non Superimposable

mirror image \rightarrow optically

Active

P q

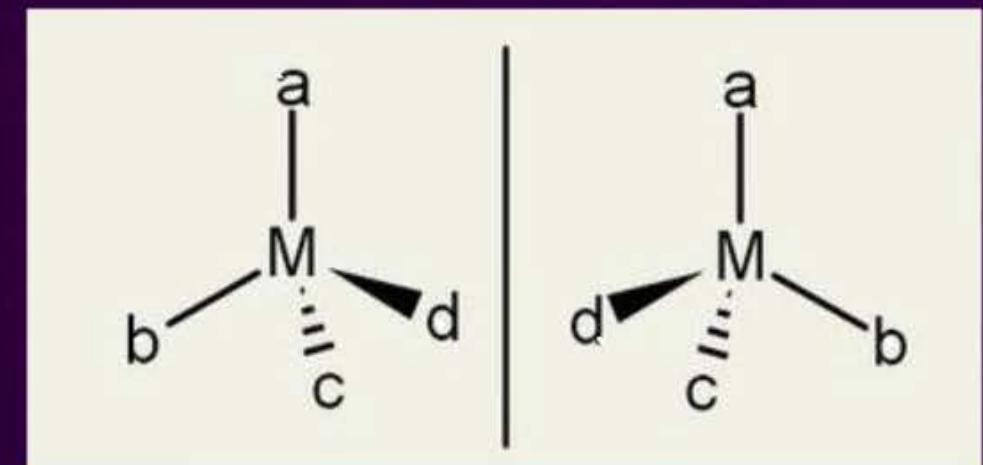
Enantiomer



Case 1 - CN = 4**(a) Tetrahedral Geometry - No Geometrical Isomers**

- ✓ Optical Isomerism - Tetrahedral complexes of the type (M_{abcd}) exhibit optical isomerism.

All ligand
different



Square Planar Geometry -

- Do not show Optical isomerism because of POS
- Geometrical isomerism



(AA) (AA) - NO GI ✓



(AA) (AB) - NO GI ✓



(AA) (BB)
(AB) (AB) - 2 GI



(AA) (BC)
(AB) (AC) - 2 GI

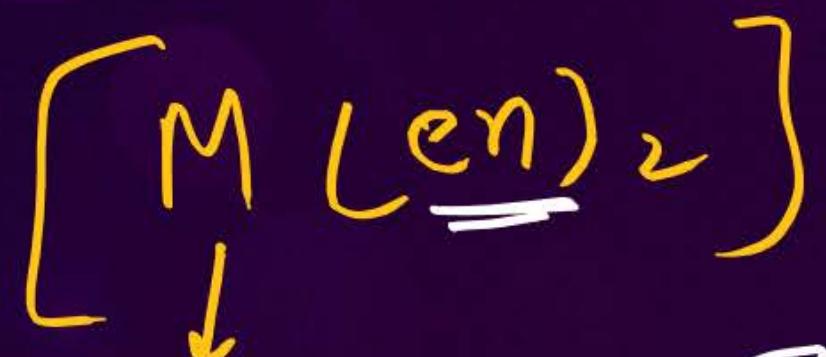


(AB) (CD)
(AC) (BD)
(AD) (BC) - 3 GI
(BC)

Complex	No. of G.I.
$[MA_4]$	0
$[MA_3B]$	0
$[MA_2B_2]$	2
$[MA_2BC]$	2
$[MABCD]$	3
$[M(AA)_2]$	0
$[M(AB)_2]$	2

$M A_4$

$M A_2 B_2$



Symmetrical bidentate ligand.



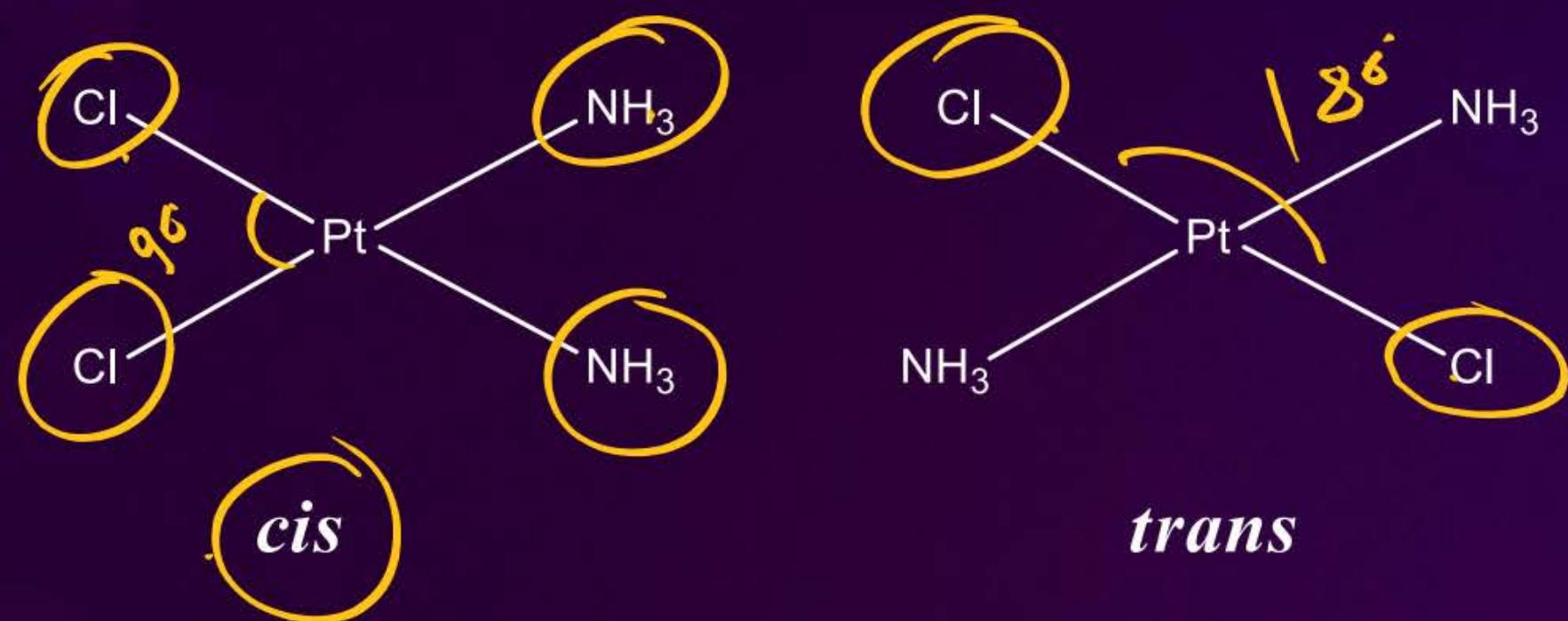
gly



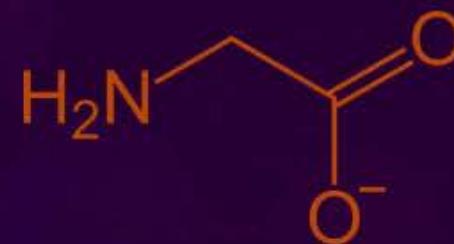
(AB)

unsymmetrical

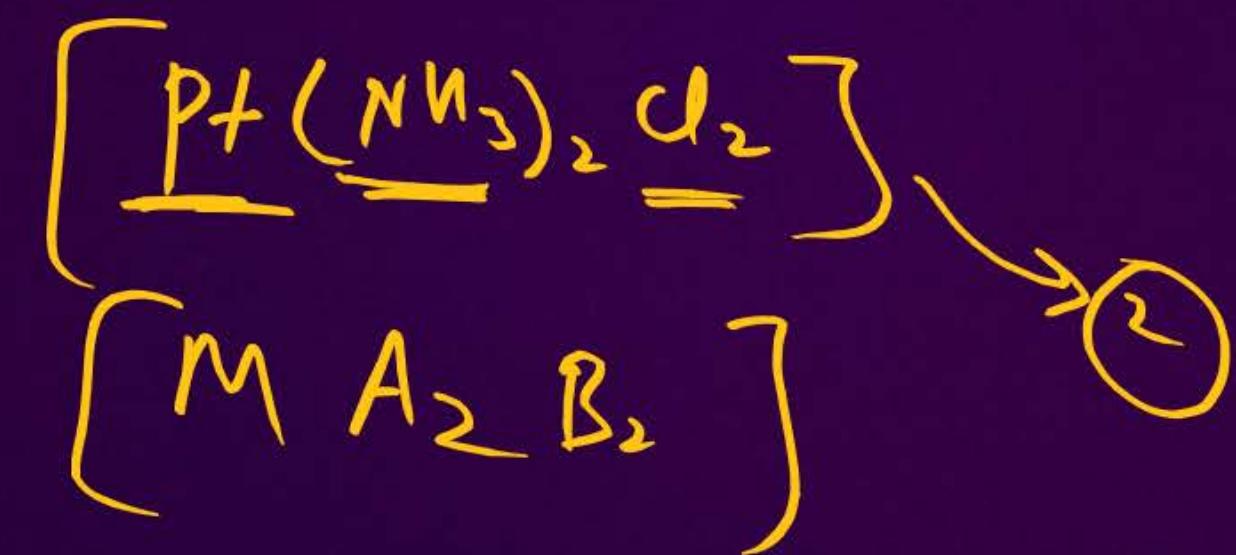
bidentate ligand.



Geometrical isomers (*cis* and *trans*) of $\text{Pt}[(\text{NH}_3)_2\text{Cl}_2]$



Glycinate ligand



$\left[\text{Pt}(\underline{N\text{H}_3})_2 \underline{\text{Cl}} \text{Br} \right]$ no. of GI
 $(M \underline{\text{A}_2 \text{B}_2 \text{C})}$

- (a) 0
- (b) 2
- (c) 3
- (d) none.

$\checkmark \left[Pt(NH_3)_4 Br(Py) \right]$ no. of 4 I Py^a
 M — A — B — C — D

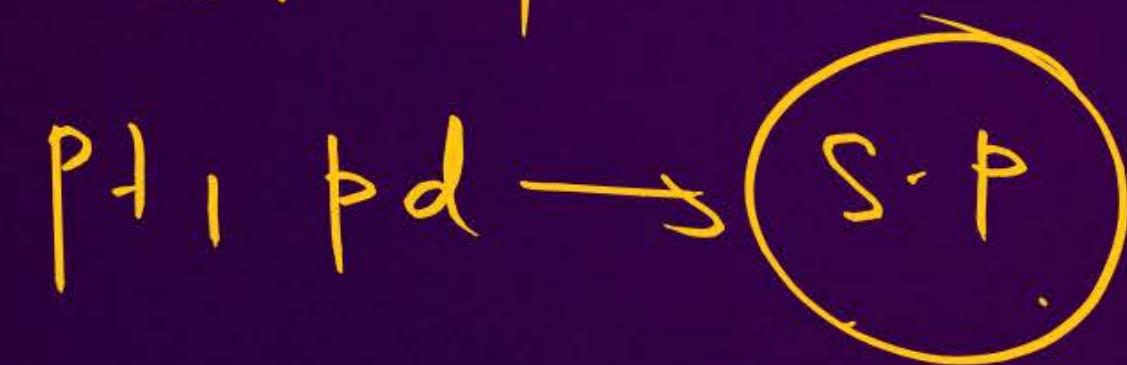
a 2

c 0

d none.

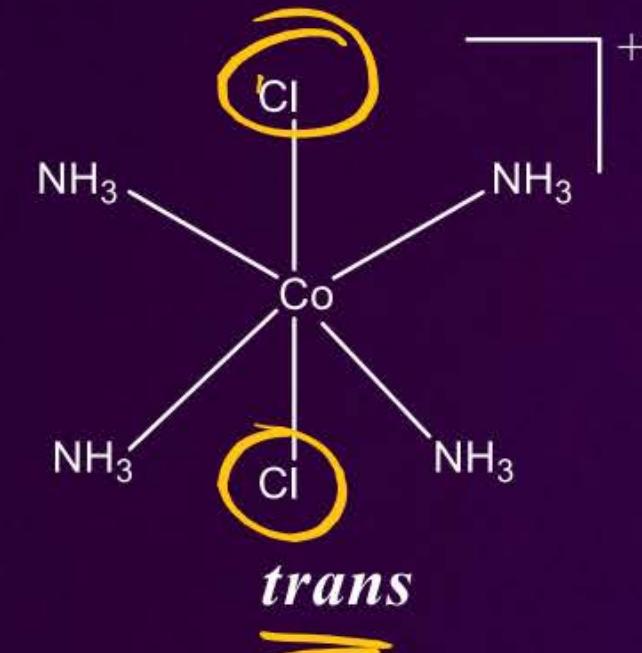
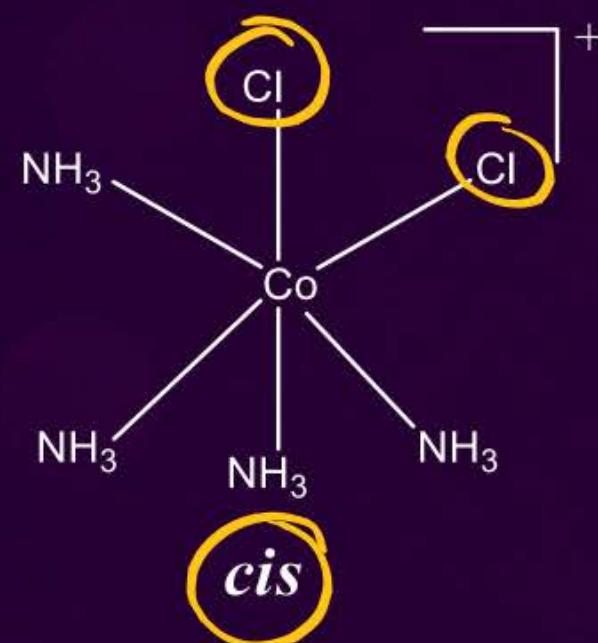


Bkt $CN = 4$



Case 2 - CN = 6

(a) Octahedral Geometry



Geometrical isomers (*cis* and *trans*)
of $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$

[M A₄ B₂]

Complex	No. of G.I.
$[\text{MA}_6]$	0
$[\text{MA}_5\text{B}]$	0
$[\text{MA}_4\text{B}_2]$	2
$[\text{MA}_4\text{BC}]$	2
$[\text{MA}_3\text{B}_3]$	2
$[\text{MA}_3\text{B}_2\text{C}]$	3
$[\text{MA}_3\text{BCD}]$	4
$[\text{MA}_2\text{B}_2\text{C}_2]$	5
$[\text{MA}_2\text{B}_2\text{CD}]$	6
$[\text{MA}_2\text{BCDE}]$	9
$[\text{MABCDEF}]$	15

Case 2 - CN = 6

(a) Octahedral Geometry

[MA₆] (AA) (AA) (AA) - NO GI

[MA₅B] (AA) (AA) (AB) - NO GI

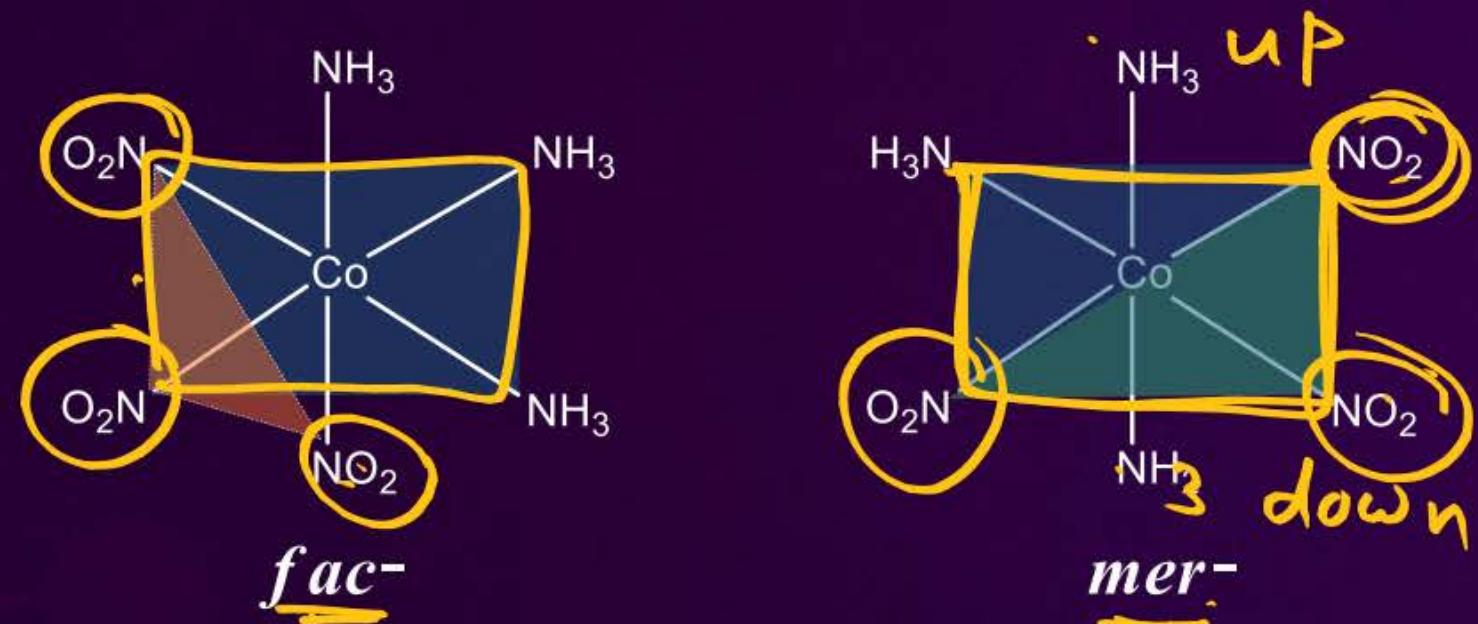
[MA₄B₂] (AA) (AA) (BB) →
 (AA) (AB) (AB)

[MA₄BC] (AA) (AA) (BC)
 (AA) (AB) (AC)

Complex	No. of G.I.
[MA ₆]	0
[MA ₅ B]	0
[MA ₄ B ₂]	2
[MA ₄ BC]	2
[MA ₃ B ₃]	2
[MA ₃ B ₂ C]	3
[MA ₃ BCD]	4
[MA ₂ B ₂ C ₂]	5
[MA ₂ B ₂ CD]	6
[MA ₂ BCDE]	9
[MABCDEF]	15

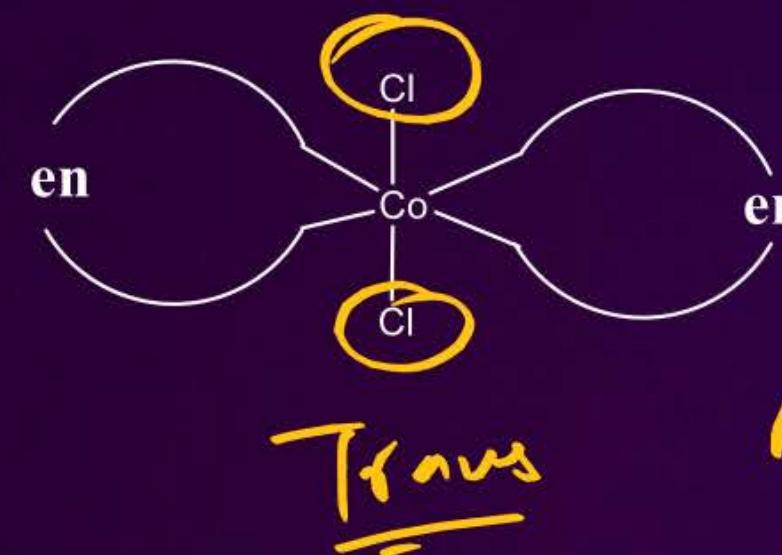
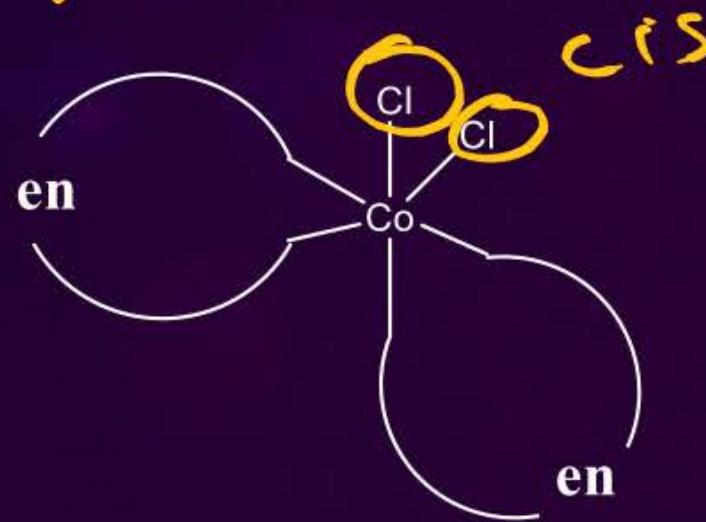
Total number of geometrical isomers of complex type Ma_3b_3

Complex type	Total number of geometrical isomers	
Ma_3b_3	2	(AA) (AB) (BB) (AB) (AB) (AB)

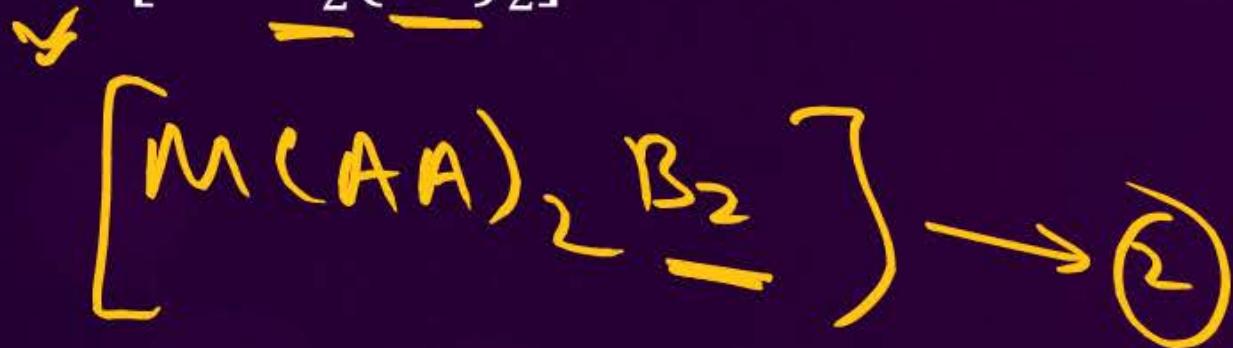


The facial (*fac*) and meridional (*mer*) isomers of $[\text{Co}(\text{NH}_3)_3(\text{NO}_2)_3]$

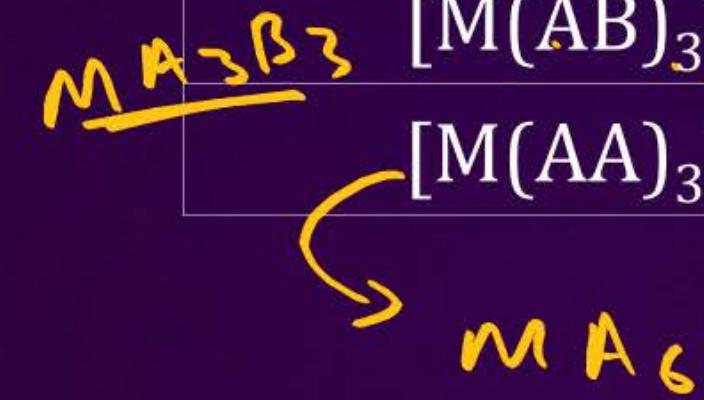
$\beta\beta\gamma$

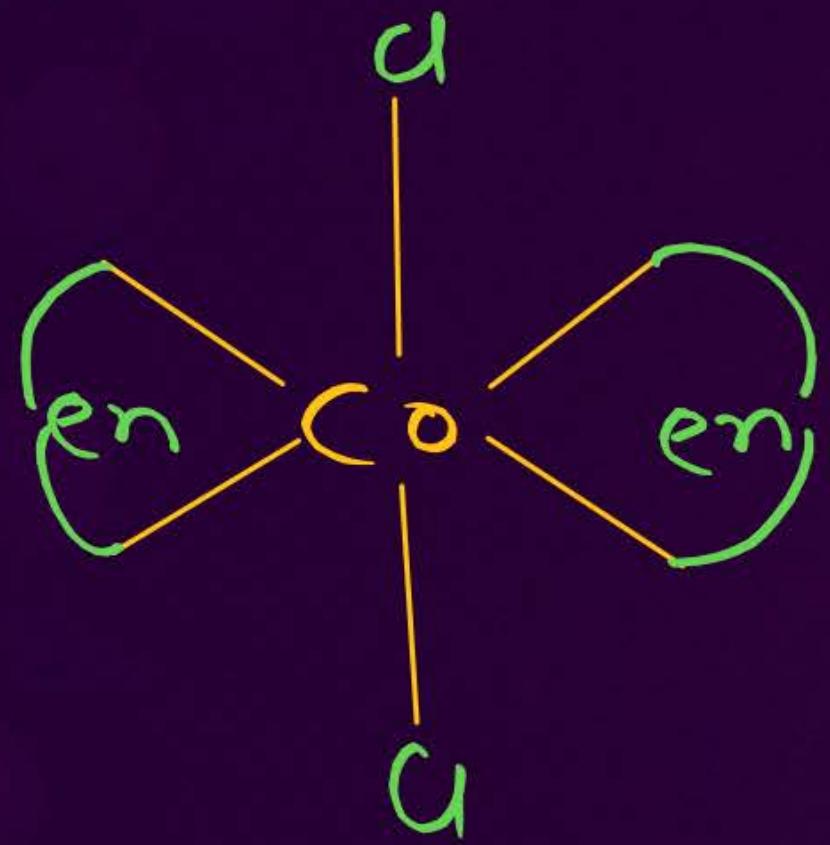


Geometrical isomers (*cis* and *trans*)
of $[\text{CoCl}_2(\text{en})_2]$

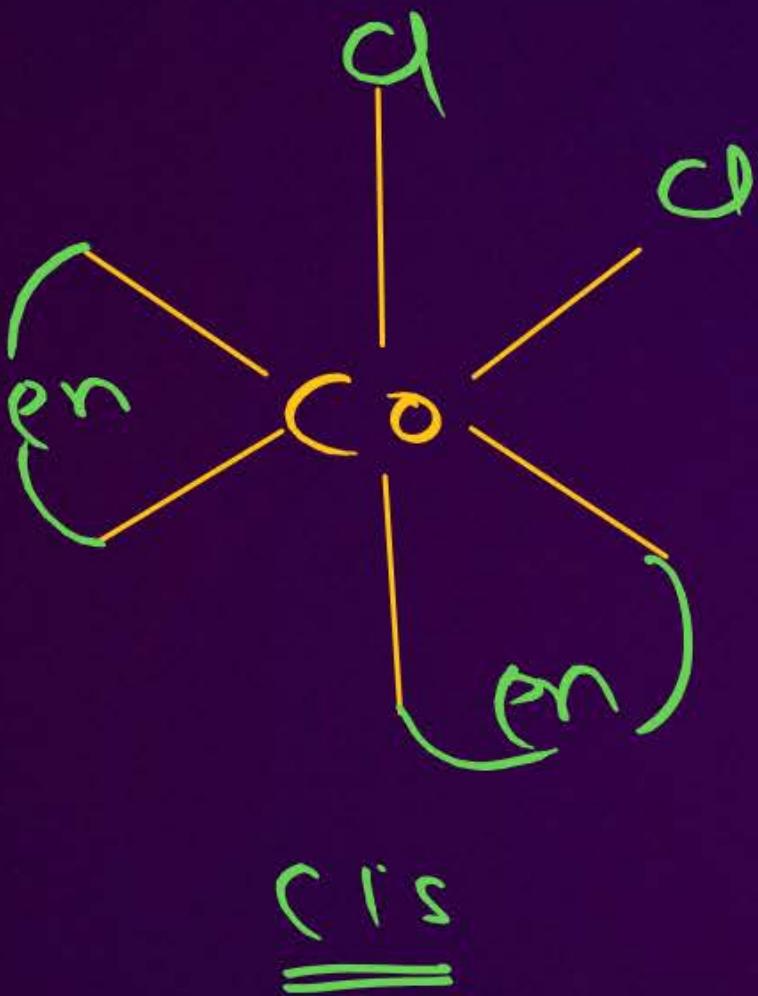


Complex	No. of G.I.
$[\text{M}(\text{AA})_2 \underline{\text{B}}_2]$	2
$[\text{M}(\text{AA})_2 \underline{\text{BC}}]$	2
$[\text{M}(\text{AB})_3]$	2
$[\text{M}(\text{AA})_3]$	0





Trans.

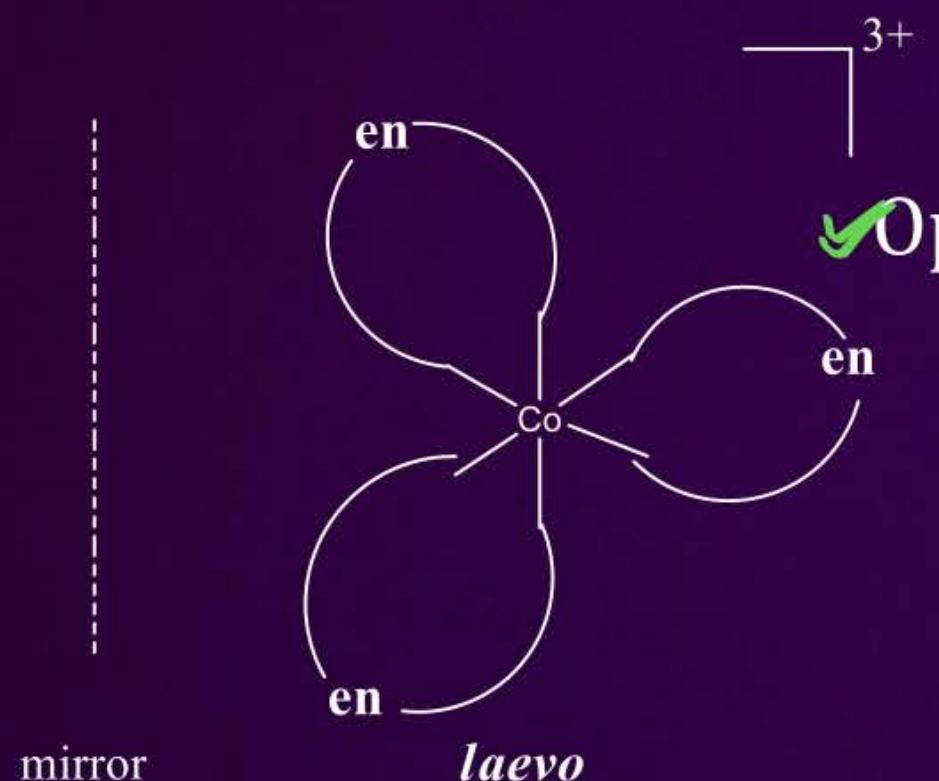
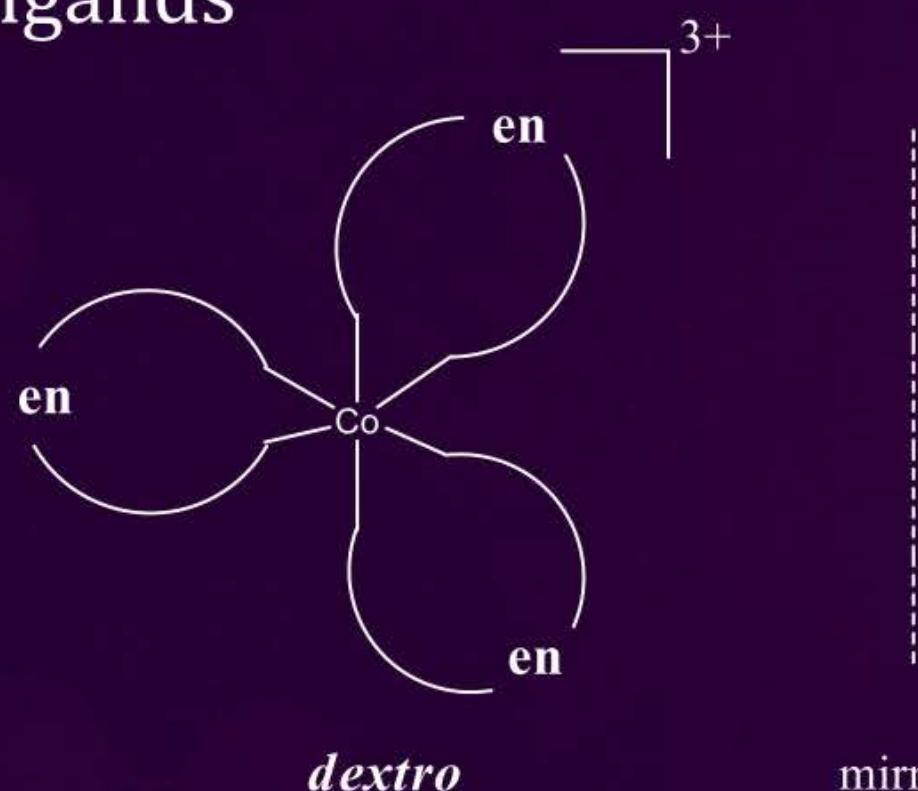


cis

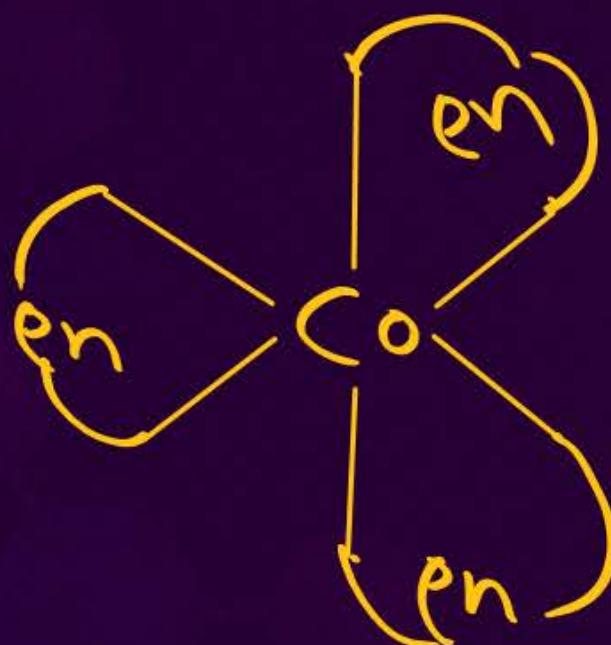
KeyNote

✓ Square planar complexes do not show optical isomerism.

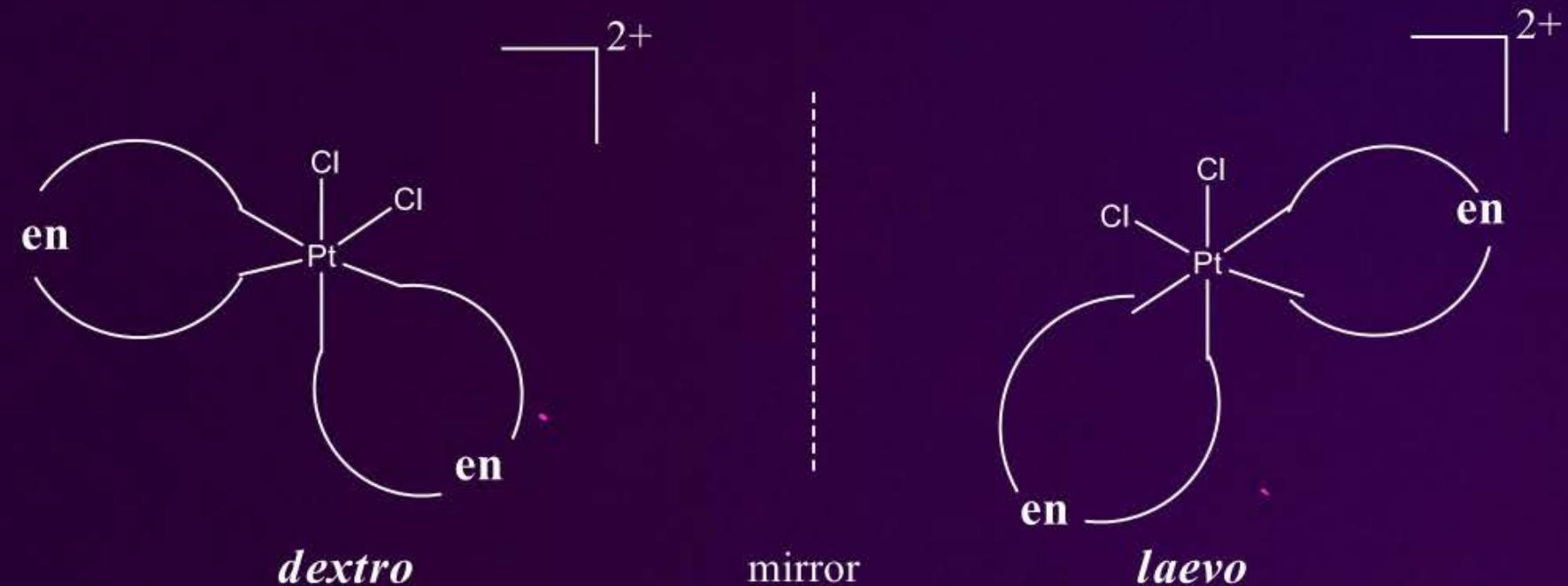
✓ Optical isomerism is common in octahedral complexes involving didentate ligands



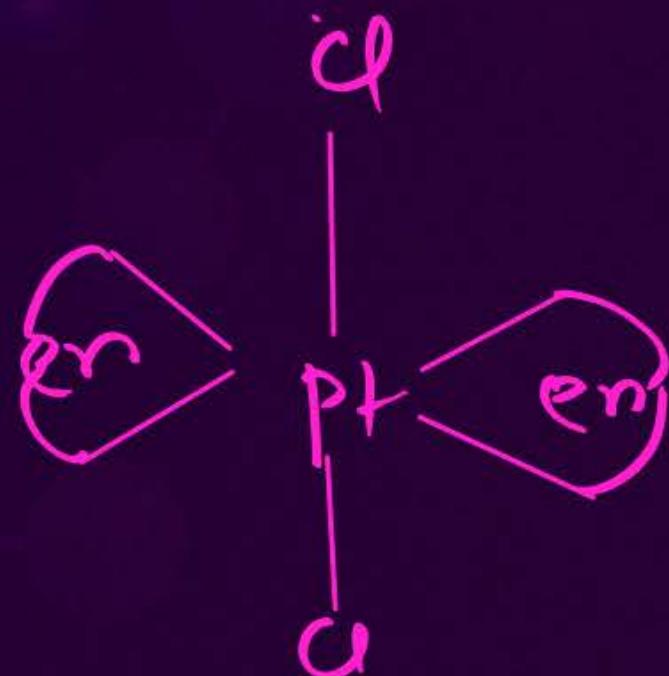
✓ Optical isomer (d and l) of $[\text{Co}(\text{en})_3]^{3+}$



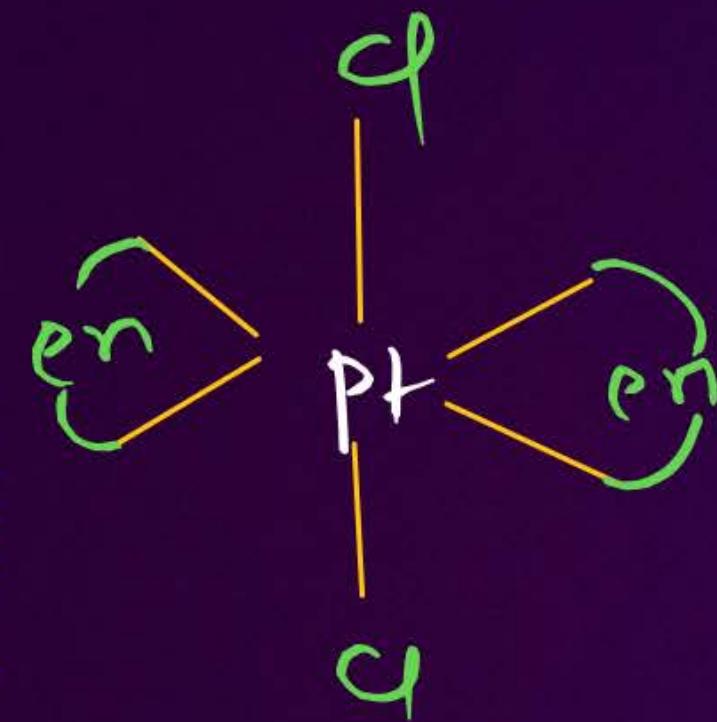
- In a coordination entity of the type $[\text{PtCl}_2(\text{en})_2]^{2+}$, only the cis-isomer shows optical activity



Optical isomer (d and l) of cis-[PtCl₂(en)₂]²⁺



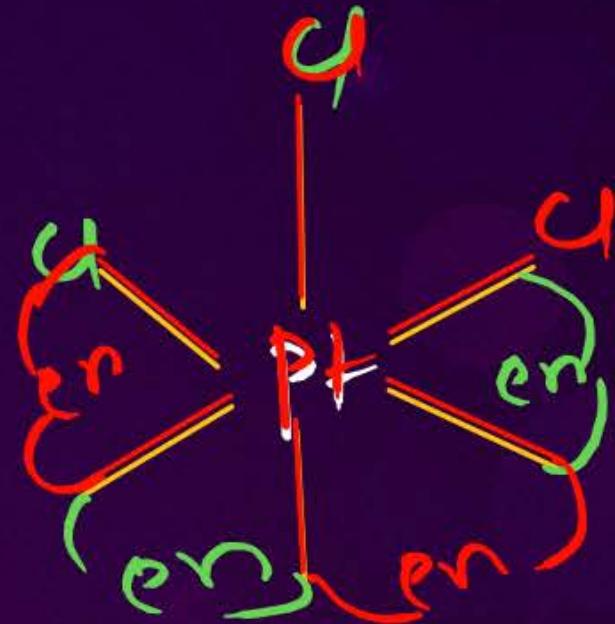
Trans
optically
Inactive.

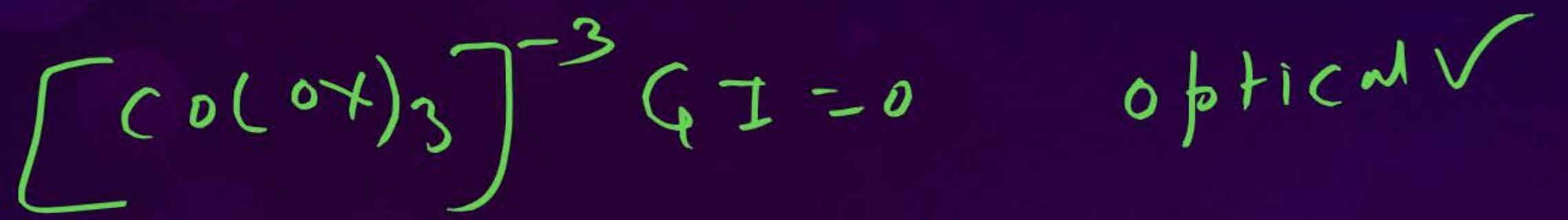


Superimposable.



Non superimposable
Optically Active.



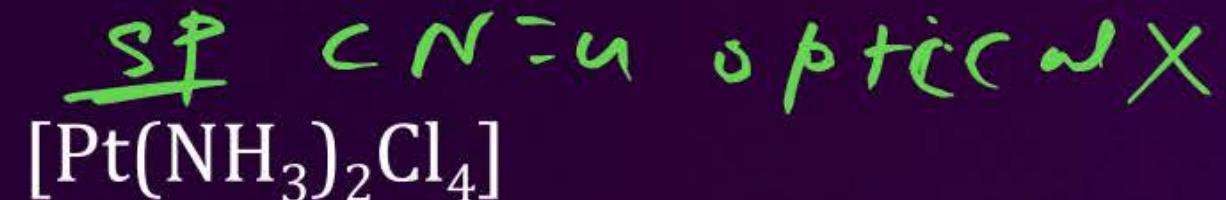


Trans optical X

Question

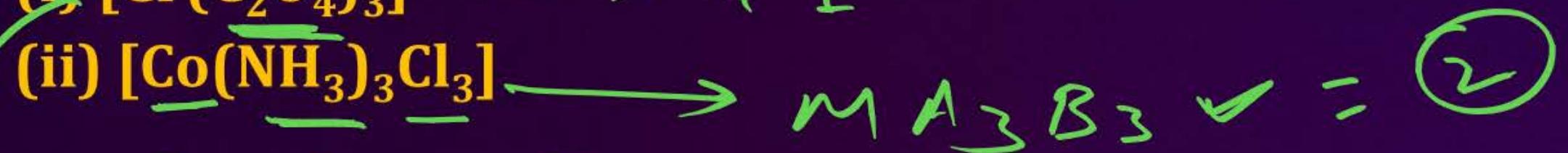
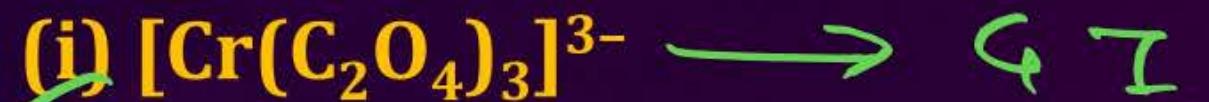
Which of the following complex will show geometrical as well as optical isomerism?

(en = ethylene diamine)

A**B****C****D**

Question - NCERT ✓

How many geometrical isomers are possible in the following coordination entities?



Question

Why is geometrical isomerism not possible for tetrahedral complexes? 



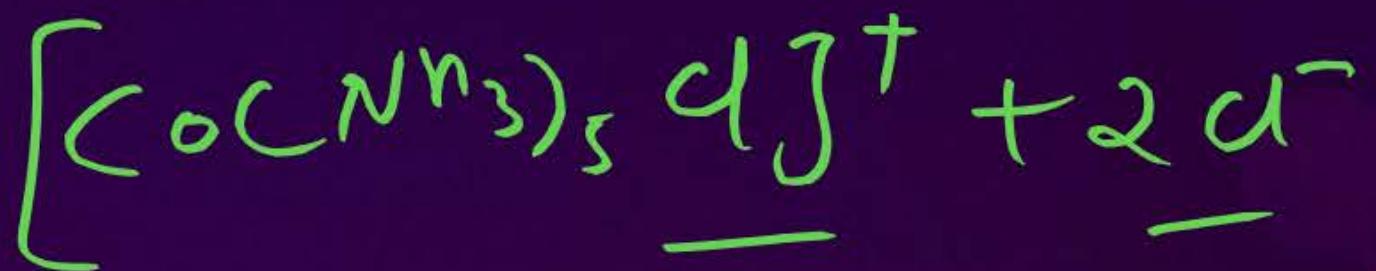
All bond Angles are Same.

109°28'

CBSE QUESTIONS BANK

How many ions are produced from the complex $[\text{Co}(\text{NH}_3)_5\text{Cl}] \text{Cl}_2$ in solution?

- A 4
- B 2
- C 3
- D 5



CBSE QUESTIONS BANK

The formula of the coordination compound tetra ammine aquachloridocobalt(III) chloride is

A



B



C



D



CBSE QUESTIONS BANK

In $[\text{Fe}(\text{CN})_6]^{4-}$ and $[\text{Fe}(\text{CN})_6]^{3-}$ number of unpaired electrons is, respectively

A 4, 5

B 0, 1

C 5, 4

D 1, 2

CBSE QUESTIONS BANK

The oxidation state of Ni in $[\text{Ni}(\text{CO})_4]$ is

A 0

B 2

C 3

D 4

Question



Coordination number of Ni in $[\text{Ni}(\text{C}_2\text{O}_4)_3]^{4-}$ is

A 3

B 4

C 5

D 6

Question



Which of the following compounds exhibits linkage isomerism?



Question



Ethylene diamine is an example of a _____ ligand.

- A monodentate
- B bidentate
- C tridentate
- D hexadentate

Question



How many EDTA molecules are required to make an octahedral complex with a Ca^{2+} ion?

A Six

B Three

C One

D Two

Question



Which one will give Fe^{3+} ions in solution?

A



B



C



D



Question



What is the coordination number of Cr in $K_3[Cr(ox)_3]$?

A 6

B 5

C 4

D 3

Question



What is the oxidation state of iron in $K_4[Fe(CN)_6]$?

A 6+

B 4+

C 3+

D 2+

Question



What is the value of x on the $[\text{Ni}(\text{CN})_4]^x$ complex ion?

A +2

B -2

C 0

D +4

Question



The oxidation state of Ni in $\text{Ni}(\text{CO})_4$ is:

- A** 0
- B** 1
- C** 2
- D** 4

Question



The EAN of cobalt in the complex ion $[\text{Co}(\text{en})_2\text{Cl}_2]^+$ is:

- A 27
- B 36
- C 33
- D 35

Question



The formula of the complex tris (ethylene diamine) cobalt (III) sulphate is:

- A** $[\text{Co}(\text{en})_2\text{SO}_4]$
- B** $[\text{Co}(\text{en})_3\text{SO}_4]$
- C** $[\text{Co}(\text{en}_3)]_2\text{SO}_4$
- D** $[\text{Co}(\text{en})_3]_2(\text{SO}_4)_3$

Question

The IUPAC name for the complex $[\text{Co}(\text{NH}_3)_5(\text{NO}_2)]\text{Cl}_2$ is:

- A** Nitrio-N-pentaammine cobalt (III) chloride
- B** nitrio-N-pentaamine cobalt (II) chloride
- C** pentaammine nitrito-N-cobalt (II) chloride
- D** pentaammine nitrito-N-cobalt (III) chlorid

Question



The IUPAC name of $\text{Ni}(\text{CO})_4$ is:

A tetracarbonyl nickelate (0)

B tetracarbonyl nickelate (II)

C tetracarbonyl nickel (0)

D tetracarbonyl nickel (II)

Question

The number of chloride ions which would be precipitated, when $\text{CrCl}_3 \cdot 4\text{NH}_3$ is treated with silver nitrate solution.

- A** 3
- B** 2
- C** 1
- D** 0

Question



$[\text{Co}(\text{NH}_3)_5\text{Br}]\text{SO}_4$ and $[\text{Co}(\text{NH}_3)_5\text{SO}_4]\text{Br}$ are related to each other as:

- A** ionisation isomers
- B** linkage isomers
- C** coordination isomers
- D** geometrical isomers

Question



Mohr's salt is

- A** $\text{Fe}(\text{NH}_4)\text{SO}_4 \cdot 6\text{H}_2\text{O}$
- B** $\text{Fe}(\text{NH}_4)_2 (\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$
- C** $(\text{NH}_4)_2\text{SO}_4 \cdot \text{FeSO}_4 \cdot 6\text{H}_2\text{O}$
- D** $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$

Question



According to Werner's theory

- A** Primary valency can be ionized
- B** Secondary valency can be ionized
- C** Primary and secondary valencies both cannot be ionized
- D** Only primary valency cannot be ionized

Question



An aqueous solution of potash alum gives

- A** Two types of ions
- B** Only one type of ion
- C** Four types of ions
- D** Three types of ions

Question



The correct IUPAC name of potassium cuprochloride is

- A** Potassium copper (I) tetrachloride
- B** Potassium tetrachlorocuprate (I)
- C** Tetrachloropotassium cuprate (I)
- D** Tetrachlorocopper (I) potassiate

Question



$[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{NO}_2$ and $[\text{Co}(\text{NH}_3)_4\text{Cl}\cdot\text{NO}_2]\text{Cl}$ are _____ isomers

- A** Geometrical
- B** Optical
- C** Linkage
- D** Ionization

Question



Which of the following compounds is colourless

A



B



C



D



Question



Which of the following will not give a precipitate with AgNO_3 ?

- A** $[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$
- B** $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$
- C** $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$
- D** $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$

Question



Which of the following species will be diamagnetic?

- A** $[\text{Fe}(\text{CN})_6]^{3-}$
- B** $[\text{FeF}_6]^{3-}$
- C** $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$
- D** None of the above

Question



Which one of the following complexes is not expected to exhibit isomerism?

A



B



C



D



Question



Which of the following compounds shows optical isomerism?

- A** $[\text{Cu}(\text{NH}_3)_4]^{2+}$
- B** $[\text{ZnCl}_4]^{2-}$
- C** $[\text{Cr}(\text{C}_2\text{O}_4)_3]^{3-}$
- D** $[\text{Co}(\text{CN})_6]^{3-}$

Question

Among $[\text{Ni}(\text{CO})_4]$, $[\text{Ni}(\text{CN})_4]^{2-}$, $[\text{NiCl}_4]^{2-}$ species, the hybridization states at the Ni atom are, respectively

- A** $\text{sp}^3, \text{sp}^3, \text{dsp}^2$
- B** $\text{dsp}^2, \text{sp}^3, \text{sp}^3$
- C** $\text{sp}^3, \text{dsp}^2, \text{dsp}^2$
- D** $\text{sp}^3, \text{dsp}^2, \text{sp}^3$

Question

$[\text{Co}(\text{NH}_3)_5\text{NO}_2]\text{Cl}_2$ and $[\text{Co}(\text{NH}_3)_5\text{ONO}]\text{Cl}_2$ are related to each other as:

- A geometrical isomers
- B linkage isomers
- C coordination isomers
- D ionisation isomers

Question



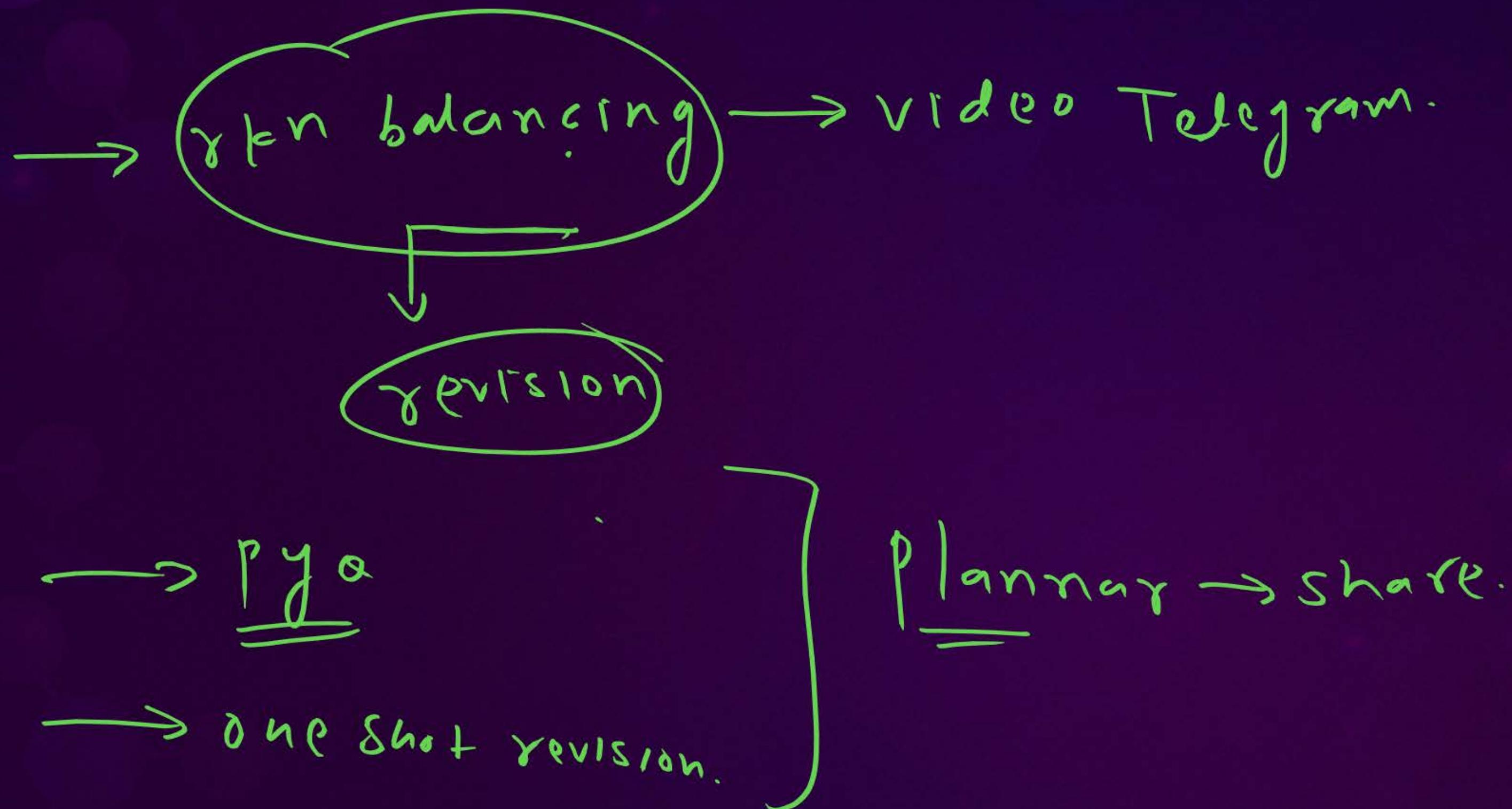
An octahedral complex is formed when central metal atom undergoes hybridization amongst the orbitals:

A sp^3

B dsp^2

C sp^3d

D sp^3d^2



Home Work

→ DPP

→ PY^o