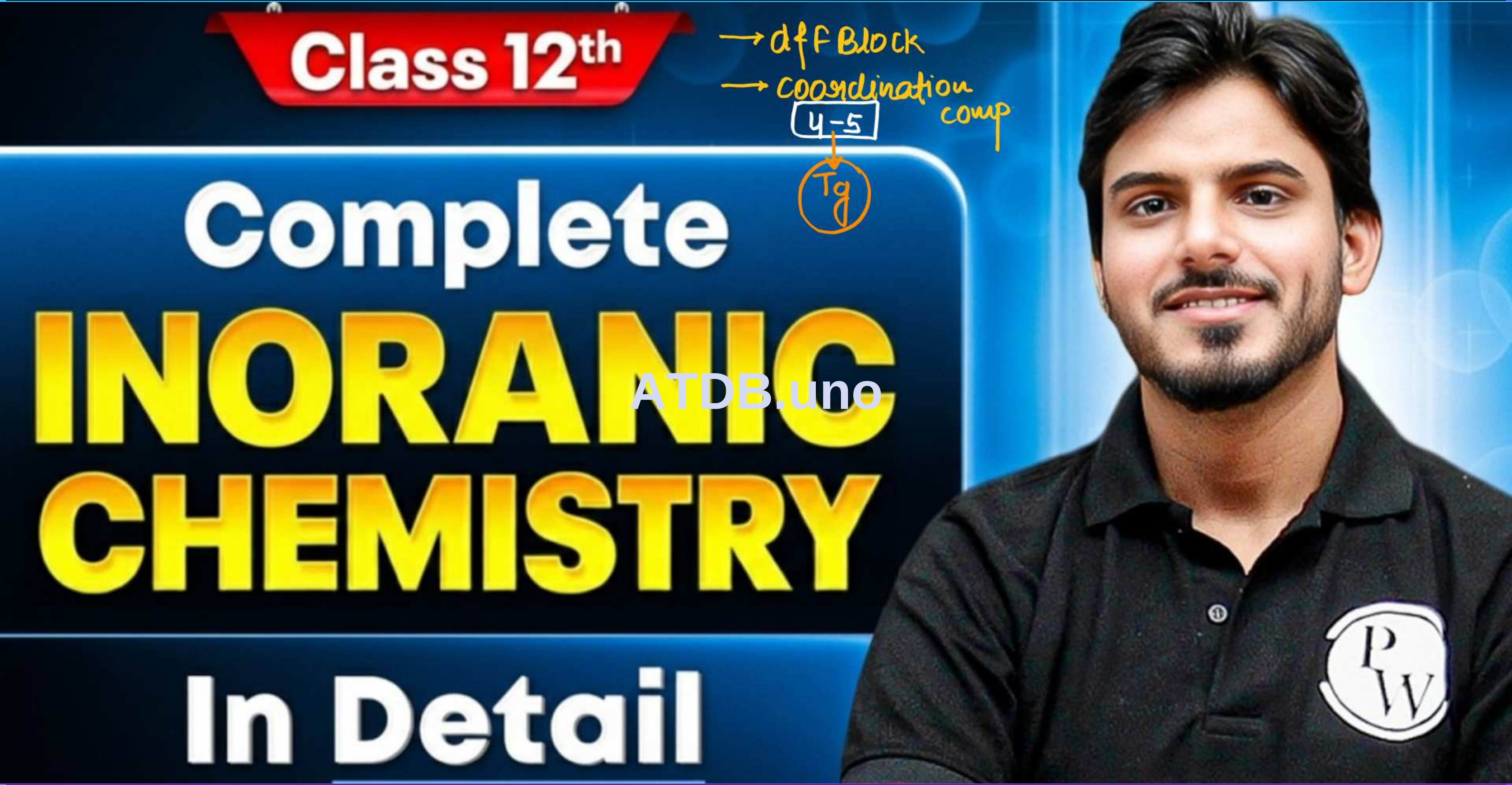


Class 12th

Complete INORANIC CHEMISTRY In Detail

Notes
Imp. Ques.

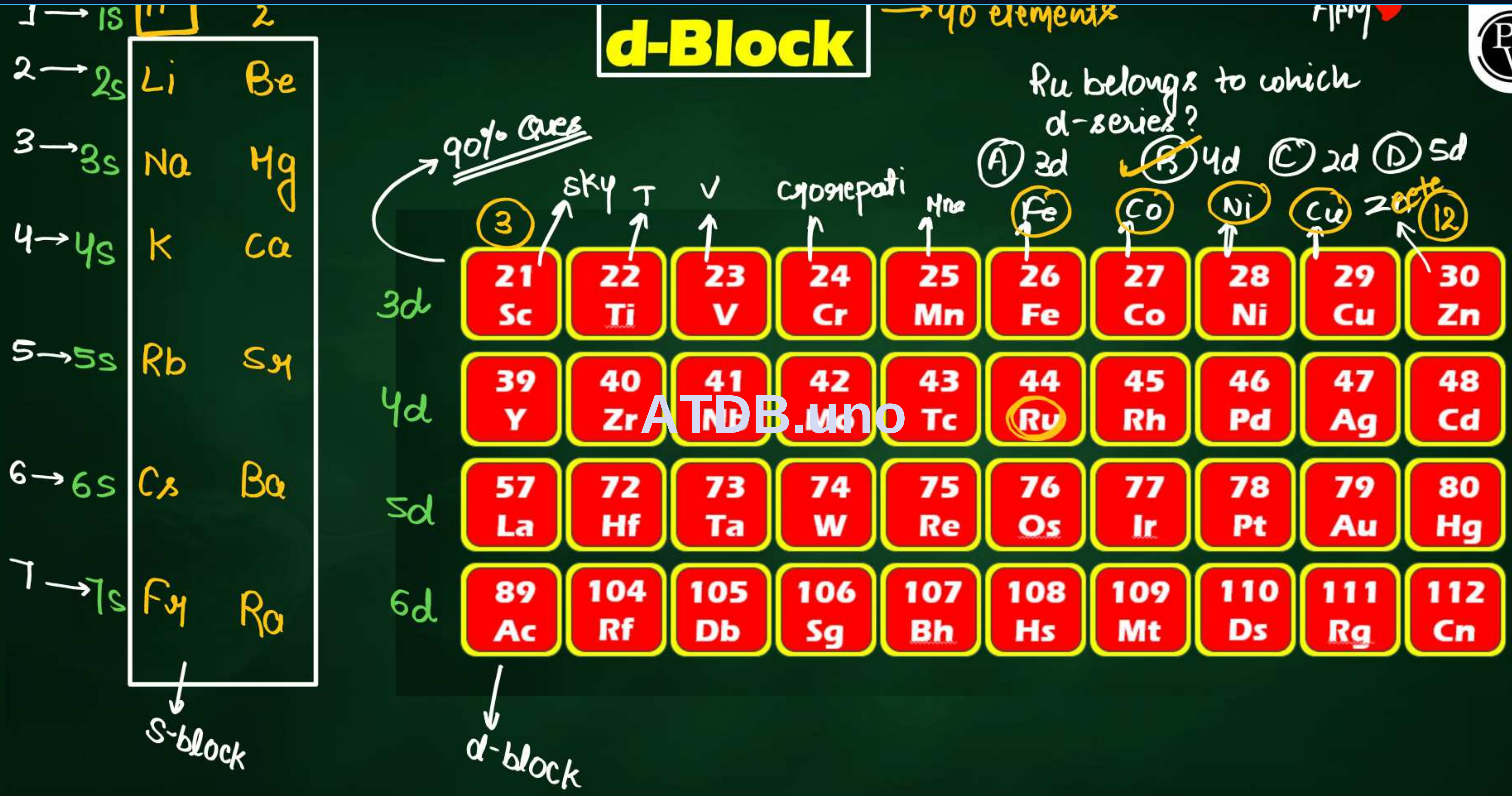
C

@CHEMISTRY_BY_AAKASH_TYAGI_SIR

Break
15 min
↓
2:40
class will
Resume

d-Block

→ 40 elements



Ru belongs to which d-series?
Ⓐ 3d ~~Ⓑ~~ ✓ 4d Ⓒ 2d Ⓓ 5d

90% Ques

1 → 1s H 2
2 → 2s Li Be
3 → 3s Na Mg
4 → 4s K Ca
5 → 5s Rb Sr
6 → 6s Cs Ba
7 → 7s Fr Ra

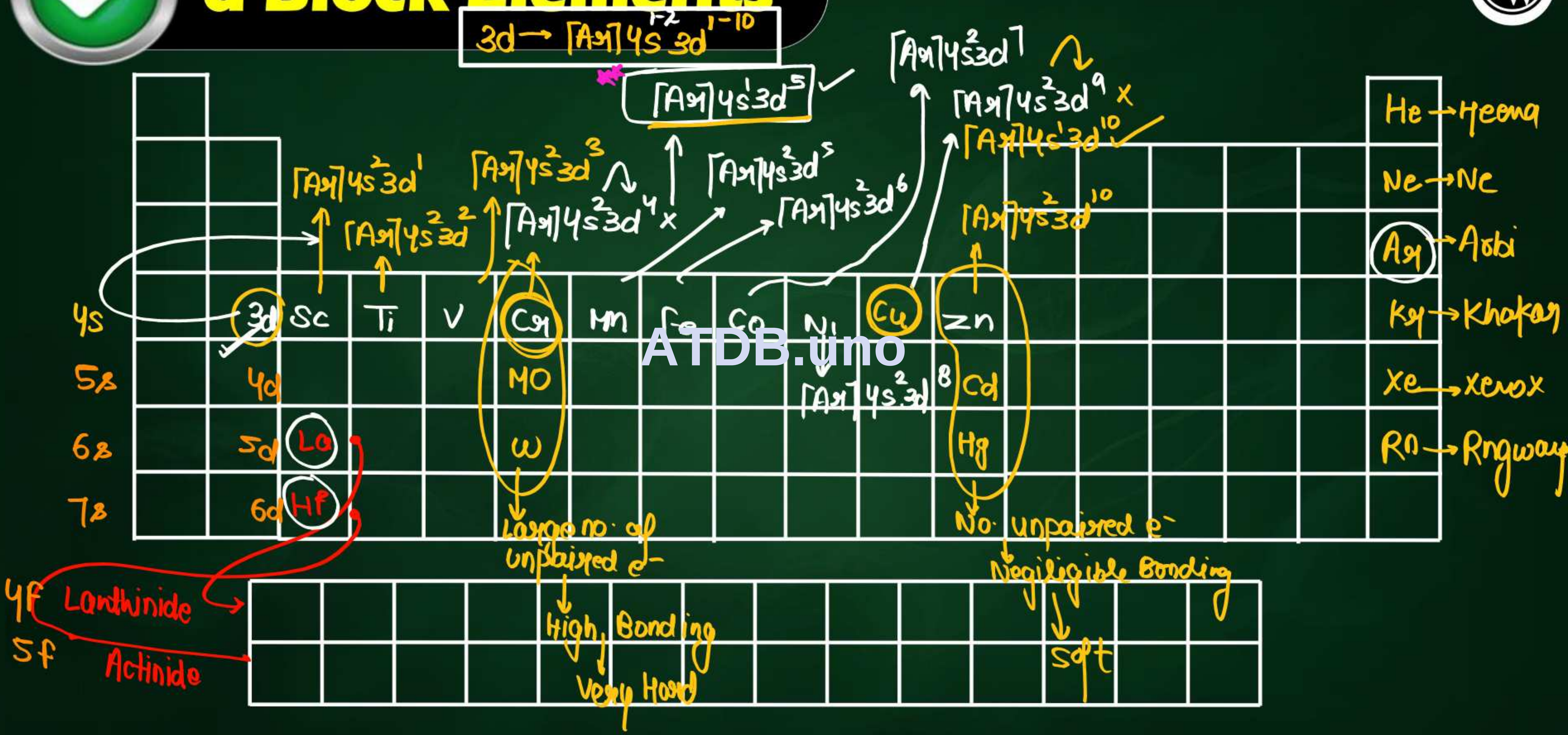
S-block

③ sky T V crorepati Mna Fe Co Ni Cu Zn ⑫

3d	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn
4d	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd
5d	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg
6d	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn

d-block

d Block Elements



Que which of the following shows exceptional behav. in Electronic Config ?

Ⓐ Zn, Cr

Ⓑ Cu, Fe

Ⓒ Cu, Cr

Ⓓ None of these

APM A|B|C|D

General E.C of d-block

$$\boxed{[\ \ ]ns^{1-2}(n-1)d^{1-10}}$$

d Block Elements

- **d-block** → Elements in d-block represent change or transition in properties from most electropositive s-block elements to most electronegative p-block elements. Therefore, these elements are called "Transition elements".

- **Transition Elements** → Elements whose outermost shell is partially filled d orbitals either in ground state or in ionic form are only called as Transition Elements, that's why Zn, Cd, Hg are not transition metals or called as Pseudo Transition metals.

Account for the following:
Zn, Cd, Hg are considered as d-block elements but not as transition elements. (1/5, 2020)

This is due to the reason that they do not have partially filled d-orbitals in their ground or ionic state.

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Some Important Basic points

$\boxed{\uparrow}$ $\boxed{\uparrow}$ → covalent Bonding

- Half/fully filled orbitals are more stable as compared to generally filled.
- **No. of Unpaired e-** → Partially filled (d) orbitals (unpaired e^-) $\boxed{\uparrow}$

3d	4s	3d	Unpaired	
$Sc \rightarrow 4s^2 3d^1$	$\boxed{\uparrow\downarrow}$	$\boxed{\uparrow}\boxed{\ }\boxed{\ }\boxed{\ }\boxed{\ }$	1	✓
$Ti \rightarrow 4s^2 3d^2$	$\boxed{\uparrow\downarrow}$	$\boxed{\uparrow}\boxed{\uparrow}\boxed{\ }\boxed{\ }\boxed{\ }$	2	✓
$V \rightarrow 4s^2 3d^3$	$\boxed{\uparrow\downarrow}$	$\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\ }\boxed{\ }$	3	✓
$Cr \rightarrow 4s^1 3d^5$	$\boxed{\uparrow}$	$\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}$	⑥	✓
$Mn \rightarrow 4s^2 3d^5$	$\boxed{\uparrow\downarrow}$	$\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}$	5	✓
$Fe \rightarrow 4s^2 3d^6$	$\boxed{\uparrow\downarrow}$	$\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}$	4	✓
$Co \rightarrow 4s^2 3d^7$	$\boxed{\uparrow\downarrow}$	$\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}$	3	✓
$Ni \rightarrow 4s^2 3d^8$	$\boxed{\uparrow\downarrow}$	$\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}$	2	✓

$Cu \rightarrow 4s^1 3d^{10}$ $\boxed{\uparrow}$ $\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}$ 1 X

$Zn \rightarrow 4s^2 3d^{10}$ $\boxed{\uparrow\downarrow}$ $\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}$ 0 X

Not a Transition element

$Cu^+ \longrightarrow 4s^0 3d^{10}$

$Cu^{2+} \longrightarrow 4s^0 3d^9$

$\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow}$ ✓

$Zn^{2+} \longrightarrow 4s^0 3d^{10}$ X

d-block

↓

1 $\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}$

Fully filled → d^{10}

Half filled → d^5

Gen. Filled → d^3/d^4...

$$\boxed{d^5/d^{10} > d^3/d^4}$$

	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd
Z	39	40	41	42	43	44	45	46	47	48
5s	2	2	1	1	1	1	1	0	1	2
4d	1	2	4	5	6	7	8	10	10	10

Metallic Character

- All the d-block elements are metals, have High M.P. and B.P. are good conductors of electricity, are hard ductile and Malleable (Hg is an exception).

→ Liq at room Temp

- d-block elements shows both metallic and Covalent bonding.

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Metallic → It is due to the presence of [illegible] in outermost shell

Covalent → It is due to the presence of partially filled d-orbital

- More unpaired e in d orbitals → More Covalent/Metallic Bonding

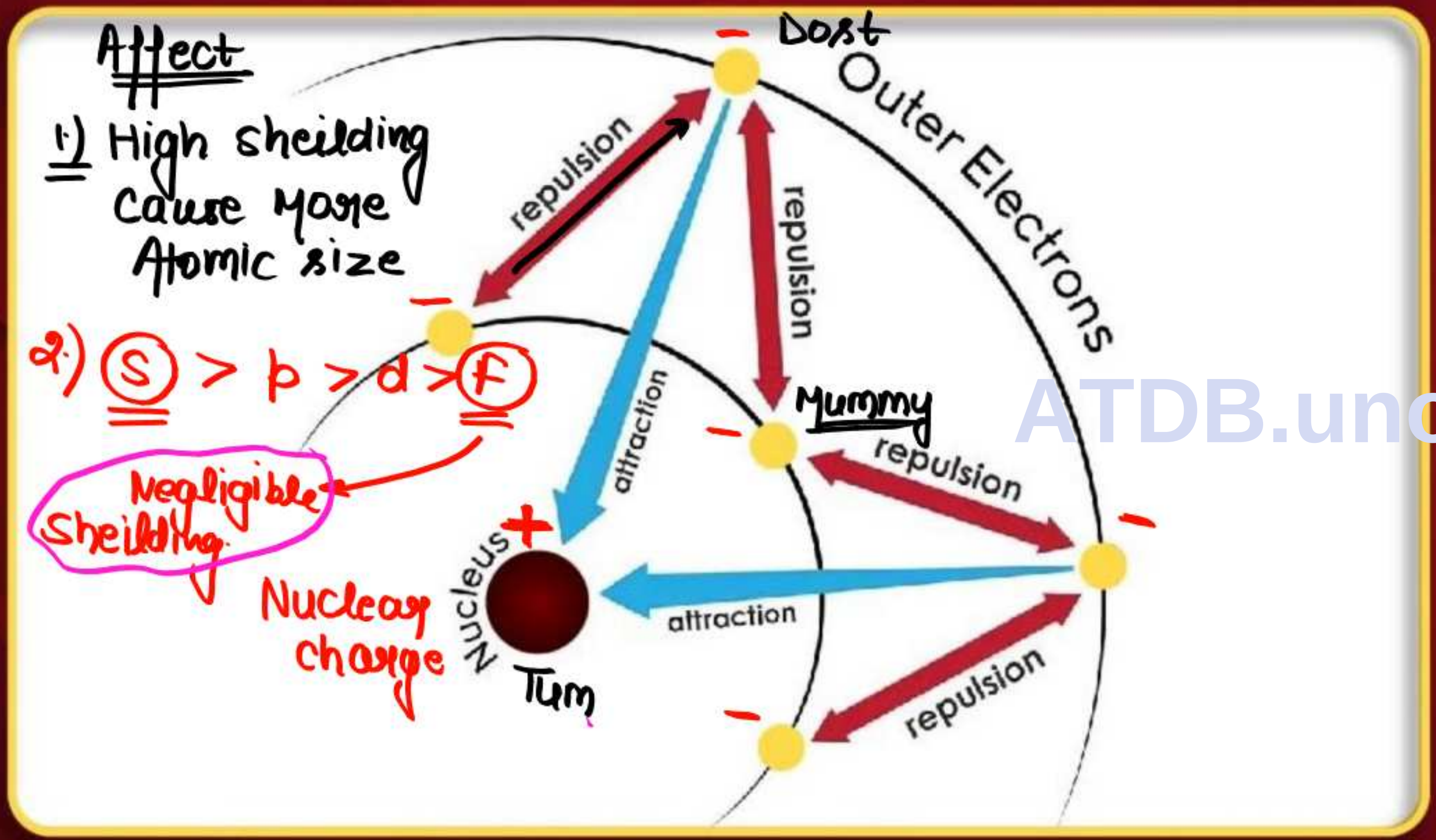
↓

Hard will be the Metal

- Cr, Mo and W are very hard. due to large no. of unpaired e⁻
- Zn, Cd, Hg are very soft due to absence of unpaired e⁻ in d-orbitals.
- Metallic character inc. down the group.

Ark

SHIELDING EFFECT



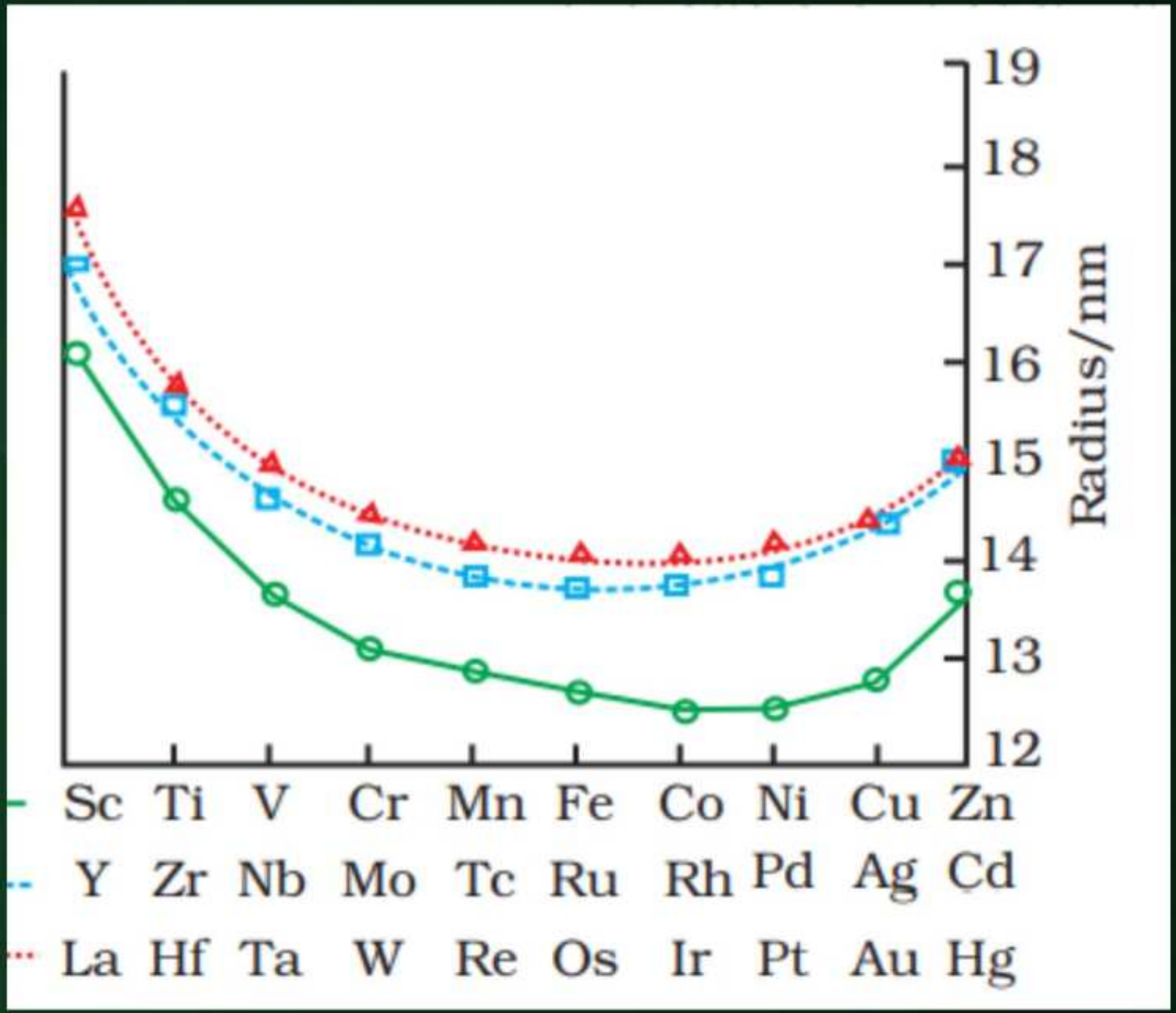
Affect

1) High sheilding Cause More Atomic size

2) s > p > d > f

Negligible Sheilding

Nuclear charge



Atomic Radii

**

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- **Left → Right**

As we move left to right in d-block, firstly size decreases due to increase nuclear charge but from midway when screening due (n – 1)d also increases the effect of inc. nuclear charge got overshadowed by screening effect and then further no change in atomic radii. but at the end due to more S.E in Zn Atomic radii inc.

Ex.

$4s^2 3d^1 > 4s^2 3d^2 > 4s^2 3d^3 > 4s^1 3d^5 \sim 4s^2 3d^5 \sim 4s^2 3d^6 \sim 4s^2 3d^7 \sim 4s^2 3d^8 \sim 4s^1 3d^{10} < 4s^2 3d^{10}$

$Sc_{21} > Ti_{22} > V_{23} > Cr_{24} \sim Mn \sim Fe \sim Co \sim Ni \sim Cu < Zn$

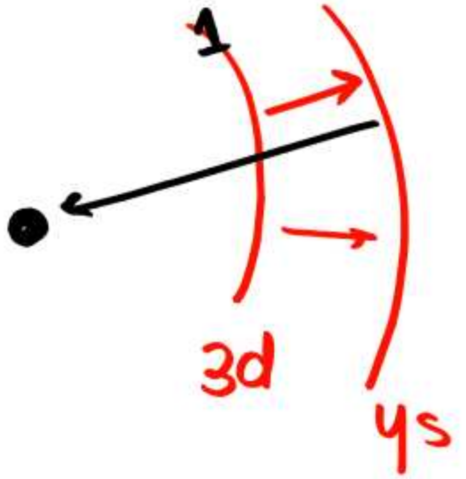
144 132 122 117 117 117 116 115 117 125

dec. constant Inc.

Nuclear Charge > Screening

N.C = S.E

N.C < S.E



Lanthanide Contraction

Top → Bottom

The filling of 4f before 5d orbital results in a regular decrease in atomic radii called Lanthanoid contraction.

No. of shell inc.
× Nuclear charge inc
Screening eff. inc
As a result size inc 3d → 4d

No. of shell inc. ✓
Nuclear charge inc. ✓
Negigibleble S.EX
As a result atomic size remains cons. from 4d → 5d

3d $4s^2 3d^1$	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Mn	27 Co	28 Ni	29 Cu	30 Zn
4d $3d^{10}\ 5s^2 4d^1$	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd
5d $6s^2 4f^{14} 5d$	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg
6d	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn

The net result of the lanthanoid contraction is that the second and the third d series exhibit similar radii (e.g., Zr 160 pm, Hf 159 pm) and have very similar physical and chemical properties

They are hard to seperate.

2. two statements are given - one labelled as Assertion (A) and the other labelled as Reason (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below. (2024)

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

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

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false, but Reason (R) is true.

Assertion (A) : Separation of Zr and Hf is difficult.

Reason (R) : Zr and Hf have similar radii due to lanthanoid contraction.

Melting/Boiling Point **

M·P/B·P ⟹ Hard ⟹ Large no of unpaired e^-
⇓
High Bonding

- As we move Left → Right,

M.P. / B.P. first inc. and then decreases this is due to the fact that initially unpaired e^- in d-orbitals inc. Therefore, more covalent/Metallic bonding Hence strong bond but then further pairing up of d-orbitals taking place. Hence less Metallic bonding & low M.P.

M.P. ⟹ Sc < Ti < V < Cr > Mn > Fe > Co > Ni > cu > Zn

1 2 3 6 5 4 3 2 1 0

E·C of Mn ⟹ $4s^2 3d^5$
Due to its Half filled configuration it is Highly stable

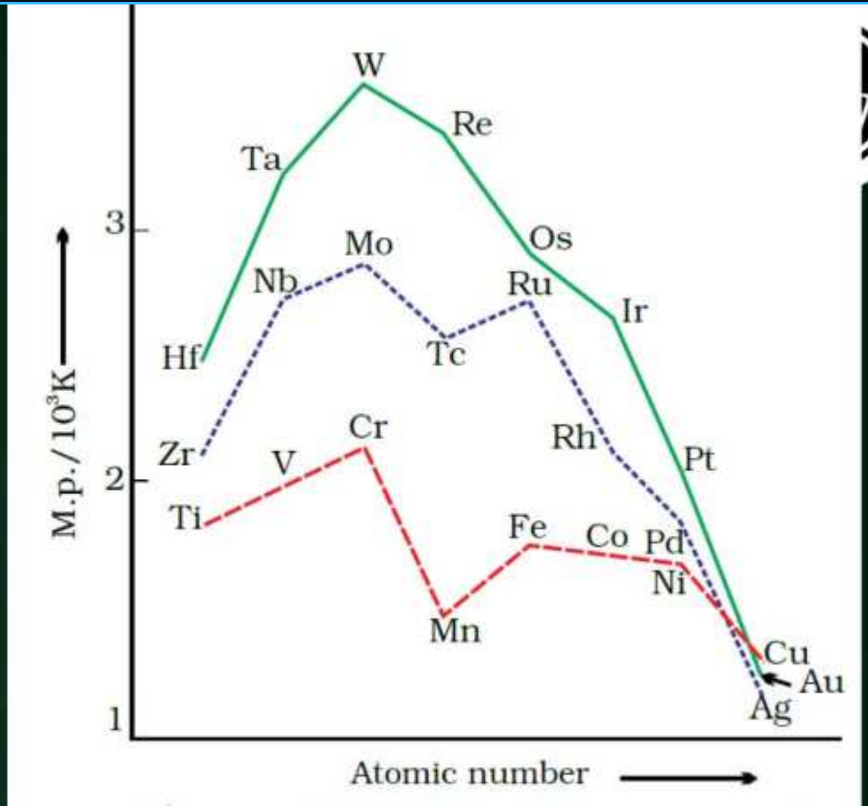


Fig. 4.1: Trends in melting points of transition elements

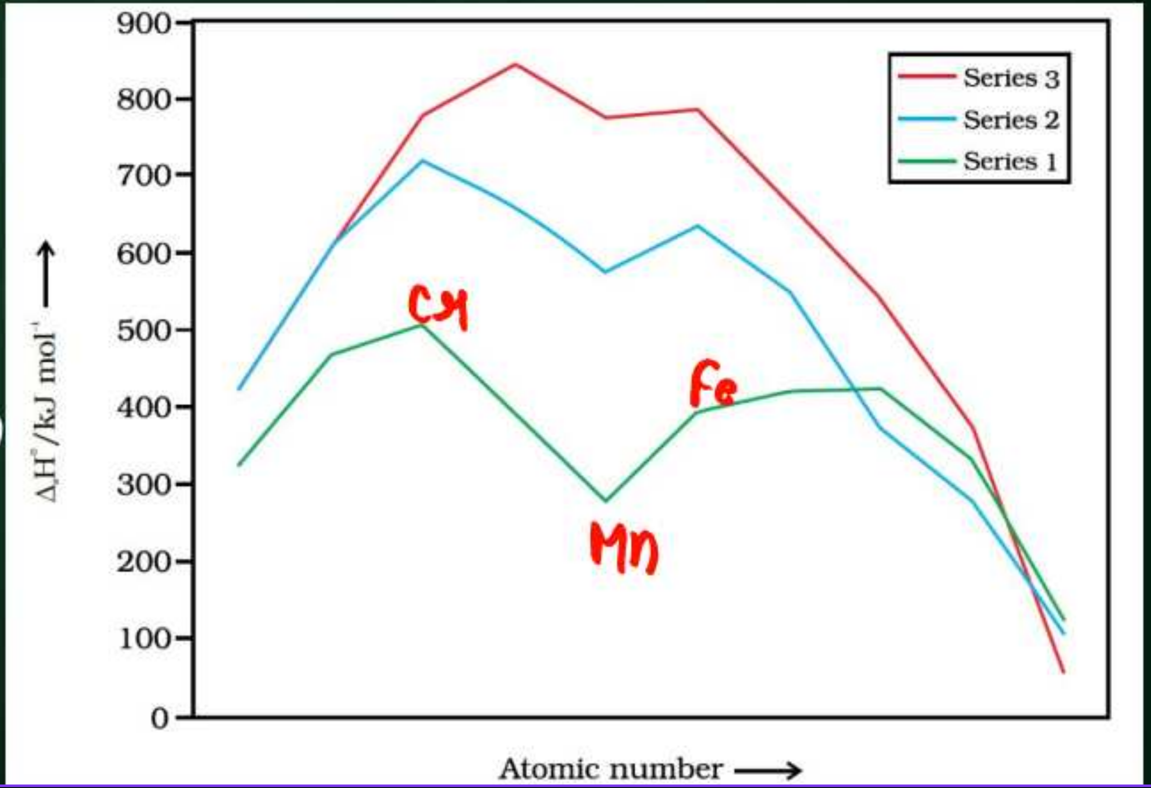
** Enthalpy of Atomisation

In general, greater the number of valence electrons, stronger is the resultant bonding and Hence higher will be the enthalpy of atomization.

No. of unpaired e^- ⟹ High Bonding ⟹ High ΔH_{atom}

$$M(s) \longrightarrow M(g)$$

ΔH_{atom}.



Que which of the following has least ΔH_{atom}? PYQ 2024

- (A) Mn
- (B) Cu
- (C) Sc
- [✓ (D) Zn]

***Ionization Energies**

It can be defined as the minimum energy required to remove an e^- from outermost shell of an isolated gaseous atom.

- As we move left to right, I.E. values increases but not regularly.

Atomic size dec.

Stable ∝ I.E

3d

Sc	Ti	V	Cr <	Mn	Fe	Co	Ni	Cu <	Zn
631	656	650	652	717	762	758	737	745	906

Mn: $4s^2 3d^5$ / Half filled

Zn: $4s^2 3d^{10}$ Fully Filled.

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***Note :** III^{rd} I.E. of Mn is very high because third e^- is to be removed from a stable configuration (Mn^{2+}, $3d^5$) i.e half filled 3d-subshell.

$$\underset{4s^2 3d^5}{Mn} - 1e^- \xrightarrow{I.E_1} \underset{4s^1 3d^5}{Mn^+} - 1e^- \xrightarrow{I.E_2} \underset{4s^0 3d^5}{Mn^{2+}} - 1e^- \xrightarrow{\boxed{I.E_3}} Mn^{+3}$$

****Note :** II^{nd} I.E. of Cu and Cr is very high as compared to neighbouring elements. This is because of the stable or fully filled or half filled configurations.

$$\underset{4s^1 3d^{10}}{Cu} - 1e^- \longrightarrow Cu^+ (\underline{3d^{10}}) - 1e^- \xrightarrow{\boxed{I.E_2}}$$

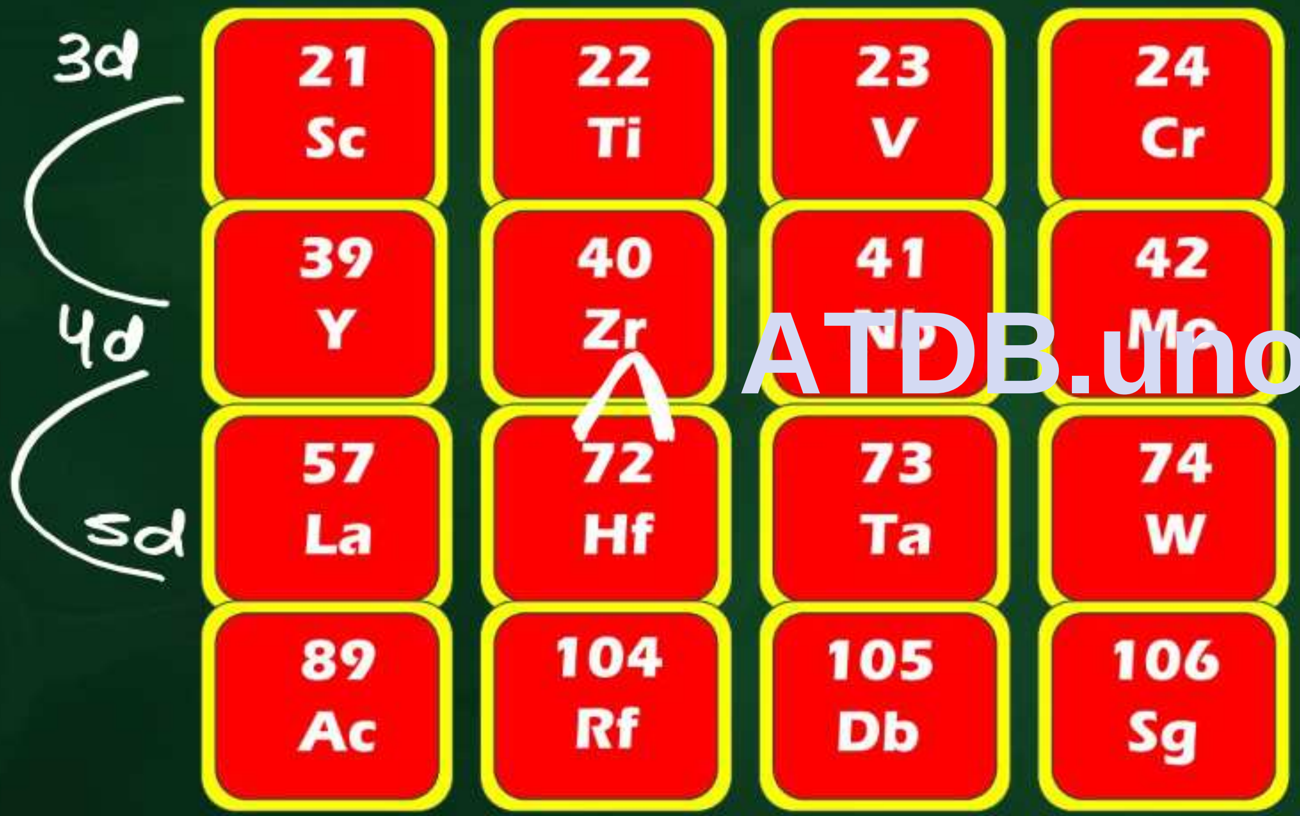
$$\underset{4s^1 3d^5}{Cr} \longrightarrow Cr^+ (3d^5) - 1e^- \xrightarrow{I.E_2}$$

Top to Bottom-

From 4d to 5d or from 5d to 6d series where differentiating e^- enters into f-subshell which causes negligible screening effect (i.e Lanthanide contraction) Hence due to More Nuclear charge I.E increases.

Size inc.
I·E dec

Size constant
Negligible S·E
High N·C
I·E inc



3d	21 Sc	22 Ti	23 V	24 Cr
4d	39 Y	40 Zr	41 [illegible]	42 Mo
5d	57 La	72 Hf	73 Ta	74 W
	89 Ac	104 Rf	105 Db	106 Sg

1. Which one of the following first row transition elements is expected to have the highest third ionization enthalpy ? (2024)

(A) Iron (Z = 26) X

✓ (B) Manganese (Z = 25)

(C) Chromium (Z = 24)

(D) Vanadium (Z = 23)

$$Fe - 1e^- \xrightarrow{I.E_1} Fe^+ - 1e^- \xrightarrow{I.E_2} Fe^{2+} - 1e^- \xrightarrow{I.E_3} Fe^{3+} - 1e^- \xrightarrow{\boxed{I.E_4}}$$

$4s^2 3d^6$ $4s^1 3d^6$ $4s^0 3d^6$ $4s^0 3d^5$

Half

$$Mn - 1e^- \xrightarrow{I.E_1} Mn^+ - 1e^- \xrightarrow{I.E_2} Mn^{2+} \xrightarrow{\boxed{I.E_3}} Mn^{+3}$$

$4s^2 3d^5$ $4s^1 3d^5$ $4s^0 3d^5$ $4s^0 3d^4$

Half filled

Why d-block elements shows variable Oxidation State

Transition elements shows variable oxidation states is due to the involvement of (n-1)d and outer ns electrons in Bonding as the energy of ns and (n-1)d subshell are nearly equal.

The lower oxidation state is generally shown when only ns elections participate in Bonding and higher oxidation states are exhibited when ns and (n-1)d electrons Both take part in Bonding.

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
$4s^2 3d^1$	$4s^2 3d^2$	$4s^2 3d^3$	$4s^1 3d^5$	$4s^2 3d^5$	$4s^2 3d^6$	$4s^2 3d^7$	$4s^2 3d^8$	$4s^1 3d^{10}$	$4s^2 3d^{10}$
	+2	+2	+2	**+2**	**+2**	**+2**	**+2**	+1	**+2**
+3	+3	+3	**+3**	+3	**+3**	**+3**	+3	**+2**	
	+4	+4	+4	+4	+4	+4	+4		
		+5	+5	+5					
			+6	+6	+6				
				+7					

Bold → High stable

Note PYQ

Sc & Zn doesn't show variable Oxidation State.

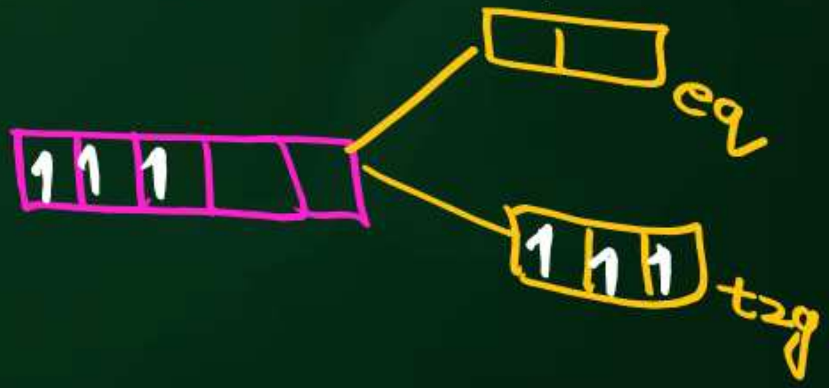
Why some of the Oxi. State are more stable

1) Due to half filled d^5 config. Fe^{3+}, Mn^{+2}
2) Due to fully filled d^{10} config. Zn^{2+}
3) Due to inert electronic config. Cr^{+6} Mn^{+7}
4) Due to half filled t_{2g} config. Cr^{+3}

Cr^{+3}

$Cr \rightarrow 4s^1 3d^5$

$Cr^{+3} \rightarrow 4s^0 3d^3$



Oxidation state

(i) Higher O.S (+4, +5, +6, +7, +8) (shown by fluorides and oxyfluoride

(ii) Common O.S (+2, +3,) (shown by chlorides and sulphides)

(iii) Lower O.S (0, +1) (shown by Metal carbonyl (CO) complex compound

$MnO_4^{\ominus}$

$Mn + 4 \times O = -1$

$Mn + 4(-2) = -1$

$Mn - 8 = -1$

$Mn = -1 + 8$

$\boxed{Mn = +7}$

Why Fluorine has ability to show higher oxidation state?

The ability of fluorine to stabilise the highest oxidation state is due to either higher lattice energy or higher bond enthalpy terms for the higher covalent compounds.

Why Oxygen has higher ability to stablises higher oxidation state than fluorine?

This is due the reason that Oxygen can make multiple bonds to stablise higher oxidation state while fluorine can't.

Standard reduction Potential

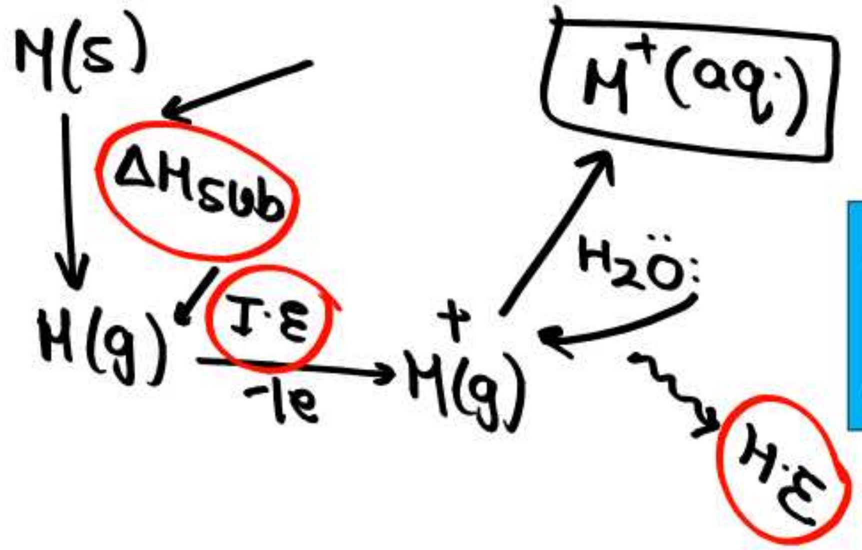
- Tendency of an element to get oxidized is called as Oxidation Potential. / Loss of e^-
- Tendency of an element to get reduced is called as Reduction Potential. / gain of e^-

D-Block Elements ⇒ **Metals** ⇒ **Oxidation** **Red. Potential**

$E_{ox}\uparrow$

$E_{Red}\downarrow \Rightarrow$ Negative

This Reduction Potential is used to measure the stability of ions in aqueous form.



$M(s) \rightarrow M^+(aq) + e^-$ $\Delta H_T = \Delta H_{sub.} + I.E. - H.E.$

Process Forward ⇒ **Stability** **Low in Energy**

Oxi. ⇒ **T.E** ↓ **Sub/I.E** ↓ **H.E** ↑ **E_{Red}** ↓ (−)

#

- The values of E^0 for **Mn, Zn and Ni** are more negative than expected. This is due to extra stability of **half filled or fully filled** d-subshell of Mn^{2+} and Zn^{2+}.

① $Mn \rightarrow Mn^{2+}$ ×

$4s^2 3d^5$ $4s^0 3d^5$

I.E ↓

H.E ↑

ΔI.E ↓

$\boxed{E_{Red} = -}$ ×

② $Zn \rightarrow Zn^{2+}$

$4s^2 3d^{10}$ $4s^0 3d^{10}$

I.E ↓ I.E ↓

H.E ↑

$E_{Red} = ⊖$

③ **Cu(s) > Cu^{2+}(aq)**

$4s^1 3d^{10}$ $4s^0 3d^9$

$E_{Red} = ⊕$

I.E ↑

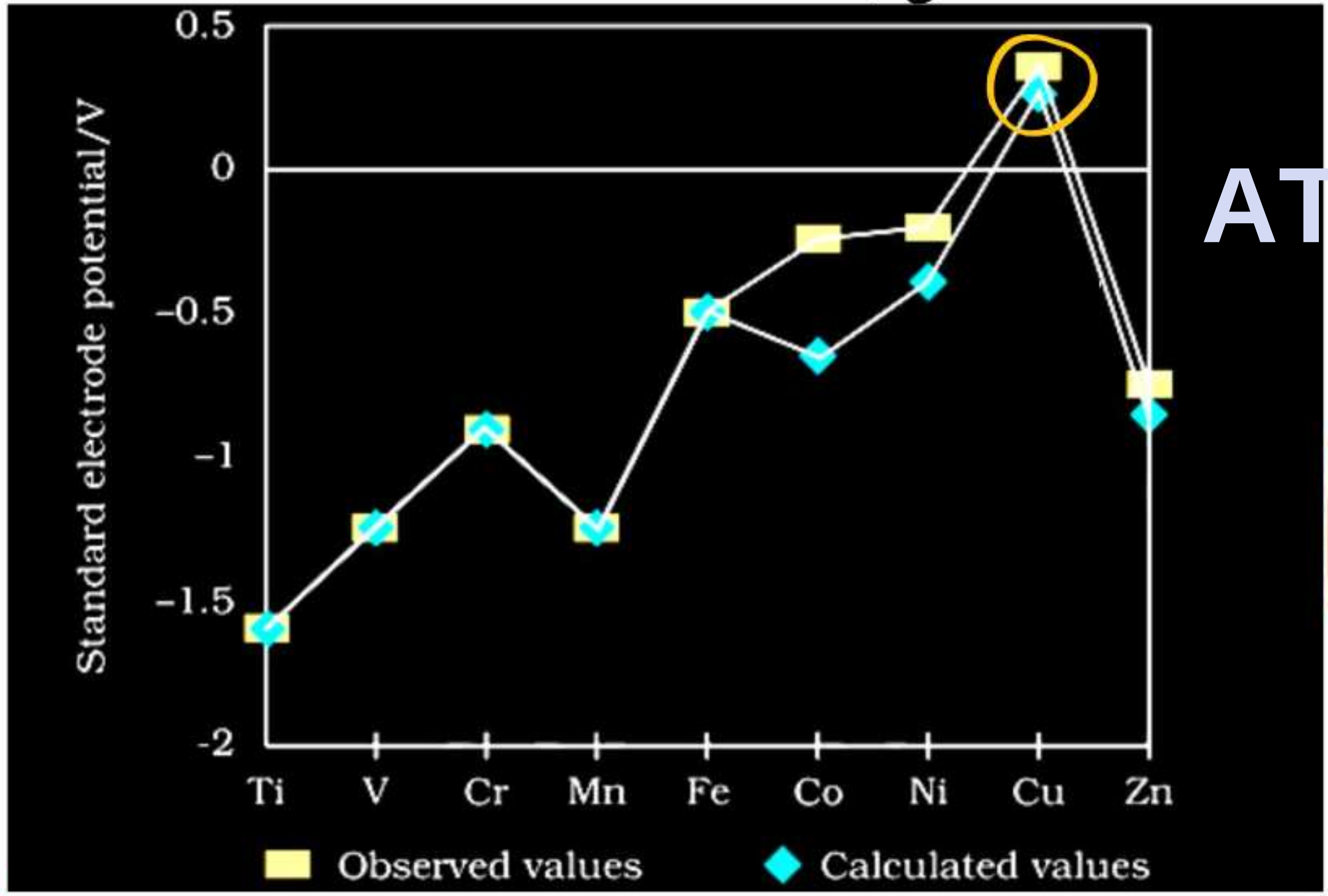
H.E ↑

④ **Cu$^+$ (aq) < Cu^{2+}(aq)**

$4s^0 3d^{10}$ $4s^0 3d^9$

I.E ↑

H.E ↑



The high energy to transform Cu(s) to Cu^{2+}(aq) is not balanced/compensated by its hydration enthalpy.

The high energy to transform Cu$^+$(aq) to Cu^{2+}(aq) is balanced compensated by its hydration enthalpy.

* why Cu has ⊕ E_{Red} potential while other d-block elements have ⊖ E_{Red} potential.

4. The elements of 3d transition series are given as: (3 Marks) (2025)

Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn

Answer the following:

(a) Copper has exceptionally positive $E^\circ_{M^{2+}/M}$ value, why ?

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Ans

Reducing agent
↓
Oxidation

$\underset{\times}{Cr^{+2}} \xrightarrow[\text{Oxi}]{} Cr^{+3}$

High Red.

(b) Which element is a strong reducing agent in +2 oxidation state and why?

Cr^{+3}

(c) Zn^{2+} salts are colourless. Why? → Due to Absence of Unpaired e^-

QUESTION

Why do the Transition elements exhibit higher enthalpies of atomization ?

Transition elements exhibit higher enthalpies of atomization due the presence of High no. of unpaired electrons which results in high bonding.

QUESTION

In the series Sc to Zn, the enthalpy of atomization of Zn is the lowest. Why ?

Since Zn has 0 unpaired electrons that's why it has lowest Enthalpy of atomistion.

Magnetic Properties

Paramagnetic Substances- A Paramagnetic substance is one which is weakly attracted into a magnetic field.

↳ Due to the presence of unpaired e^-

$\mu = \sqrt{n(n+2)}$ Bohr Magneton

n = unpaired e^-

Diamagnetic Substances- A Diamagnetic substance is one which is repelled by a magnetic field.

↳ Due to absence of unpaired e^-

Substances which are attracted very strongly are said to be ferromagnetic. In fact, ferromagnetism is an extreme form of paramagnetism.

$Cr \rightarrow 4s^1 3d^5$

$Cr^{+3} \rightarrow 4s^0 3d^3$

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

1. The magnetic moment is associated with its spin angular momentum and orbital angular momentum. Spin only magnetic moment value of Cr^{3+} ion (Atomic no. : Cr = 24) is ____________. (1 Marks) (2025)

$\boxed{n=3}$

$\mu = \sqrt{3(3+2)}$

$\mu = \sqrt{15}$

(A) 2.87 B.M.

[✓ (B) 3.87 B.M.]

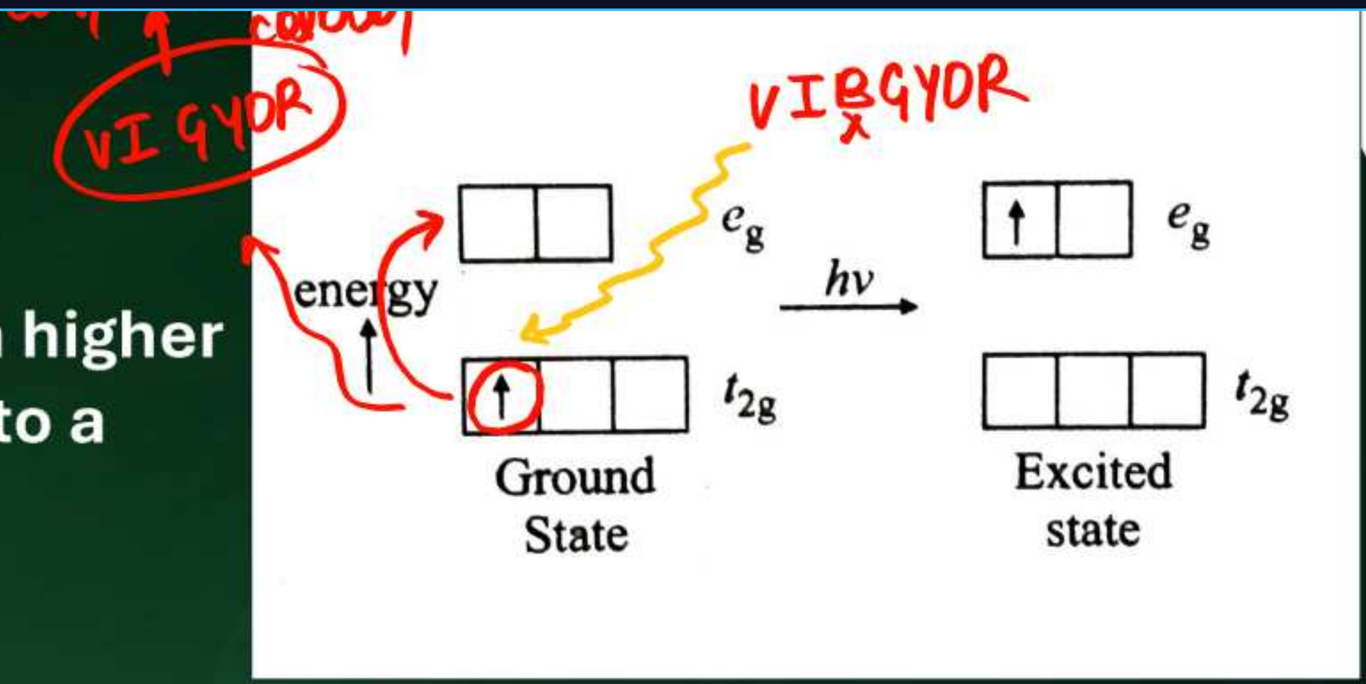
(C) 3.47 B.M.

(D) 3.57 B.M.

Colour

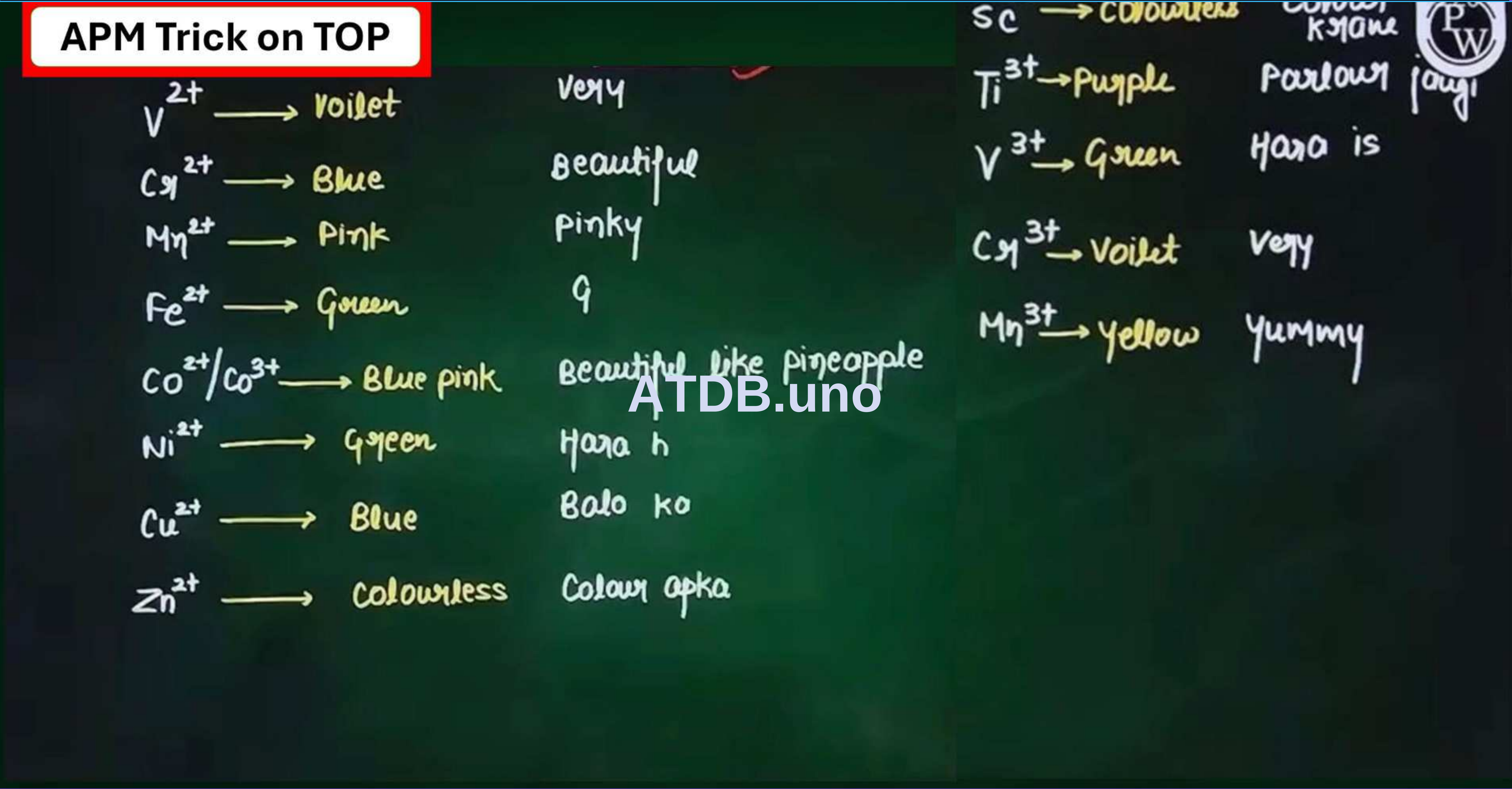
When an e⁻ from a lower energy d-orbital is excited to a higher energy d-orbital, the energy of excitation corresponds to a particular frequency of light absorbed And rest of the frequencies are passed giving complimentary colour.

This is called as d-d transition



Config.	Example	Colour
$3d^0$	Sc^{3+}	Colourless
$3d^0$	Ti^{4+}	Colourless
$3d^1$	Ti^{3+}	Purple
$3d^1$	V^{4+}	Blue
$3d^2$	V^{3+}	Green
$3d^3$	V^{2+}	Voilet
$3d^3$	Cr^{3+}	Voilet
$3d^4$	Cr^{2+}	Blue

Config.	Example	Colour
$3d^4$	Cr^{2+}	Blue
$3d^4$	Mn^{3+}	violet
$3d^5$	Fe^{3+}	Yellow
$3d^6$	Fe^{2+}	Green
$3d^7/3d^6$	CO^{2+}/CO^{3+}	Blue pink
$3d^8$	Ni^{2+}	Green
$3d^9$	Cu^{2+}	Blue
3d10	Zn^{2+}	Colurless



APM Trick on TOP

$V^{2+} \longrightarrow$ Voilet	Very
$Cr^{2+} \longrightarrow$ Blue	Beautiful
$Mn^{2+} \longrightarrow$ Pink	pinky
$Fe^{2+} \longrightarrow$ Green	G
$Co^{2+}/Co^{3+} \longrightarrow$ Blue pink	Beautiful like pineapple
$Ni^{2+} \longrightarrow$ Green	Hara h
$Cu^{2+} \longrightarrow$ Blue	Balo ko
$Zn^{2+} \longrightarrow$ Colourless	Colour apka

$Sc \longrightarrow$ Colourless	Colour Krane
$Ti^{3+} \longrightarrow$ Purple	Parlour jaugi
$V^{3+} \longrightarrow$ Green	Hara is
$Cr^{3+} \longrightarrow$ Voilet	Very
$Mn^{3+} \longrightarrow$ Yellow	Yummy

Tendency to form complexes

- d-block elements have a marked ability to from complex compounds. This is due to their :-

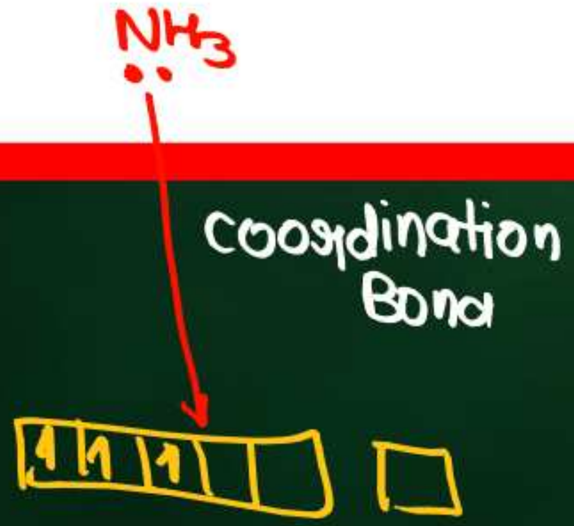
1. Small size
2. High nuclear charge
3. No. of vacant d-orbitals which can accommodate lone pair of ligands.

Ex. $Fe(CO)_5$, $Ni(CO)_4$, $[Cr(NH_3)_6]Cl_3$

$[Cr(NH_3)_6]Cl_3$

↓

$Cr^{+3} \rightarrow 4s^0 3d^3$

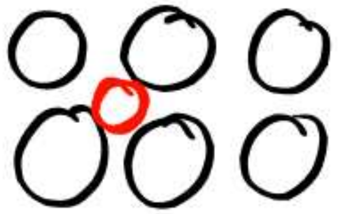


Formation of Interstitial compounds

- Interstitial compounds are those which are formed when small atoms like H, C, B or N are trapped inside the crystal lattice of metal.

They are neither ionic nor covalent.

Ex. TiC, Mn_4N, Fe_3H, $TiH_{1.7}$ etc.

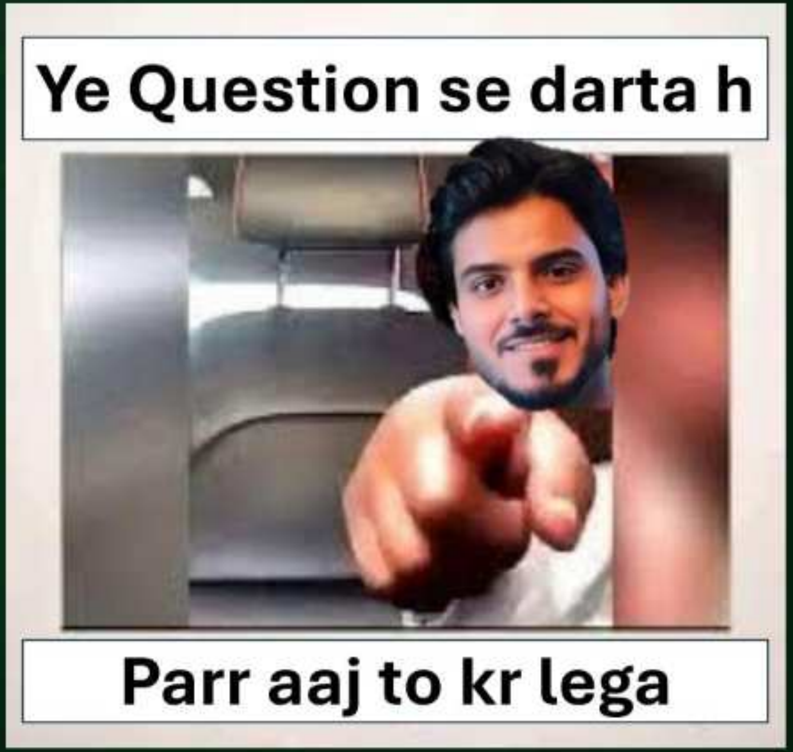


Charteristics :-

1. They have high M.P. that of pure metals.
2. They are very hard.
3. They are chemically inert

The incorrect statement about interstitial compounds is

(a) they are chemically reactive.
(b) they are very hard.
(c) they retain metallic conductivity.
(d) they have high melting point. (2020)



Catalytic Properties

- The transition metals and their compounds are known for catalytic activity.
- Catalyst at a solid surface involve the formation of bonds between reactant molecules and atoms of the surface of the catalyst.

Cr^{+3}
↓
Cr^{+6}

Since transition metal ions can change their oxidation state they become more effective or catalyst or they can utilize (n –1)d orbitals and use Multiple oxidation state in Bonding.

Catalyst	Process
Fe	Haber's process
Ni	Addition Reaction
V_2O_3	Contact process (H_2SO_4 formation)
Co salt	Bleaching power Decomposition

Catalyst	Used as
Ziegler's Natta catalyst $TiCl^{4+}$ $Al(C_2H_5)$	Production of polythene
$PdCl_2$	In wacker process $C_2H_4 \rightarrow CH_3CHO$
Pt/Rh	Making of HNO_3 in Ostwald process

Important Compounds

Very imp

$K_2Cr_2O_7$

K_2CrO_4

K_2MnO_4

$KMnO_4$

(A) Potassium Dichromate ($K_2Cr_2O_7$) :

Prep: Chromite ore

$$FeO\cdot Cr_2O_3 + O_2 + Na_2CO_3 \longrightarrow Fe_2O_3 + Na_2CrO_4$$

$$2Na_2CrO_4 + H_2SO_4 \longrightarrow Na_2Cr_2O_7 \quad Na_2SO_4$$

$$Na_2Cr_2O_7 + 2KCl \longrightarrow K_2Cr_2O_7 + 2NaCl$$

K_2CrO_4 $K_2Cr_2O_7$

The chromate and dichromate are interconvertible in aqueous solution depending upon pH of the solution.

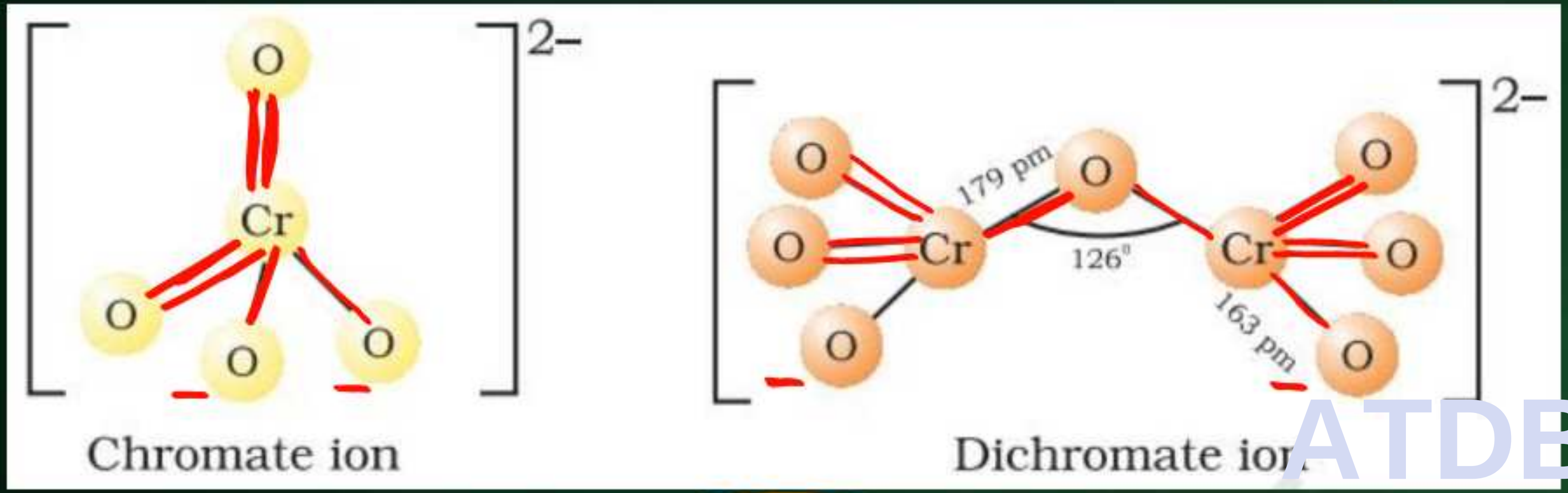
2024 PYQ

$$\begin{tikzcd} \underset{\text{Dichromate}}{K_2Cr_2O_7} \arrow[r, bend left, "\text{Basic}|OH^-|PH>7"] & \underset{\text{Chromate}}{K_2CrO_4} \arrow[l, bend left, "\text{Acidic}|H^+|PH<7"] \end{tikzcd}$$

Structure of Chromate and Dichromate

APM

Chromate/CrO_4^{2-} Dichromate | $\overset{+6}{Cr_2O_7^{2-}}$



Chromate ion Dichromate ion

CrO_4^{2-}
↓
$Cr + 4 \times O = -2$
$Cr + 4(-2) = -2$
$Cr - 8 = -2$
$Cr = -2 + 8$
$\boxed{Cr = +6}$

K$_2$Cr$_2$O$_7$ will oxidize Iodide to Iodine, Sulphides to Sulphur, sn^{2+} to sn^{4+} ✓ and Fe^{2+} to Fe^{3+}

$$\boxed{I^-} + \overset{+6}{Cr_2O_7^{2-}} \longrightarrow \underline{Cr^{+3}} + \overset{0}{I_2}$$ ✓

$$\overset{-2}{H_2S} + \overset{+6}{Cr_2O_7^{2-}} \longrightarrow Cr^{+3} + \overset{0}{S}$$ ✓

$$Fe^{2+} + \overset{+6}{Cr_2O_7^{2-}} \longrightarrow Cr^{3+} + Fe^{+3}$$ ✓

__Note__ Cr^{+6} is less stable than Cr^{+3}

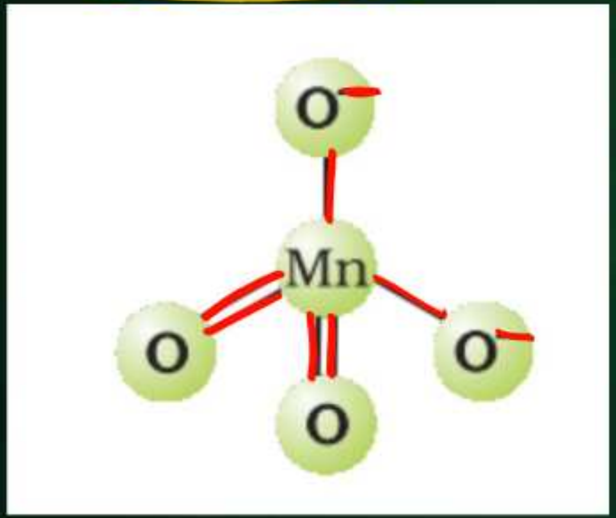
$Cr^{+6} < Cr^{+3}$

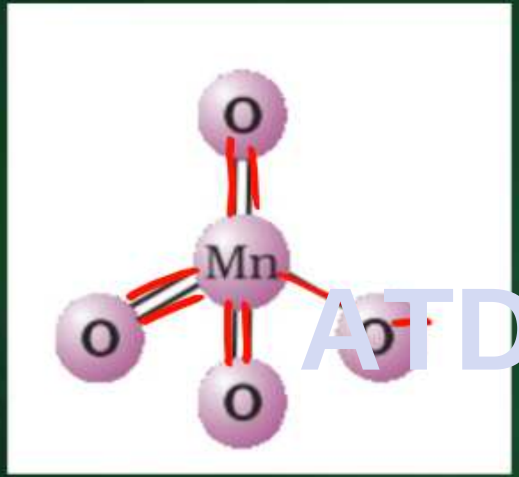
Reduction

Oxidising agent

Manganate and Permanganate

(B) **Manganate** (MnO_4^{2-}) **Permanganate** $(\overset{+7}{Mn}O_4^-)$





MnO_4^{2-}

$Mn + 4 \times O = -2$

$Mn + 4(-2) = -2$

$Mn - 8 = -2$

$Mn = -2 + 8$

$\boxed{Mn = +6}$

MnO_4^{2-} is only stable in strong alkaline solution. If MnO_4^{2-} present is acidic/less basic/Neutral sol. It undergoes disproportionation.

✱✱

$$\overset{+6}{MnO_4^{2-}} \xrightarrow{H^+} \overset{+7}{MnO_4^-} + \overset{+4}{MnO_2}$$

Green Purple Brown

Preparation of Manganate

K_2MnO_4

Pyrolusite

$$MnO_2 \xrightarrow[\text{Boil}]{KOH + O_2} K_2MnO_4$$

Laboratory preparation of $KMNO_4$

$$\underset{\text{manganate}}{MnO_4^{2-}} \xrightarrow{\text{Electrolytic oxidation in alkaline solution}} \underset{\text{permanganate ion}}{MnO_4^-}$$

Preparation of Permanganate

$$K_2MnO_4 + H_2SO_4 \longrightarrow KMnO_4 + MnO_2$$

Oxidising Properties of MnO_4^- (In acidic Medium)

✓ (1) $\overset{+7}{Mn}O_4^- + Fe^{+2} \rightarrow Mn^{2+} + Fe^{3+}$

✓ (2) $\overset{+7}{Mn}O_4^- + I^- \rightarrow Mn^{2+} + I_2$

✓ (3) $\overset{+7}{Mn}O_4^- + H_2O_2 \rightarrow Mn^{2+} + O_2$

✓ (4) $\overset{+7}{Mn}O_4^- + \overset{+4}{S}O_2 \rightarrow Mn^{2+} + H_2\overset{+6}{S}O_4$

(5) $MnO_4^- + NO_2^- \rightarrow Mn^{2+} + NO_3^-$

✓ (6) $MnO_4^- + C_2O_4^{2-} \rightarrow Mn^{2+} + CO_2$

(7) $MnO_4^- + H_2S \rightarrow Mn^{2+} + S\downarrow$

(8) $MnO_4^- + SO_3^{2-} \rightarrow Mn^{2+} + SO_4^{2-}$

Oxidising Behaviour of Mn^{+7}

Mn^{+7} is less stable thant Mn^{+2}

$$\begin{tikzcd} Mn^{+7} \arrow[r, phantom, "<"] \arrow[r, bend right, "Red."'] \arrow[d] & Mn^{2+} \\ \text{Oxidizing agent} & \end{tikzcd}$$

3. Complete and balance the following chemical equations: (2 Marks) (2025) ✓

(a) $2\overset{+7}{Mn}O_4^-(aq) + 10I^-(aq) + \boxed{16H^+}(aq) \longrightarrow 2Mn^{+2} + 5I_2 + 8H_2O$

(b) $\overset{+6}{Cr_2}O_7^{2-}(aq) + 6Fe^{2+}(aq) + \boxed{14H^+}(aq) \longrightarrow 2Cr^{+3} + 6Fe^{+3} + 7H_2O$

F-Block Elements

General e⁻

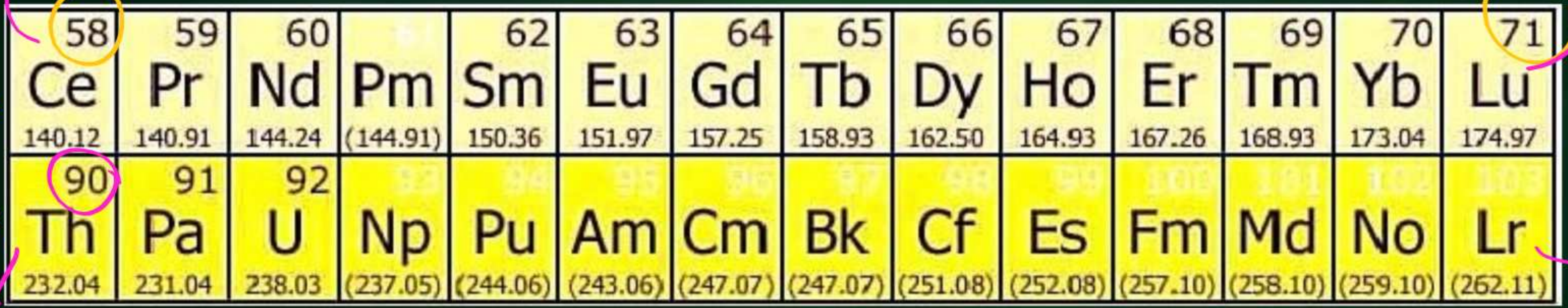
$[\ ]ns^2(n-1)d^{0-1}(n-2)f^{1-14}$

28 elements from 58 to 71 and from atomic no. 90 to 103,These elements are collectively called as f-block element as the last or differentiating electrons of these elements enters into f- orbital.

Electrons in f-orbital always present in Anti pen-ultimate shell ie. (n -2)f.

cerium

Lutetium



4f	58	59	60	61	62	63	64	65	66	67	68	69	70	71
	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
	140.12	140.91	144.24	(144.91)	150.36	151.97	157.25	158.93	162.50	164.93	167.26	168.93	173.04	174.97
5f	90	91	92	93	94	95	96	97	98	99	100	101	102	103
	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
	232.04	231.04	238.03	(237.05)	(244.06)	(243.06)	(247.07)	(247.07)	(251.08)	(252.08)	(257.10)	(258.10)	(259.10)	(262.11)

Thorium

Lawrencium

Ce → Cerium	can → 58 → $[Xe]\ 4f^1 5d^1 6s^2$
Pr → Praseodymium	Put → 59 → $4f^3 6s^2$
Nd → Neodymium	Needle → 60 → $4f^4 6s^2$
Pm → Presmothium	Properly in → 61 → $4f^5 6s^2$
Sm → samarium	Slot → 62 → $4f^6 6s^2$
Eu → europium	Every → 63 → $4f^7 6s^2$
Gd → Gadolinium	Guy → 64 → $4f^7 5d^1 6s^2$
Tb → Terbium	Tries → 65 → $4f^9 6s^2$
Dy → Dysprosmium	Daily → 66 → $4f^{10} 6s^2$
Ho → Holium	However → 67 → $4f^{11} 6s^2$
Er → Erbium	Every → 68 → $4f^{12} 6s^2$
Tm → Thulium	Time → 69 → $4f^{13} 6s^2$
Yb → Ytterbium	you → 70 → $4f^{14} 6s^2$
Lu → lutetium	Loose → 71 → $4f^{14} 5d^1 6s^2$

d^1

$[Xe]\ 6s^2\ 5d^1 > 4f^1$

$5+2$ $4+3$

7 7

s = 0
p = 1
d = 2
f = 3

Electronic configurations

Actinides

Th → 90 → $[Rn]6d^{2}7s^{2}$	d^{2}	Thorium → Th → Thor
Pa → 91 → $[Rn]5f^{2}6d^{1}7s^{2}$	d^{1}	Protoactinium → Pa → Protect
U → 92 → $[Rn]5f^{3}6d^{1}7s^{2}$	d^{1}	Uranium → U → Uranium
Np → 93 → $[Rn]\ 5f^{4}6d^{1}7s^{2}$	d^{1}	Neptunium → NP → Neptune
Pu → 94 → $[Rn]\ 5f^{6}7s^{2}$		Plutonium → Pu → Pluto
Am → 95 → $[Rn]\ 5f^{7}7s^{2}$		Americium → Am → American
Cm → 96 → $[Rn]\ 5f^{7}6d^{1}7s^{2}$		Curium → Cm → Computer/chemistry
Bk → 97 → $[Rn]5f^{9}7s^{2}$		Berkelium → Bk → Book in
Cf → 98 → $[Rn]5f^{10}7s^{2}$		Californium → Cf → California explains
Es → 99 → $[Rn]5f^{11}7s^{2}$		Einsteinium → Es → Einstein
Fm → 100 → $[Rn]5f^{12}7s^{2}$		Fermium → Fm → Fermi
Md → 101 → $[Rn]5f^{13}7s^{2}$		Mendeleevium → Md → Maded
No → 102 → $[Rn]5f^{14}7s^{2}$		Nobelium → No → Noble gas
Lr → 103 → $[Rn]5f^{14}6d^{1}7s^{2}$		Lawrencium → Lr → Laws

$[Rn]\ 7s^{2}\ 6d^{1} > 5f$

$6+2 \rightarrow 8$ $\quad$ $5+3 \rightarrow 8$

1 2 1 1 1

Ce d^{1} $\quad$ Th d^{2}

Lanthanoids	Actinoids
Differentiating electron eneters in 4f orbital	Differentiating electron eneters in 5f orbital
Binding energy of 4f orbitals are higher	Binding energy of 5f orbitals are lower
They show less tendency to form complexes	They show greater tendency to form complexes
Besides +3 oxidation states lanthanoids show +2 and +4 oxidation states in few cases.	Besides +3 oxidation states actinoids show higher oxidation states such as +4, +5, +6 and +7.

Why Actinoid contraction is greater than Lanthanide Contraction ?

Actinoid contraction is greater than Lanthanide contraction because the 5f electrons in Actinoid provides much poor shielding of nuclear charge as compared to 4f electrons of Lanthanide.

Lanthanides

↓

Rare Earth Metals

Actinides

↓

Radioactive elements

The best single use of the lanthanoids is for the production of alloy steels for plates and pipes.

A well known alloy is misch metal which consists of a lanthanoid metal (~ 95%) and iron (~ 5%) and traces of S, C, Ca and Al. A good deal of misch metal is used in Mg-based alloy to produce bullets, shell and lighter flint.

Samaj Aaya ?

APM

CH-2

Board supermacy < APM supemacy

Coordination Compounds

Molecular Or Addition Compounds

When solution containing two or more simple stable compounds in molecular proportions are allowed to evaporate, crystals of new substance are obtained. These substance are termed as molecular or Addition compounds.

Ex.

$KCl + MgCl_2 + 6H_2O \longrightarrow$ $KCl \cdot MgCl_2 \cdot 6H_2O$ Carnallity

$K_2SO_4 + Al_2(SO_4)_3 + 24H2O \longrightarrow$ Alum

$FeSO_4 + (NH_4)_2SO_4 + 6H2O \longrightarrow$ Mohr's salt

Salt I
+
salt II
+
salt III

✓

*** ① Double Salts Or Lattice Compounds

The addition comp. which are stable but broken down into individual constituents when dissolved in water. Their solutions have the same proportions as the mixture of individual comp. Ex. Mohr's salt

$FeSO_4.(NH_4)_2SO_4.6H_2O \downarrow$

$Fe^{2+} + 2SO_4^{2-} + 2NH_4^+$

$+ 6H_2O$

② Coordination Or Complex Compounds

The addition comp. in which some of the constituent ions or molecules retain their identity & when dissolved in water they do not break up completely into individual ions.

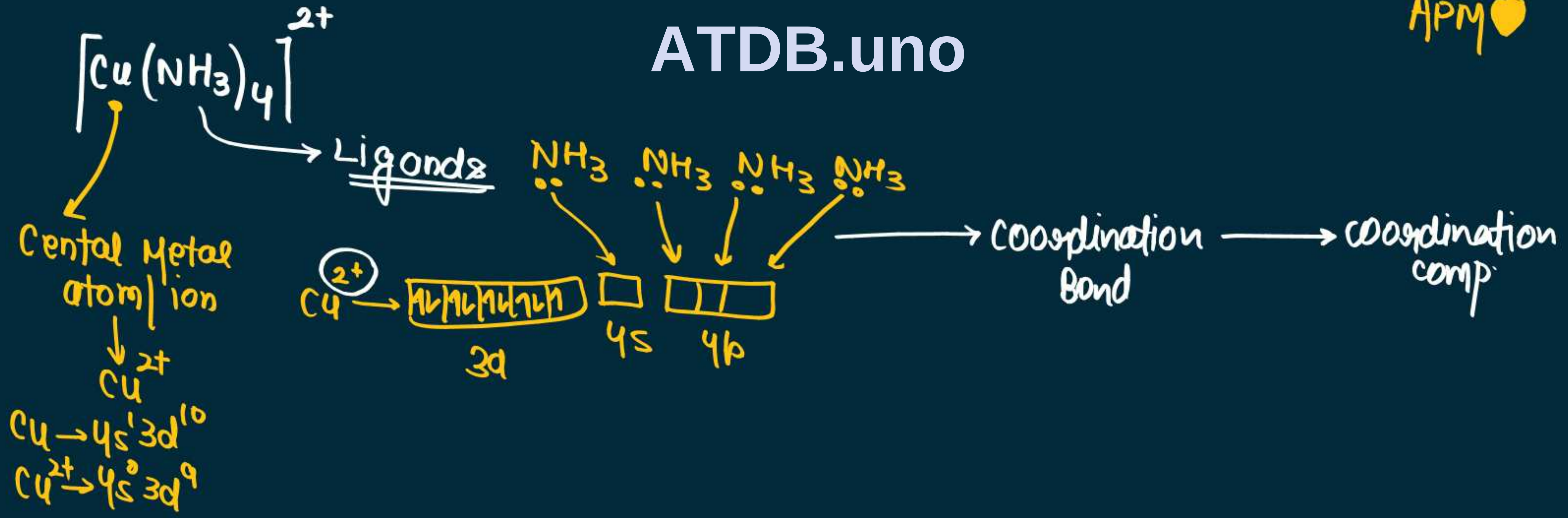
Ex- CuSO4.4NH3 $\longrightarrow [Cu(NH_3)_4]^{2+} + SO_4^{2-}$

Important Terminology

✓ **Ligands :-** The neutral molecules, anions or cations which are directly linked with the central metal atom or ion in a complex are called ligands. They behave as an electron donor due to the presence of Lone pair.

✓ **Central Metal atom/ion :-** These are the metal atom/ions which behave as an electron acceptor due to the absence of empty d orbital or positive charge.

APM ♥



$Cu \rightarrow 4s^1 3d^{10}$

$Cu^{2+} \rightarrow 4s^0 3d^9$

An atom can only donate a single lone pair.

denticity ⇒ No. of Donor atoms.

On the basis of charge

Negative ligands

CN^-, F^-, Cl^-, NO_2^-, NO_3^-, OH^-, O^{2-}

Positive ligands

NO_2^+, NO^+, $N_2H_5^{5+}$

Neutral ligands

$H_2\ddot{O}$, $\ddot{N}H_3$, CO, NH_2OH, $CH_3\ddot{N}H_2$

On the basis of number of donor sites

Monodentate : (d=1)

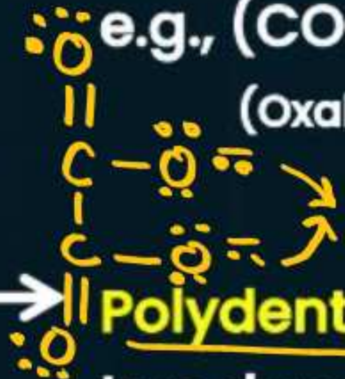
Only one donor site

e.g., H_2O, NH_3, F^-, Cl^-

Bidentate : Two donor site (d=2)

e.g., $(COO^-)_2$, CH_2-NH_2 / CH_2-NH_2

(Oxalato) (Ethylenediamine) (en)

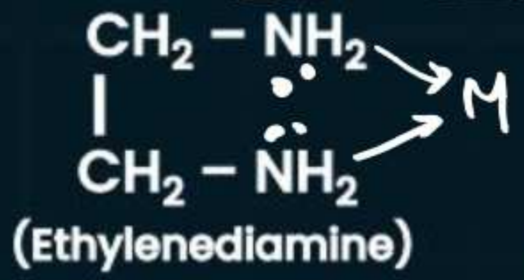


Polydentate: More than two donor sites e.g., EDTA (Hexadentate)

d=6

On the basis of bonding

Chelating ligands: A bidentate or polydentate ligand which forms more than one coordinate bonds in such a way that a ring formed.



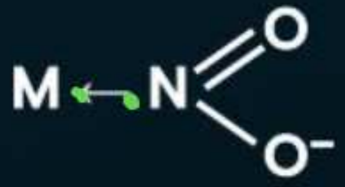
(Ethylenediamine)

$NH_3 \rightarrow M$

Chleation ∝ Stable

Ambidentate ligands: Monodentate (d=1) ligand which contains more than one coordinating atom (or donor atom).

$M \leftarrow O^- - N = O$, or



$M \leftarrow SCN$, or $M \leftarrow NCS$

$M \leftarrow CN$ or $M \leftarrow NC$

QUESTIONS

Which of the following ligands form a 'chelate' complex with metal ion?

(2021C)

1. H_2O
2. CN^-
3. $C_2O_4^{2-}$
4. Cl^-

EDTA
D=6
D=6
D=4

Types of Ligands

Flexidentate Ligand –

A ligand which show variable denticity in different coordination compounds is called as Flexidentate Ligand.

Ex- SO_4^{2-}, EDTA.

D=2 D=1

$\leftarrow NO_2^-$

$\leftarrow ONO^-$

d=2
COO^-
|
COO^-

$SCN^- \rightarrow$

$\leftarrow SCN^-$

QUESTIONS

The set which does not have ambidentate ligand(s) is:

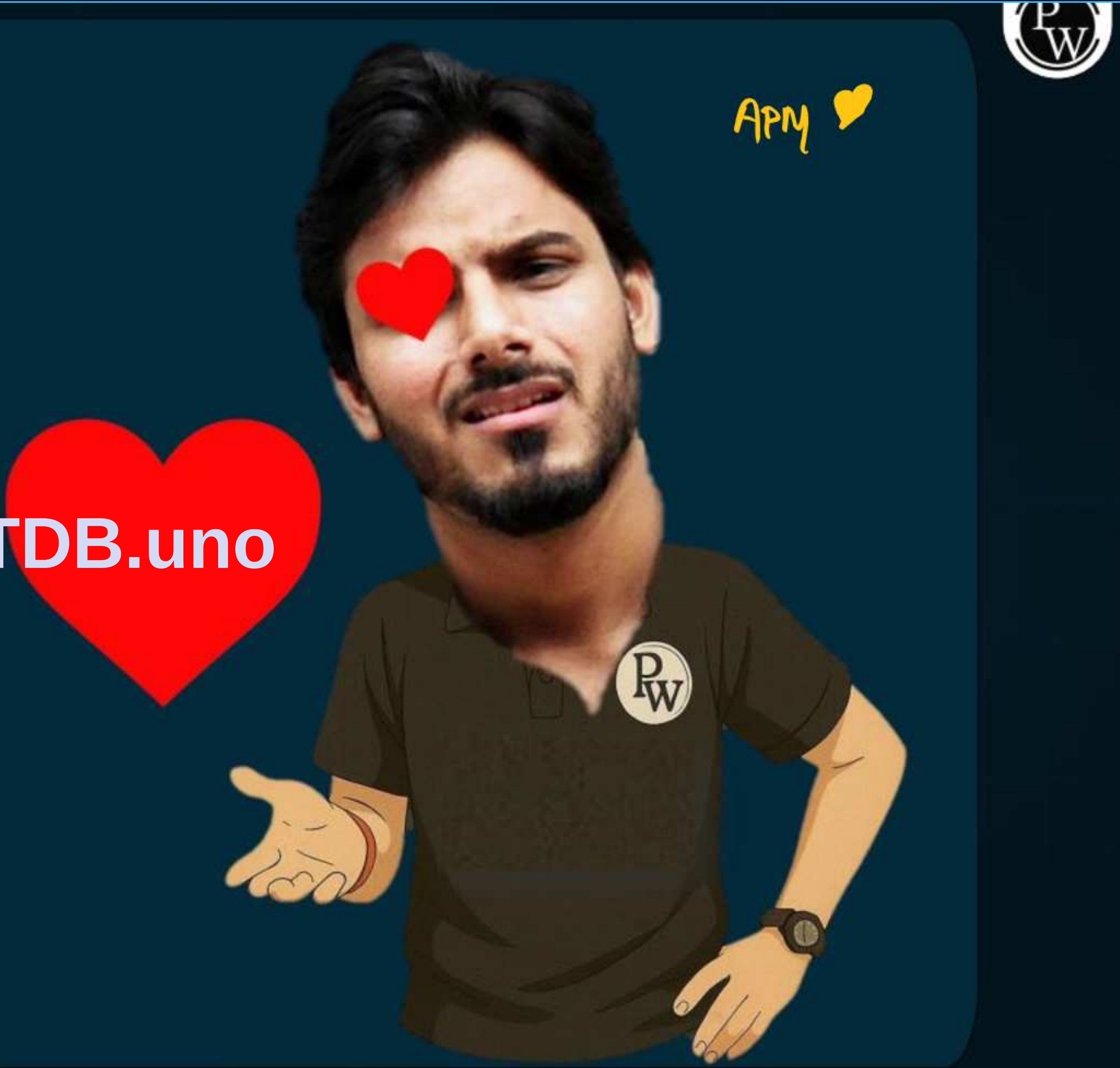
JEE

(2023, 11 April Shift – I)

1. NO_2^-, $C_2O_4^{2-}$, $EDTA^{4-}$
2. $EDTA^{4-}$, NCS^-, $C_2O_4^{2-}$
3. $C_2O_4^{2-}$, NO_2^-, NCS^-
4. $C_2O_4^{2-}$, ethylene diamine, H_2O

Samaj Aaya ?

APM



Coordination Number

Metal ke Brabar
Me Hone chiye

The no. of atoms of the ligands that are directly bound to the central metal atom or ion by coordinate bond is known as the coordination no. of the metal ion.

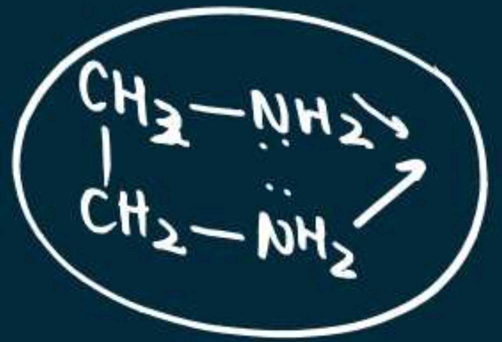
Ex. $[Cu(\underbrace{NH_3)_4}]^{2+} = \textcircled{4}$

$[Cu(\underbrace{en)_3}]^{3+} = 3 \times 2 = \textcircled{6}$

Most common coordination no. are 2, 4, & 6.

C.N. = No. of ligands × Dentate charc. of ligands.

$\ddot{N}H_3$ $\boxed{d=1}$



Example :-

$\cancel{K_4}[Fe(\underbrace{CN)_6}] \Rightarrow 6 \times 1 = 6$

$[Ag(\underbrace{CN)_2}] \Rightarrow 2 \times 1 = 2$

$[Pt(\underbrace{NH_3)_2}(\underbrace{Cl)_2}] = 2 \times 1 + 2 \times 1 = 4$

$[Ca(\underbrace{edta)}] = 1 \times 6 = 6$

$Fe(\underbrace{CO)_5} = 5 \times 1 = 5$

$[Ni(\underbrace{CN)_5}]^{3-} = 5 \times 1 = 5$

$[Zr\underbrace{F_7}]^{3-} = 7 \times 1 = 7$

$\boxed{CN^-}$ $d=1$
Cl^- $d=1$
NH_3 $d=1$
edta $= 6$
$CO = d = 1$
$:\ddot{F}^- = d = 1$

Coordination Sphere

Ex $K_4[Fe(CN)_6]$

Ionisation sphere

→ coordination sphere

The central atom or ion and the ligands that are directly attached to it are enclosed in a square bracket.

This has been called coordination entity or coordination sphere.

* Any ion present outside this sphere is separated form the complex when dissolved in water.

Ex. $K_4[Fe(CN)_6] \rightarrow 4K^+ + [Fe(CN)_6]^{4-}$

Charge on the complex ion :- O. No of metal + charge on the ligand

CN^-

$$4K + Fe + 6CN = 0$$
$$4(+1) + Fe + 6(-1) = 0$$
$$4 + Fe - 6 = 0$$
$$Fe - 2 = 0$$
$$\boxed{Fe = +2}$$

$$\boxed{Fe + 6CN = -4}$$
$$Fe + 6(-1) = -4$$
$$Fe - 6 = -4$$
$$Fe = -4 + 6$$
$$\boxed{Fe = +2}$$

QUESTIONS

$CH_2-\ddot{N}H_2$
$CH_2-\ddot{N}H_2$
$\boxed{\text{charge} = 0}$

PYQ
(2021C)

The oxidation number of Co in $[Co(en)_3]_2(SO_4)_3$ is

- 1 +2
- [✓ 2 +3]
- 3 +4
- 4 +6

$2[Co(en)_3]^{+3}$ $\quad$ $3SO_4^{2-}$

$\boxed{-6}$

2×3

$\boxed{6}$

$Co + 3en = +3$

$Co + 3(0) = +3$

$\boxed{Co = +3}$

$2Co + 6en + 3SO_4 = 0$

$2Co + 6 \times 0 + 3(-2) = 0$

$2Co + 0 - 6 = 0$

$2Co = +6$

$\boxed{Co = \frac{+6}{2} = +3}$

QUESTIONS

2025

(PYQ)

The oxidation state Cr in $[Cr(NH_3)_4Cl_2]^{+}$ is

1 0

3 +2

2 +1

[✓ 4] +3

$$Cr + 4NH_3 + 2Cl = +1$$
$$Cr + 4(0) + 2(-1) = +1$$
$$Cr + 0 - 2 = +1$$
$$\boxed{Cr = +1 + 2 = +3}$$

$$\frac{\text{Coordin. No}}{L \times d}$$

QUESTIONS

(2019, 12 April Shift-II)

The coordination numbers of Co and Al in $[CoCl(en)_2]Cl$ and $K_3[Al(C_2O_4)_3]$, respectively, are

$$1 \times 1 + 2 \times 2$$
$$1 + 4$$
$$\textcircled{5}$$

$$3 \times 2$$
$$\textcircled{6}$$

$$\begin{array}{c} COO^- \\ | \\ COO^- \end{array}$$

1 5 and 3

3 6 and 6

2 3 and 3

[✓ 4] 5 and 6

Homoleptic and Heteroleptic Complexes

2024

Homoleptic → Complexes in which a metal is bound to only one kind of donor group.

Ex. → $[Cr\underbrace{(NH_3)_6}]^{3+}$, $[Fe\underbrace{(CN)_6}]^{3-}$

Heteroleptic → Complexes in which a metal is bound to diff. kind of donor group.

Ex. → $[Co\underbrace{(en)_2}\underbrace{Cl_2}]^{+}$, $[Cr\underbrace{(NH_3)_4}\underbrace{Cl_2}]^{+}$

QUESTIONS

2024

Which of the following is an example of homoleptic complex? (PYQ)

[✓ 1] $[Co(NH_3)_6]Cl_3$ ✗

2 $[Pt(NH_3)_2Cl_2]$ ✗

3 $[Co(NH_3)_4Cl_2]$ ✗

4 $[Co(NH_3)_5Cl]_2$ ✗

Nomenclature of Coordination Compounds

IUPAC

Name of the Ligands-

a) Anionic ligands ending with -ide are named by replacing- ide with suffix -o or replacing -e by - o.

b) Ligands whose names ends in –ite or –ate become –ito or –ato i.e by replacing the ending –e with -o.

Anion		Ligand Name	Anion		Ligand Name
Chloride	Cl^-	Chlorido	Carbonate	CO_3^{2-}	Carbonato
Bromide	Br^-	Bromido	Oxalate	$C_2O_4^{2-}$	Oxalato
Cyanide	CN^-	Cyano	Sulphate	SO_4^{2-}	Sulphato
Oxide	O^{2-}	Oxo	Nitrate	NO_3^-	Nitrato
Sulphide	S^{2-}	Sulphido	Nitrite	NO_2^-	Nitrito

Nomenclature of Coordination Compounds

c) Neutral ligands are called with the same names as their neutral molecules or with their special names.

$H_2O \rightarrow$ Aqua $NH_3 \rightarrow$ Ammine
$CO \rightarrow$ Carbonyl $NO \rightarrow$ Nitrosyl
$CS \rightarrow$ Thio carbonyl $NS \rightarrow$ Thio Nitrosyl

$M(NH_3)_2$
diammine

$[M\,Cl_2]$
dichlorido

$M(en)_2$
bis ethylenediamine

d) If the number of a particular ligand is more than one in the complex ion, then the Number used as di, tri, tetra, penta, hexa, etc. But when the name of the ligands Includes a number Ex- Diamine, then bis, tris, tetrakis will be used.

e) Complex positive ions and neutral coordination compounds have no special ending but complex negative ions always ends with suffix- ate.

f) Oxidation state of the central metal is shown by Roman numeral in bracket following its name.

IUPAC Nomenclature

complex
Ligand → Metal
(Alphabetical)

oxidation
no

1. $[Co(NH_3)_4H_2O(Cl)]Cl_2$ — $2+$, $2Cl^-$ → Tetra ammine, aqua, chlorido cobalt (_) Chloride ✓✓

2. $[Cu(en)_2]SO_4$ — $2+$, SO_4^{2-} → Bis ethylenediamine copper ( ) sulphate

3. $[Cr(H_2O)_4Cl_2]^+$

4. $[Fe(H_2O)_4(C_2O_4)]_2SO_4$ — $+$, SO_4^{2-} → Tetraaqua Oxalato Iron (_) sulphate

5. $[Ag(NH_3)_2]Cl$ — $+$, Cl^- → Diammine silver (_) chloride

6. $K_3[Fe(CN)_6]$ — $3-$, $3K^+$ → Potassium Hexacyano ferrate(III)

7. $Na[Ag(CN)_2]$ — $-$, Na^+

$3K + Fe + 6CN = 0$
$3(+1) + Fe + 6(-1) = 0$
$3 + Fe - 6 = 0$
$Fe - 3 = 0$
$Fe = +$

⊕/Neutral	⊖
cobalt	cobaltate
Iron	ferrate
silver	Argentate
chromium	chromate
Platinum	Platinate
Copper	cuprate

IUPAC Nomenclature

(PYQ)

1. $[Cr(NH_3)_6][Co(CN)_6]$

2. $[Ag(NH_3)_2][Ag(CN)_2]$

Metal	C.N.
Ag^+	2

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

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

QUESTIONS

diammine dichlorido platinum(IV) ion

PYQ (2025)

The correct IUPAC name of $[Pt(NH_3)_2Cl_2]^{2+}$ is

$Pt + 2NH_3 + 2Cl = +2$
$Pt + 2\times0 + 2(-1) = +2$
$Pt + 0 - 2 = +2$
$\boxed{Pt = +2+2 = +4}$

1. Diamminedichloridoplatinum (II)
2. ✓ Diamminedichloridoplatinum (IV)
3. Diamminedichloridoplatinum (0)
4. Diamminedichloridoplatinate (IV)

QUESTIONS

(PYQ) 2024

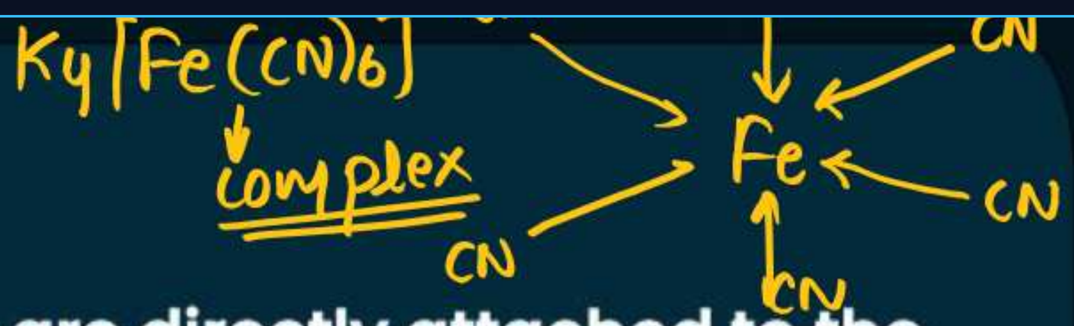
$Co + NO_2 + 5NH_3 + 2Cl = 0$
$Co + (-1) + 5\times0 + 2(-1) = 0$
$Co - 1 + 0 - 2 = 0$

The IUPAC name for the complex $[Co(NO_2)(NH_3)_5]^{2+}Cl_2$ is

$\boxed{Co = +3}$ $\quad 2Cl^-$

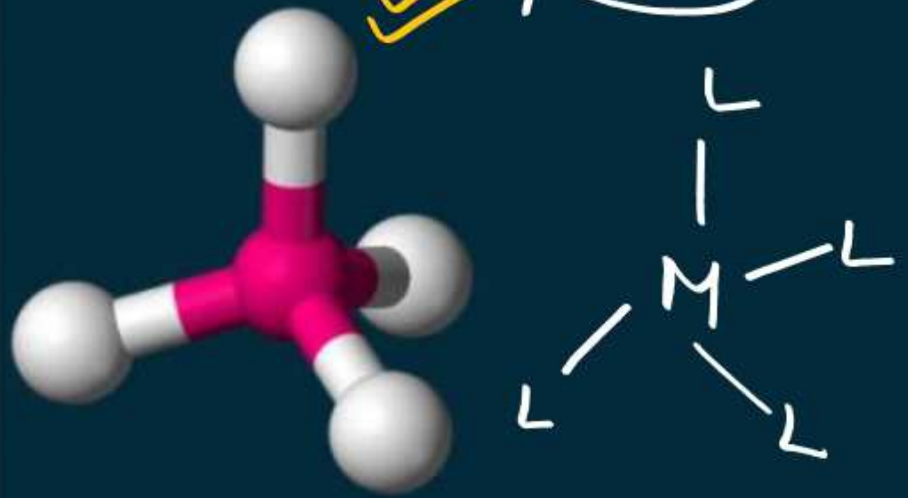
1. ✗ nitrito-N-pentamminecobalt (III) chloride
2. ✗ nitrito-N-pentamminecobalt (II) chloride
3. pentammine nitrito-N-cobalt(II) chloride
4. ✓ pentammine nitrito-N-cobalt(III) chloride

Coordination polyhedron

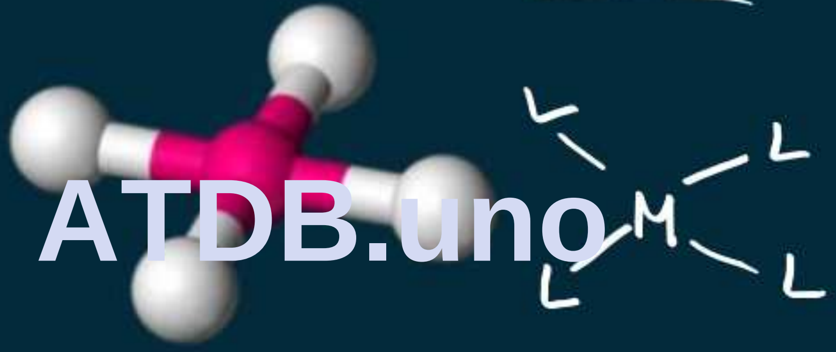


The spatial arrangement of the ligand atoms which are directly attached to the central ion or atom is called coordination polyhedron.

Tetrahedral ✓ CN=4

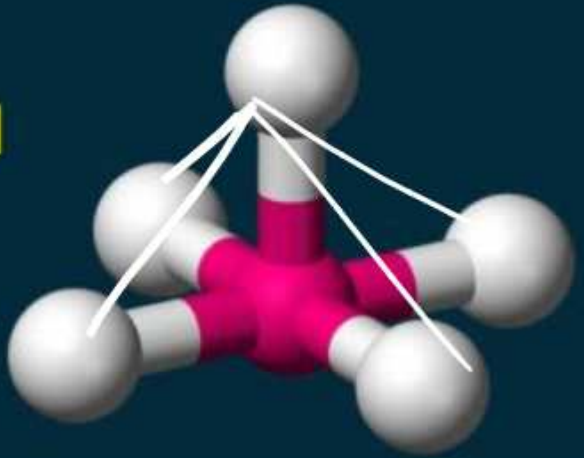


✓ Square Planar C·NO=4

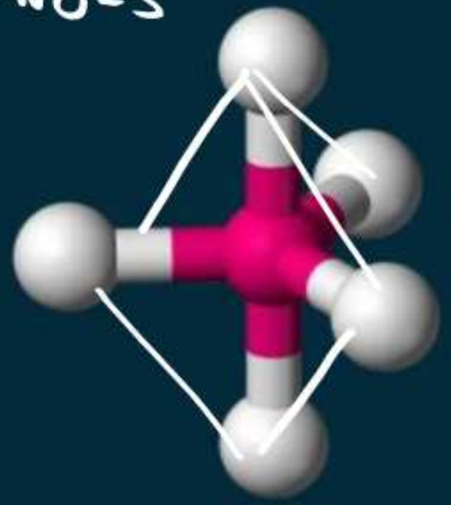


✓ Octahedral CN=6

Square Pyramidal CN=5 ✗



C·NO=5

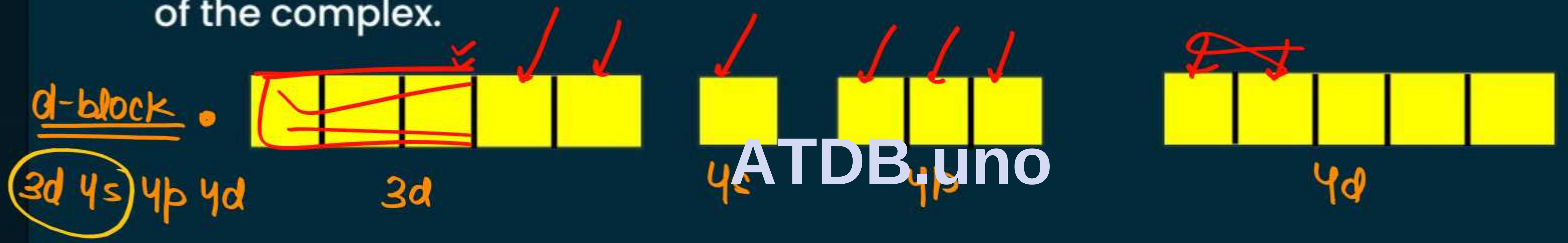


✗ Trigonal Bipyramidal

Bonding

(A) Valence Bond Theory

- This theory describes the bonding in terms of hybridized orbitals of the central metal atom or ion.
- The theory mainly deals with the geometry (shape) and magnetic properties of the complex.



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

Diamagnetic $n=0$

SFL → Hund's Rule ✗

Postulates

1. The central atoms loses a requisite no. of electrons to form the ion. The no of electrons lost is the valency of the resulting cation.
2. The central metal ion or atom makes available a no. of empty s, p & d orbitals equal to its coordination no.

(i) $[NiCl_4]^{2-}$ → WFL

$Ni + 4Cl = -2$

$Ni + 4(-1) = -2$

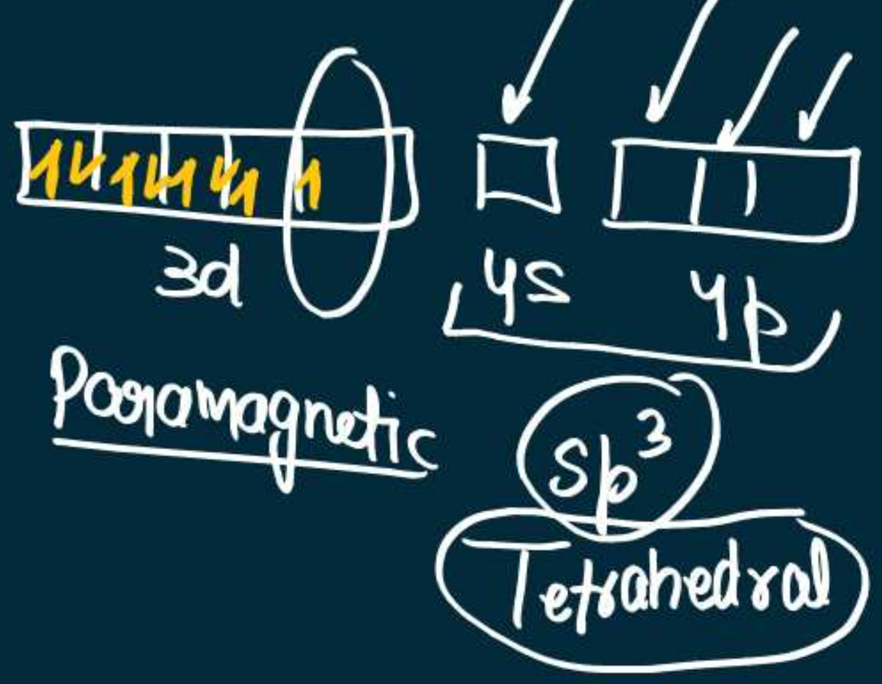
$Ni - 4 = -2$

$Ni = -2+4$

$\boxed{Ni = +2}$

$Ni \rightarrow 4s^2 3d^8$

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



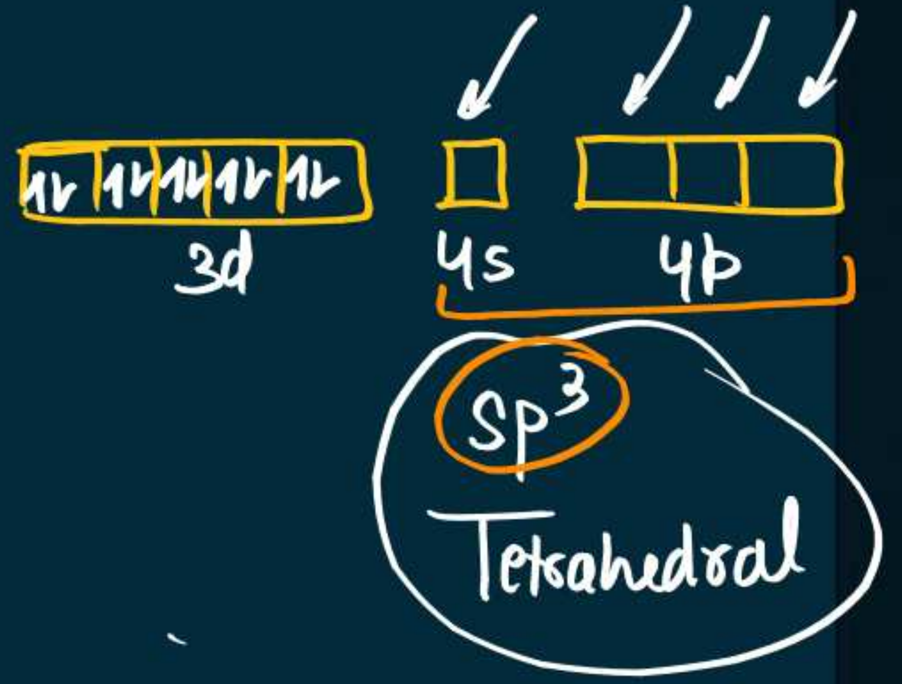
(i) $[Ni(CO)_4]$ → SFL

$Ni + 4\times CO = 0$

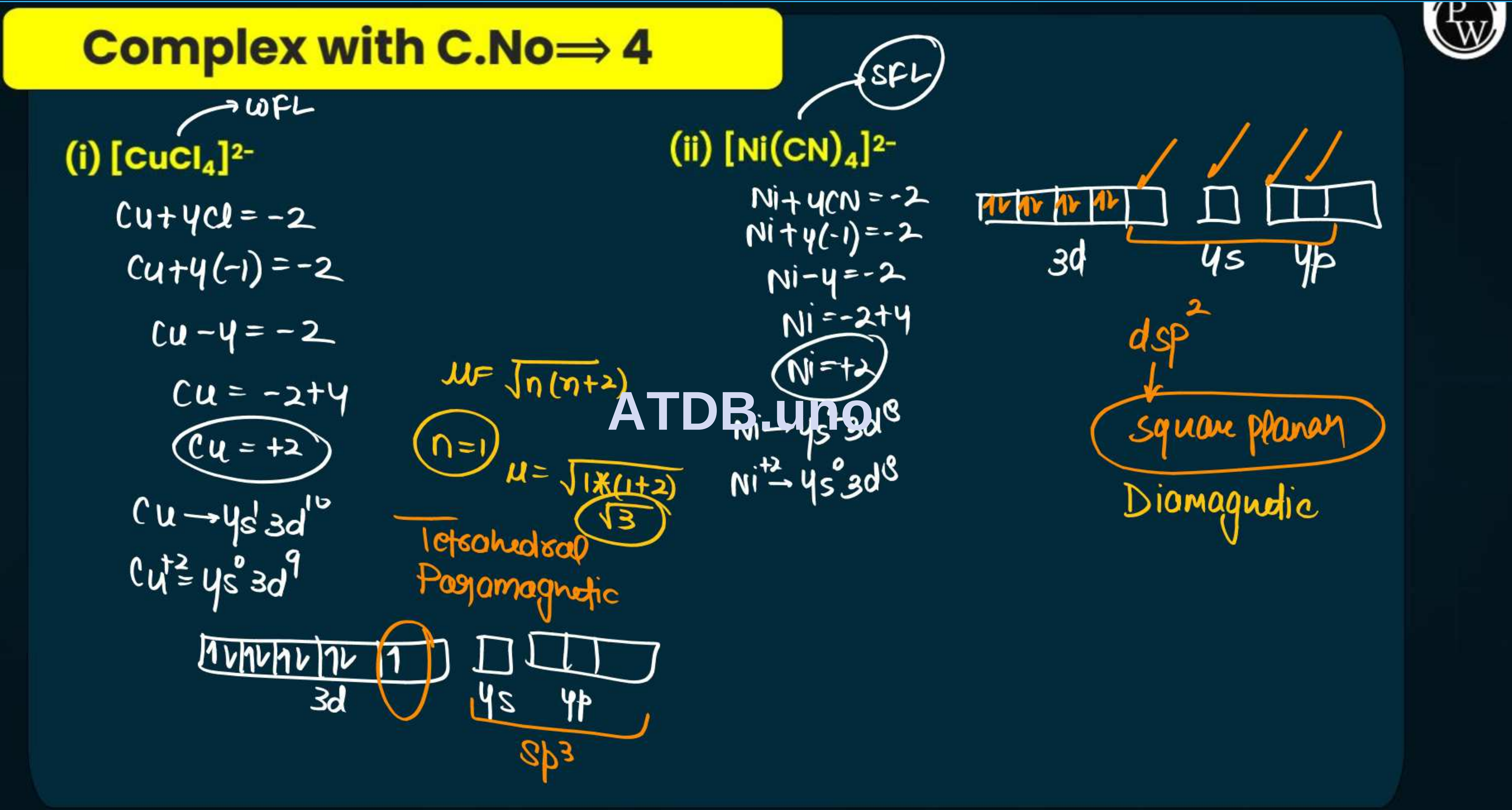
$Ni + 4\times 0 = 0$

$Ni = 0$

$Ni \rightarrow 4s^2 3d^8$



Diamagnetic



Complex with C.No ⇒ 4

(i) $[CuCl_4]^{2-}$ → WFL

$Cu + 4Cl = -2$

$Cu + 4(-1) = -2$

$Cu - 4 = -2$

$Cu = -2 + 4$

$Cu = +2$

$Cu \rightarrow 4s^1 3d^{10}$

$Cu^{+2} = 4s^0 3d^9$

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

$n = 1$

$\mu = \sqrt{1*(1+2)}$

$\sqrt{3}$

Tetrahedral

Paramagnetic

(ii) $[Ni(CN)_4]^{2-}$ → SFL

$Ni + 4CN = -2$

$Ni + 4(-1) = -2$

$Ni - 4 = -2$

$Ni = -2 + 4$

$Ni = +2$

$Ni \rightarrow 4s^2 3d^8$

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

dsp^2 ↓

square planar

Diamagnetic

QUESTIONS

WPL

Atomic number: Ni = 28

PYQ

The magnetic moment of $[NiCl_4]^{2-}$ is

(2023)

$Ni + 4Cl = -2$

$Ni + 4(-1) = -2$

$Ni - 4 = -2$

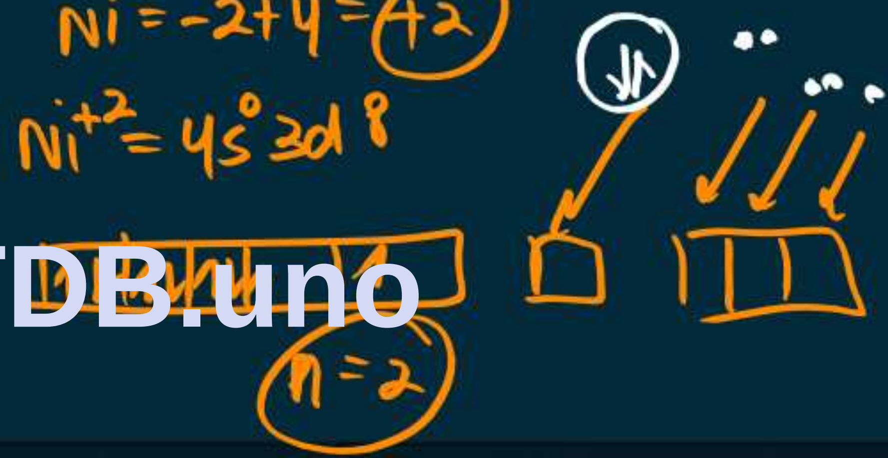
$Ni = -2 + 4 = \boxed{+2}$

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

$\mu = \sqrt{2(2+2)}$

$= \boxed{\sqrt{8}}$

1. 1.82 B.M.
2. [✓ 2.82 B.M.]
3. 4.42 B.M.
4. 5.46 B.M.



QUESTIONS

Why is $[NiCl_4]^{2-}$ paramagnetic but $[Ni(CO)_4]$ is diamagnetic? (At. no.: Cr = 24, Co = 27, Ni = 28)

(NCERT Intext, 1/3, AI 2014)

Complex with C.No ⟹ 6

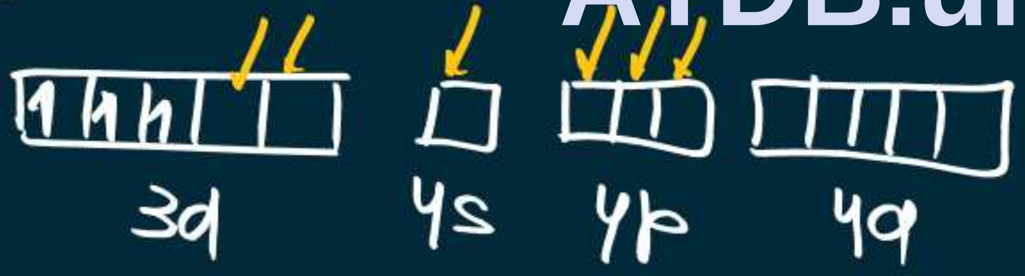
They posses two type of complexes:

(i) Inner orbital octahedral complexes ⟶ These are formed by d_2sp_3 hybridized involving strong ligands. These are also known as Low spin complexes (Less unpaired e^-)

(ii) Outer orbital octahedral complexes ⟶ These are formed by sp_3d_2 hybridization involving weak ligands. These are also known as high spin complexes. (More unpaired e^-)

WFL

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



$Cr + 6NH_3 = +3$

$Cr + 6 \times 0 = +3$

$\boxed{Cr = +3}$

$Cr^{+3} = 4s^0 3d^3$

d^2sp^3

Inner octahedral

$\boxed{n = 3}$

Paramagnetic

wFL

(i) $[Fe(H_2O)_6]^{+3}$

$Fe + 6H_2O = +3$

$Fe + 6 \times 0 = +3$

$Fe + 0 = +3$

$Fe = +3$

$Fe^{+3} \rightarrow 4s^0 3d^5$

sp^3d^2

Outer Octahedral

Paramagnetic

Limitations of VBT

1. This theory doesn't after any explanation about spectra of complex (Colour of the complex)
2. This theory was failed to explain why at one time the electron are rearranged against the Hund's rule and other time electronic configuration is not disturbed.
3. This theory doesn't after any explanation for the existence of inner and outer orbital complexs.

4. $NH_3 \rightarrow$ SFL $\rightarrow$ For higher C.NO i.e Co^{+3}

$NH_3 \rightarrow$ WFL $\rightarrow$ For lower C.NO. i.e Ni^{+2}

Crystal Field Theory A-AA

APM ♥

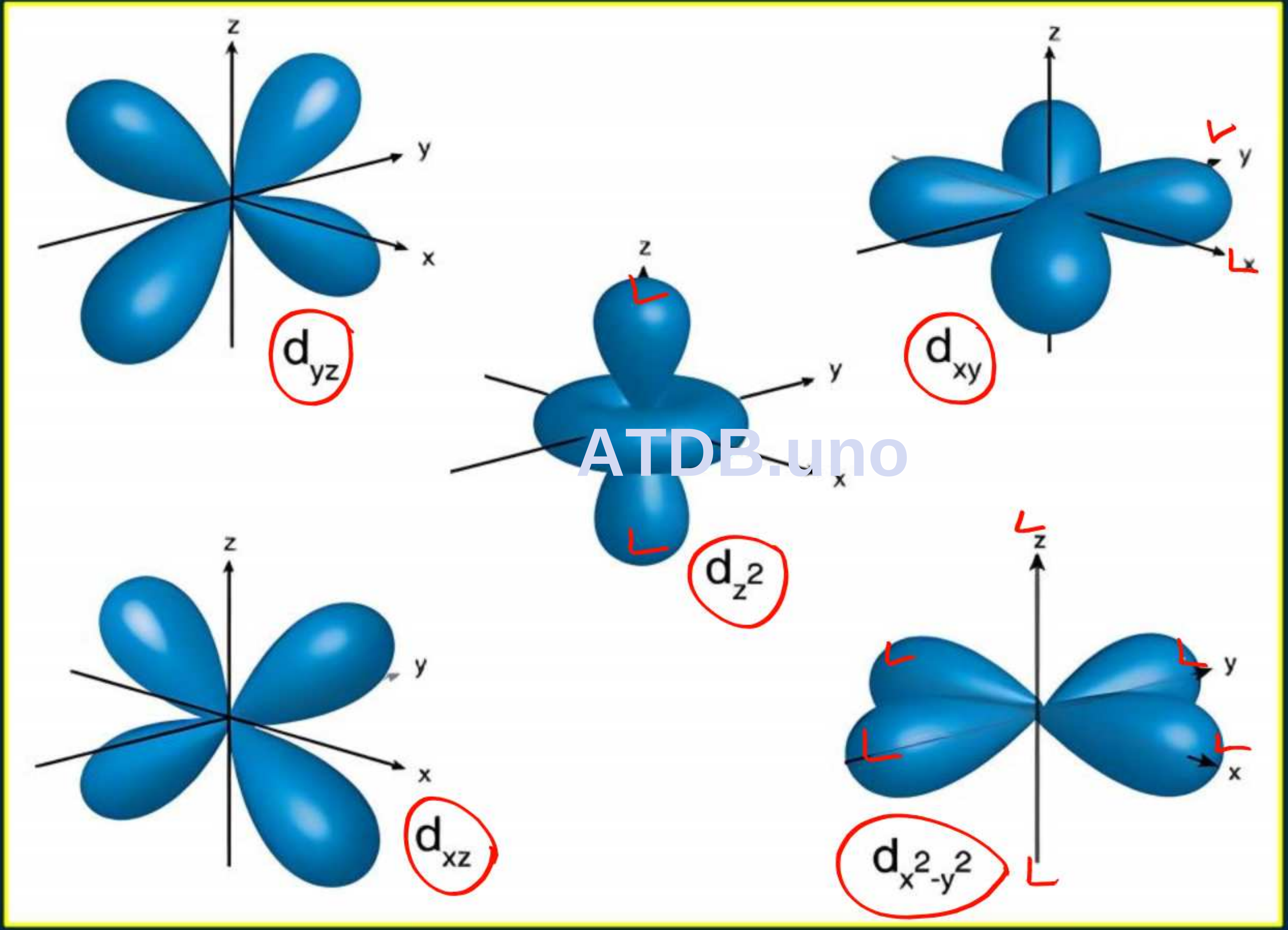
According Crystal Field theory the bonding in complex is not covalent or by overlapping of orbitals but it is purely electrostatic.

There are two types of Force exist between Metal ion and Ligand-

1) Force of attraction $M^+ \leftarrow L^-$

2) Force of Repulsion

Crystal field theory mainly focus on the Force of Repulsion between Lone pair of ligands and Electrons in d orbital of Metal ion.



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

B/w the axis

double dumbell

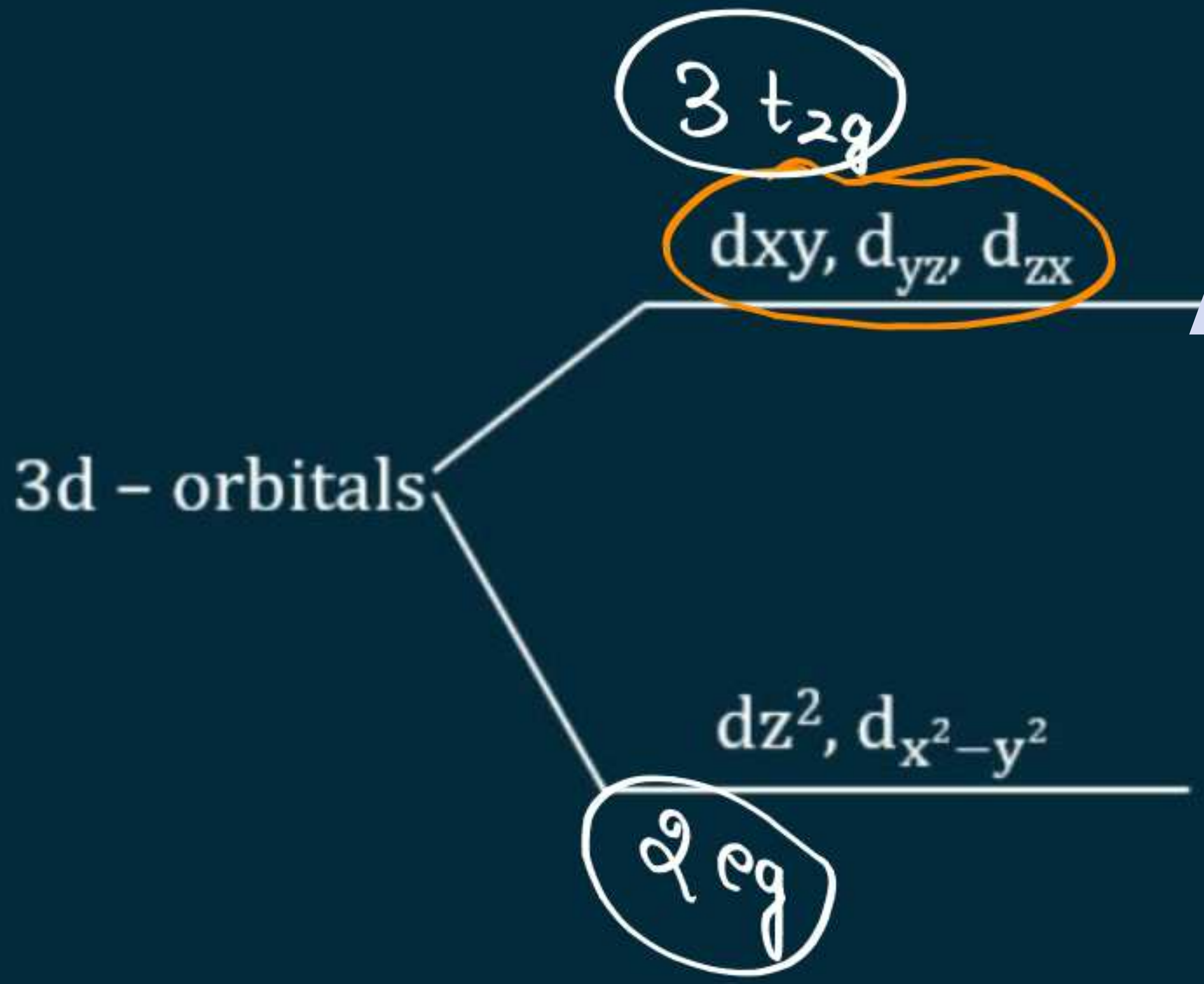
on the axis

Crystal Field Theory

C·NO = 4 | Tetrahedral
C·NO = 6 | Octahedral

In a free transition metal or ion, there are 5d-oribtals which are designated as dxy, dyz, dzx dx^2-y^2, dz^2.

These are divided into two sets:



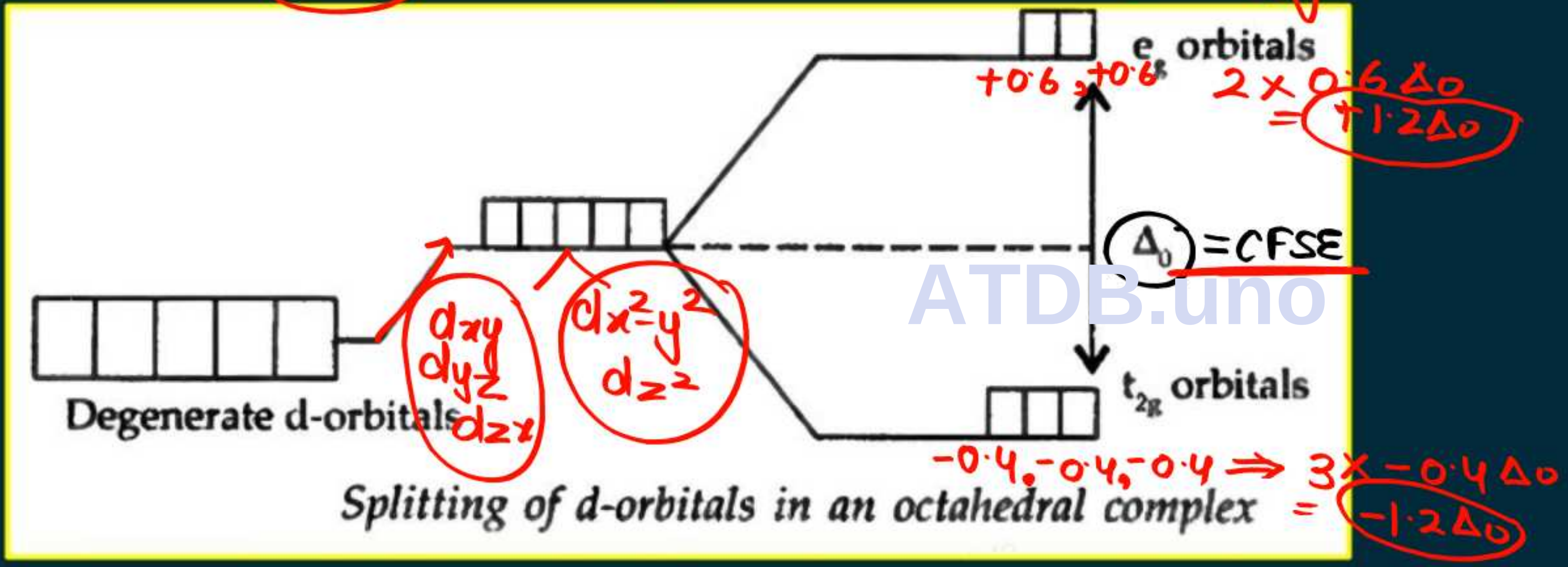
- These orbitals orient in the region between the coordinate axis.
- These are non-axial orbitals
- These are designated as t2g orbitals

- These orbitals orient along the axes are called eg orbitals.
- These are axial orbitals.

Splitting or d-orbitals in octahedral complex

$[ML_6]^{n+}$ → CN=6

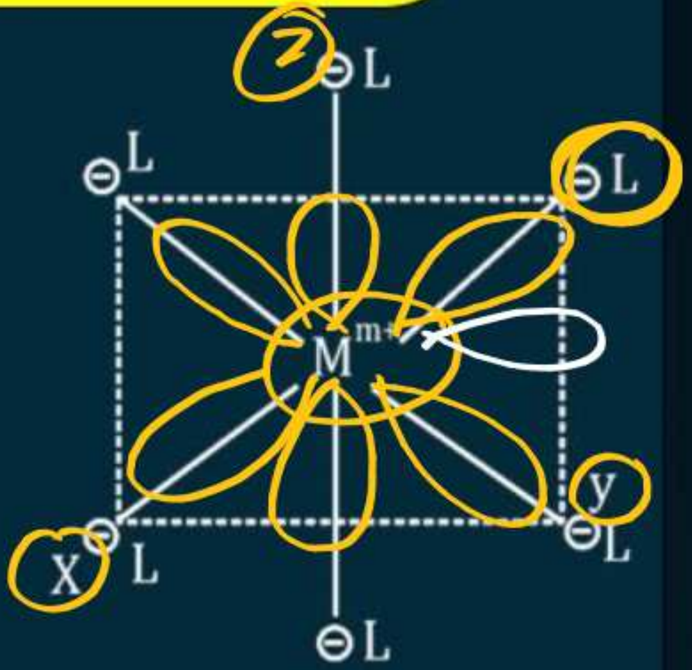
CFSE
↓
Crystal field splitting energy



Splitting of d-orbitals in an octahedral complex

$2 \times 0{\cdot}6\Delta_o = +1{\cdot}2\Delta_o$

$-0{\cdot}4, -0{\cdot}4, -0{\cdot}4 \Rightarrow 3 \times -0{\cdot}4\Delta_o = -1{\cdot}2\Delta_o$

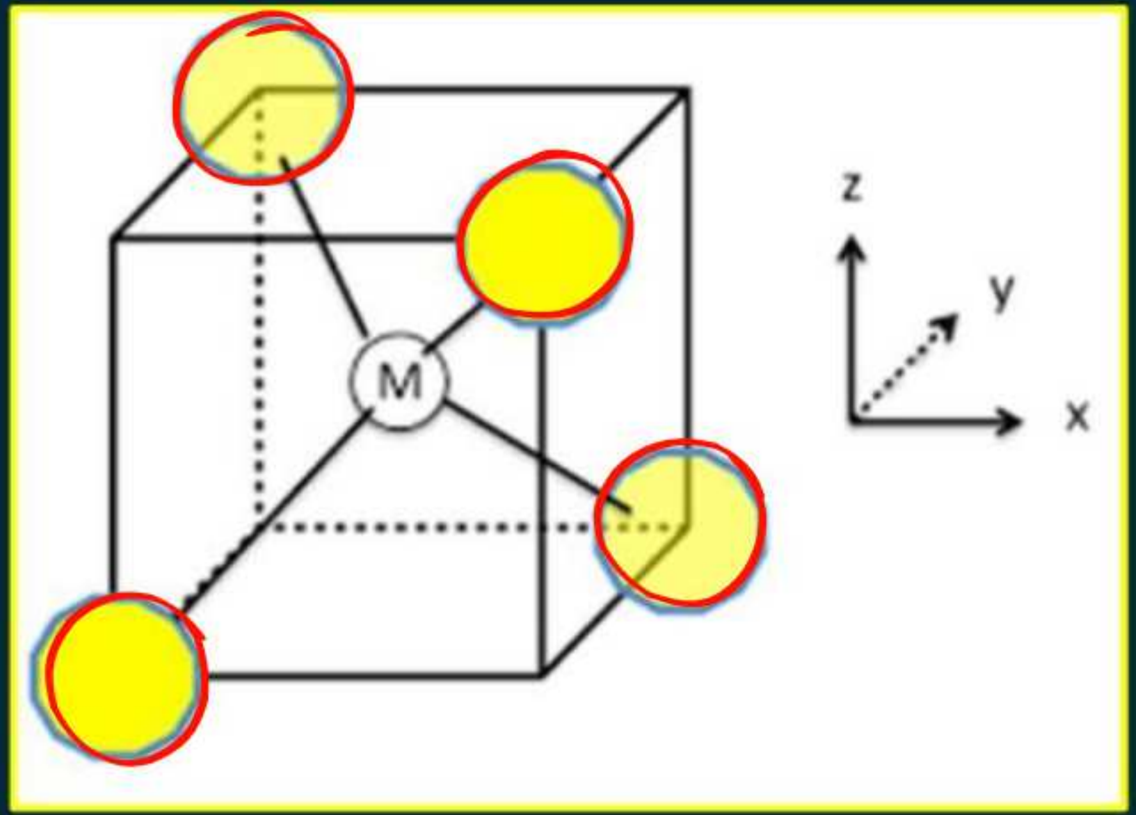


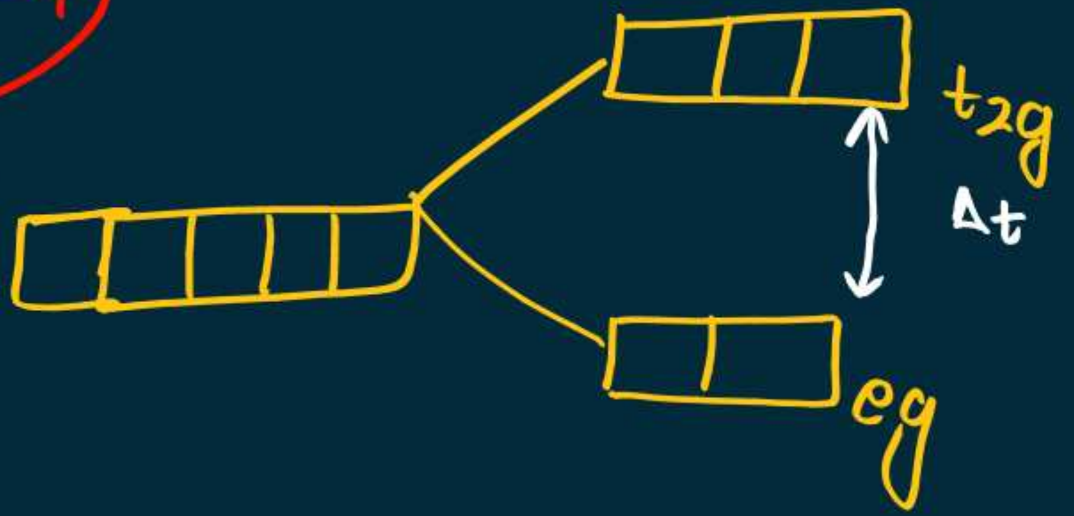
$d_{x^2-y^2}$

Splitting or d-orbitals in Tetrahedral complex

CN=4

$[ML_4]^{n+}$





$\Delta_t < \Delta_o$

$\Delta_o = \frac{4}{9}\Delta_t$

More ligands ⇒ More splitting

Less ligands ⇒ Less splitting

In this case, three d-orbitals i.e t2g orbitals are close to the approaching ligands. As a result of this, t2g electrons suffer more repulsion than eg electron.

Spectrochemical series

For any given metal cation, the magnitude of crystal field splitting energy depends on the nature of the ligands.
The greater the ease with which the ligand can approach the metal ion, the greater will be the splitting caused by it.

$\text{CFSE } L_{S.F} > \text{CFSE } L_{W.K}$

Strong Field Ligand

Ligands which can approach the central metal ion with ease and cause High repulsion thus high splitting.

Weak Field Ligand

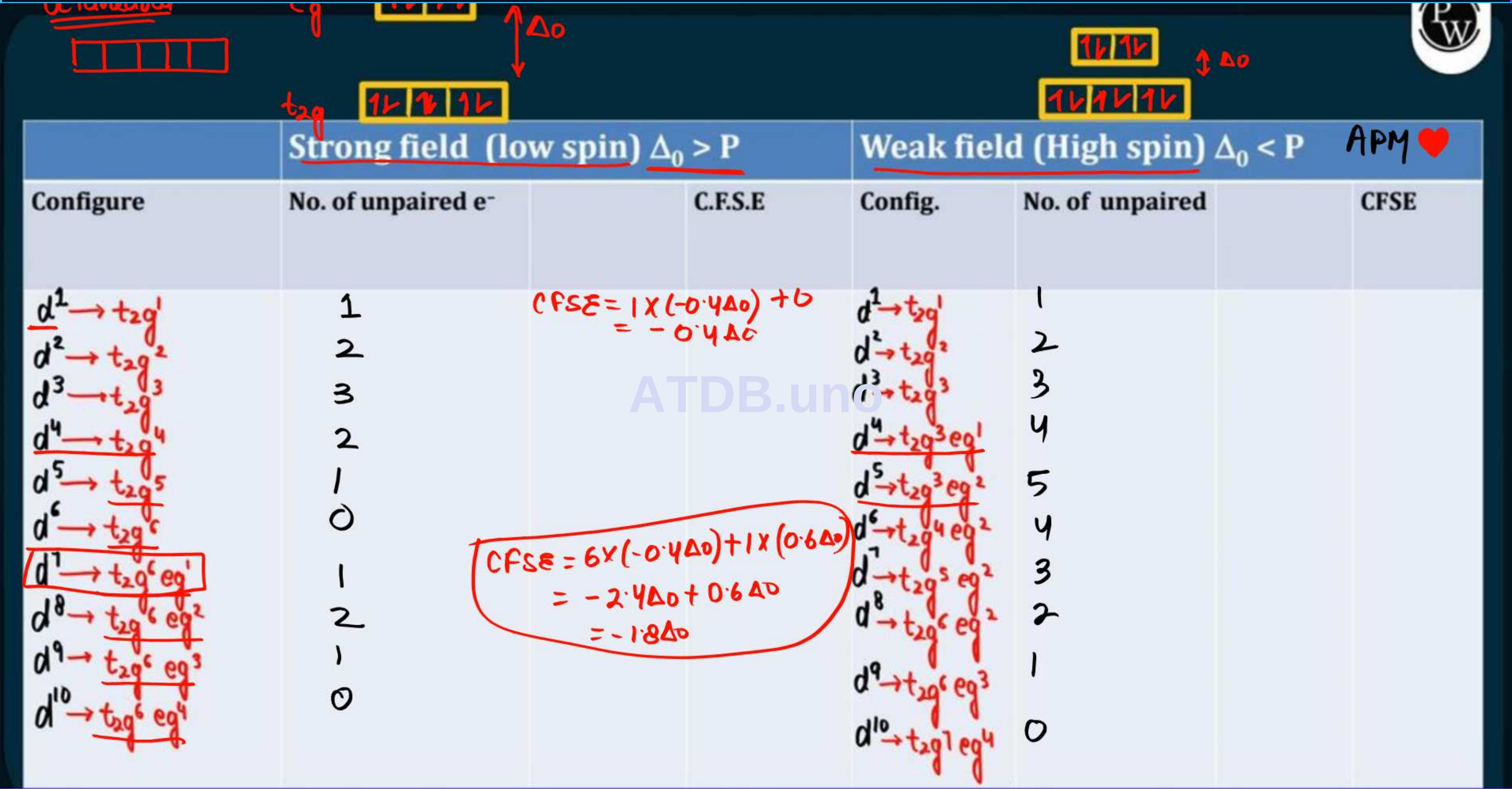
Ligands which can't approach the central metal ion with ease and cause Low repulsion thus less splitting.

I Brought some Colourful sweets from office containing water | Nancy

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

ate Nine in Canteen Corridor

$EDTA < NH_3 < en < CN^-$ CO



APM ♥

	Strong field (low spin) $\Delta_0 > P$			Weak field (High spin) $\Delta_0 < P$			
Configure	No. of unpaired e⁻		C.F.S.E	Config.	No. of unpaired		CFSE
$d^1 \to t_{2g}^1$	1	$CFSE = 1 \times (-0.4\Delta_0) + 0$ $= -0.4\Delta_0$		$d^1 \to t_{2g}^1$	1		
$d^2 \to t_{2g}^2$	2			$d^2 \to t_{2g}^2$	2		
$d^3 \to t_{2g}^3$	3			$d^3 \to t_{2g}^3$	3		
$d^4 \to t_{2g}^4$	2			$d^4 \to t_{2g}^3 e_g^1$	4		
$d^5 \to t_{2g}^5$	1			$d^5 \to t_{2g}^3 e_g^2$	5		
$d^6 \to t_{2g}^6$	0			$d^6 \to t_{2g}^4 e_g^2$	4		
$\boxed{d^7 \to t_{2g}^6 e_g^1}$	1	$CFSE = 6 \times (-0.4\Delta_0) + 1 \times (0.6\Delta_0)$ $= -2.4\Delta_0 + 0.6\Delta_0$ $= -1.8\Delta_0$		$d^7 \to t_{2g}^5 e_g^2$	3		
$d^8 \to t_{2g}^6 e_g^2$	2			$d^8 \to t_{2g}^6 e_g^2$	2		
$d^9 \to t_{2g}^6 e_g^3$	1			$d^9 \to t_{2g}^6 e_g^3$	1		
$d^{10} \to t_{2g}^6 e_g^4$	0			$d^{10} \to t_{2g}^7 e_g^4$	0		

Calculation of CFSE

Octahedral

$$\boxed{\text{C.F.S.E} = \text{No. of } e^- \text{ in } t_{2g} \times (-0.4\Delta_o) + \text{No. of } e^- \text{ in } e_g (+0.6\Delta_o)}$$

QUESTIONS

(a) On the basis of crystal field theory, write the electronic configuration for d^4 with a strong field ligand for which $\Delta_0 > P$. SFL

$\boxed{t_{2g}^4 e_g^0}$

(b) A solution of $[Ni(H_2O)_6]^{2+}$ is green but a solution of $[Ni(CO)_4]$ is colourless. Explain.

PYQ

(2023)

QUESTIONS

The crystal field splitting energy for octahedral (Δ_0) and tetrahedral (Δ_t) complexes is related as

PYQ
(2020)

1. $\Delta_t = 2/9\ \Delta_0$
2. $\Delta_t = 5/9\ \Delta_0$
3. [✓ 3] $\Delta_t = 4/9\ \Delta_0$
4. $\Delta_t = 2\Delta_0$

Samaj Aaya ?

APM

Werner's coordination Theory

Werner proposed coordination theory to explain properties and structure of various coordination compounds.

Primary valency corresponds to oxidation state of the central metal.
It is satisfied by the negative ions. This is also called principle, Ionisable or Ionic valency.
Its attachment to the metal is shown by dotted lines.

- **Secondary valency** is satisfied by neutral molecules or negative ions.
- It represents the coordination no. of the metal
- This valency is non-ionic or non-ionizable. The atoms of the ligands which satisfy the coordination number are directly attached to the metal atom and shown by thick lines.

Example

$COCl_3.6NH_3$

+3

$[CO(NH_3)_6]Cl_3$

P.V=3 S.V=6

P.V = 3
S.V = 6

QUESTIONS

(2023, 24 Jan Shift-I)

The primary and secondary valencies of cobalt respectively in $[Co(\underbrace{NH_3)_5}\underbrace{Cl}]Cl_2$ are

$\boxed{P.V=3}$

$\boxed{S.V=6}$

$Co + 5NH_3 + Cl + 2Cl = 0$

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

$Co + 0 - 1 - 2 = 0$

$Co - 3 = 0$

$\boxed{Co = +3}$

[✓ 1 3 and 6]

2 2 and 6

3 3 and 5

4 2 and 8

QUESTIONS

$+ AgNO_3 \longrightarrow$ white ppt.

$[Co(NH_3)_5SO_4]Cl \longrightarrow Cl^-$

Assertion: $[Co(NH_3)_5SO_4]Cl$ gives a white precipitate with silver nitrate solution. ✓

Reason: The complex dissociates to give Cl^- ✓ and SO_4^{2-} ✓ ions. ✗

(PYQ) 2024

1. Both Assertion (A) and Reason (R) are correct statements, and Reason (R) is the correct explanation of the Assertion (A).
2. Both Assertion (A) and Reason (R) are correct statements, but Reason (R) is not the correct explanation of the Assertion (A).
3. [✓ 3] Assertion (A) is correct, but Reason (R) is incorrect statement
4. Assertion (A) is incorrect, but Reason (R) is correct statement.

QUESTIONS

One mole of $\underbrace{CrCl_3\cdot 6H_2O}$ compound reacts with excess $\underbrace{AgNO_3}$ solution to yield $\underbrace{\text{two moles of}}$ $\boxed{AgCl(s)}$.

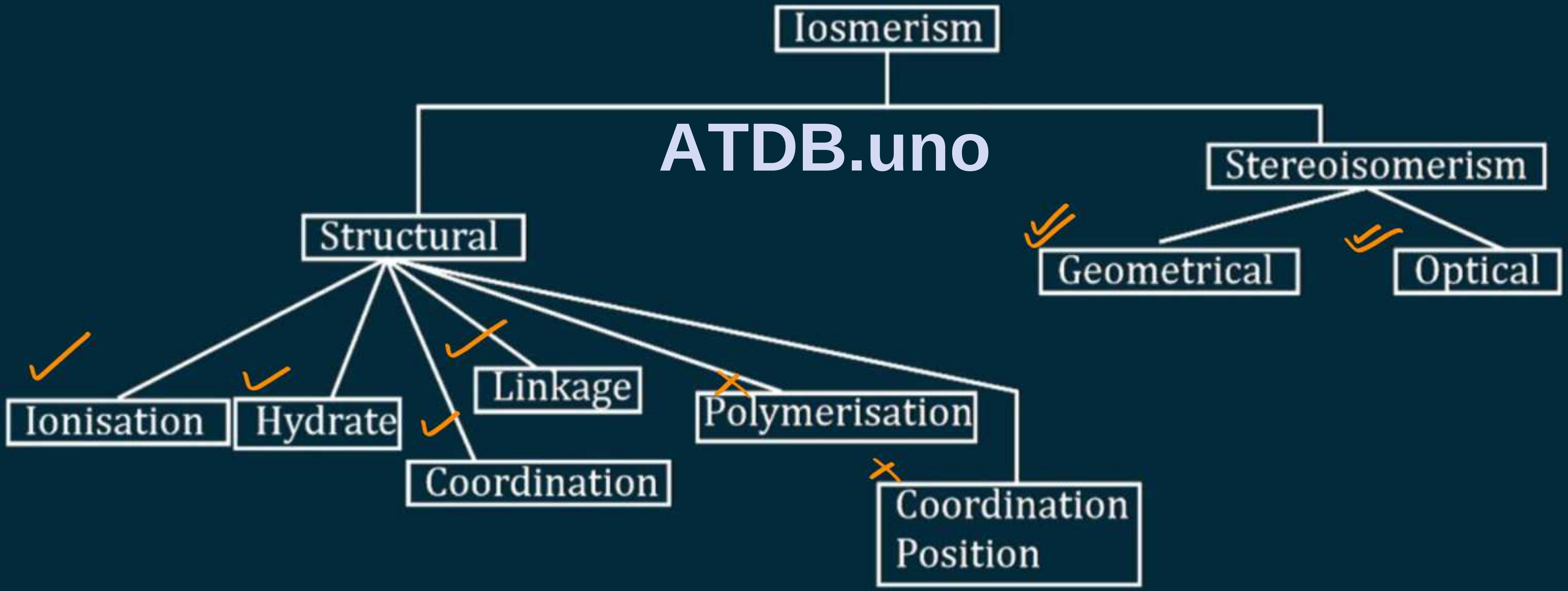
The structural formula of the compound is:

(PYQ) $\boxed{2023}$

1. $[Cr(H_2O)_5Cl] \mid Cl_2\cdot H_2O$ ✓ $\rightarrow 2Cl^-$
2. $[Cr(H_2O)_3Cl_3]\cdot 3H_2O$
3. $[Cr(H_2O)_4Cl_2] \mid Cl\cdot 2H_2O$ $\rightarrow Cl^-$
4. $[Cr(H_2O)_6] \mid Cl_3$ $\rightarrow 3Cl^-$

Isomerism in coordination compounds

The compounds have same molecular formula but different physical and chemical properties on account of different structures or spatial arrangement are called isomers.



- Iosmerism
  - Structural
    - ✓ Ionisation
    - ✓ Hydrate
    - ✓ Coordination
    - ✓ Linkage
    - ✗ Polymerisation
    - ✗ Coordination Position
  - Stereoisomerism
    - ✓ Geometrical
    - ✓ Optical

Structural

(i) Ionisation

When the coordination compound having same empirical formula give different ions in solution .

$[Co(NH_3)_5 SO_4]Br \rightarrow$ yellow AgBr

$[Co(NH_3)_5 Br]SO_4 \rightarrow$ white $BaSO_4$

(ii) Hydrate Isomerism ✓

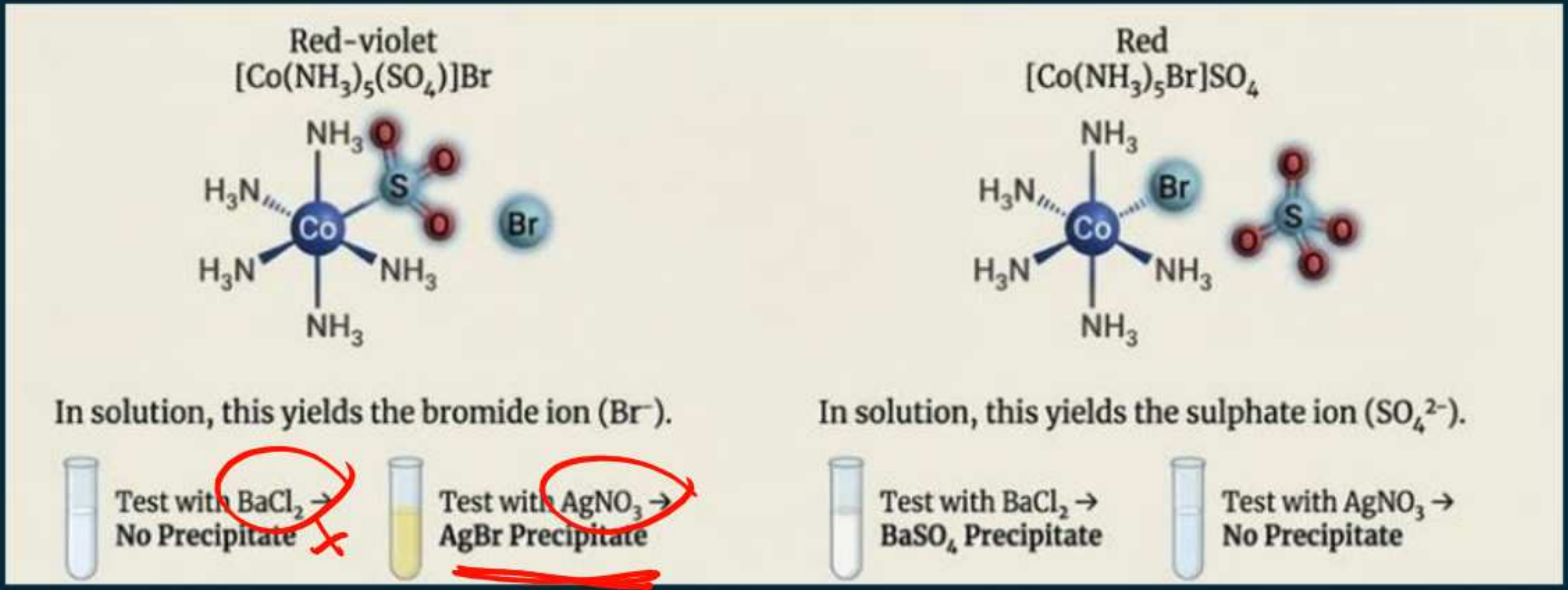
When the empirical formula of coordination comp. is same but have different no. water molecules inside and outside the coordination sphere

Example:

$[Cr(H_2O)_6]Cl_3 \rightarrow$ Voilet

$[Cr(H_2O)_5Cl]Cl_2.H_2O \rightarrow$ Green

$[Cr(H_2O)_4Cl_2]Cl.\ 2H_2O \rightarrow$ Green



Red-violet
$[Co(NH_3)_5(SO_4)]Br$

In solution, this yields the bromide ion (Br^-).

Test with $BaCl_2 \rightarrow$ No Precipitate ✗

Test with $AgNO_3 \rightarrow$ AgBr Precipitate

Red
$[Co(NH_3)_5Br]SO_4$

In solution, this yields the sulphate ion (SO_4^{2-}).

Test with $BaCl_2 \rightarrow$ $BaSO_4$ Precipitate

Test with $AgNO_3 \rightarrow$ No Precipitate

Coordination Isomerism

When the empirical formula of coordination compound is same but both having both cationic and anionic complex ion.

Then Ligands are interchanged in both cationic and anionic ions to form isomers.

Example

$\overset{+}{[Pt(NH_3)_4]}\overset{-}{[CuCl_4]}$ and $[Cu(NH_3)_4]\ [PtCl_4]$

$[Cr(NH_3)_6][Co(C_2O_4)_3]$ and $[Co(NH_3)_6]\ [Cr(C_2O_4)_3]$

Linkage Isomerism

This type of isomerism occurs in complex compound. Which contain ambidentate ligands like NO^-_2, SCN^-, $S_2O^{2-}_3$ and CO. These ligands have two donor atoms but at a time only 1 atoms is directly linked to the central metal of the complex.

Example: $[Co(NH_3)_5NO_2]Cl_2$ ✓ and $[Co(NH_3)_5ONO]Cl_2$ ✓

QUESTIONS

The compounds $[Co(SO_4)(NH_3)_5]Br$ and $[Co(Br)(NH_3)_5]SO_4$ represent: (PYQ) 2023

1 Optical isomerism
[✓ 3] Ionisation isomerism
2 Linkage isomerism
4 Coordination isomerism

QUESTIONS

Assertion (A): Linkage isomerism arises in coordination compounds because of ambidentate ligand.
Reason (R): Ambidentate ligand like NO_2 has two different donor atoms i.e., N and O.

2024

(PYQ)

[✓ 1] Both Assertion (A) and Reason (R) are correct statements, and Reason (R) is the correct explanation of the Assertion (A).

2 Both Assertion (A) and Reason (R) are correct statements, but Reason (R) is not the correct explanation of the Assertion (A).

3 Assertion (A) is correct, but Reason (R) is incorrect statement

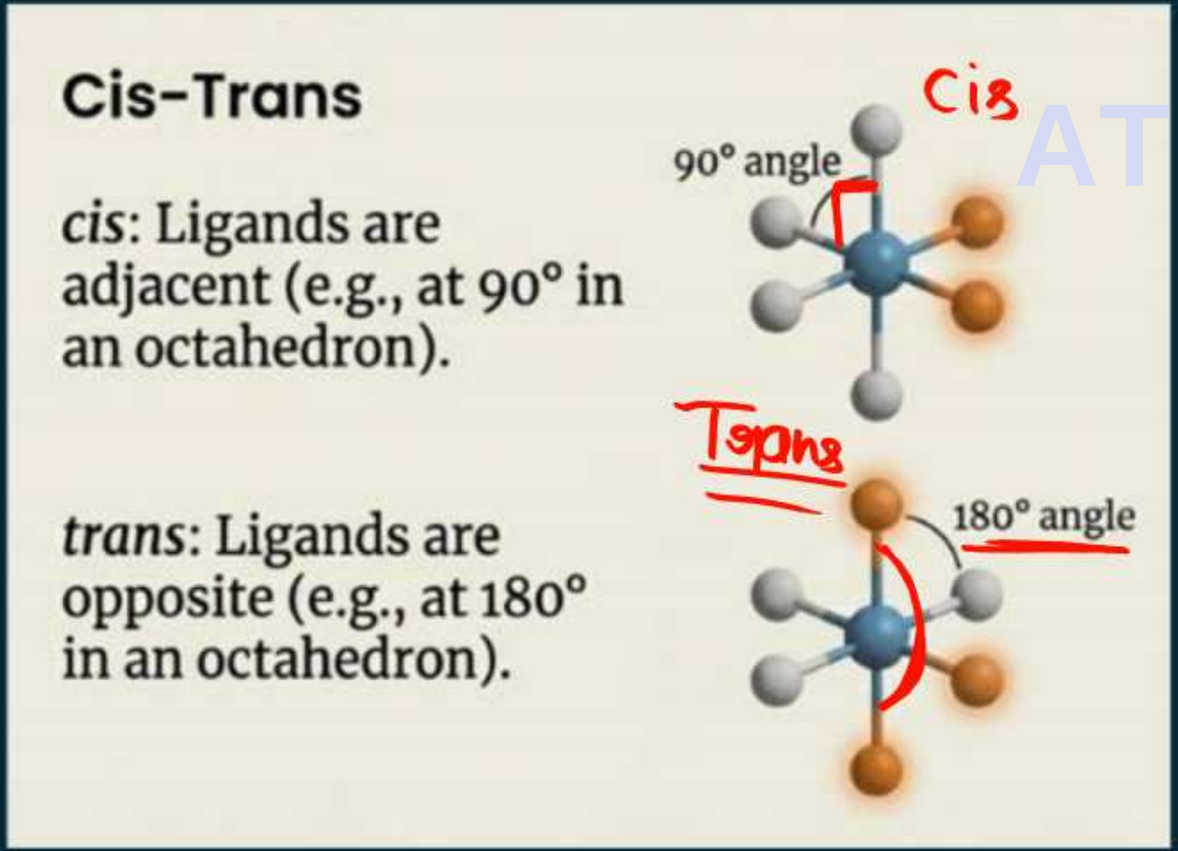
4 Assertion (A) is incorrect, but Reason (R) is correct statement.

Stereoisomerism

1. Geometrical isomerism

The isomerism is due to ligands occupying different position around the central metal atom or ion. The ligands occupy positions either adjacent or opposite to one another.

This type of isomerism is called as Cis-trans isomerism

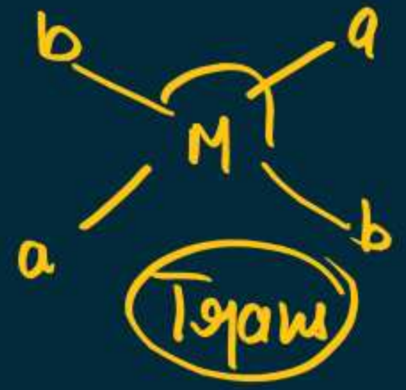


Cis-Trans

cis: Ligands are adjacent (e.g., at 90° in an octahedron).

trans: Ligands are opposite (e.g., at 180° in an octahedron).

Ma_2b_2



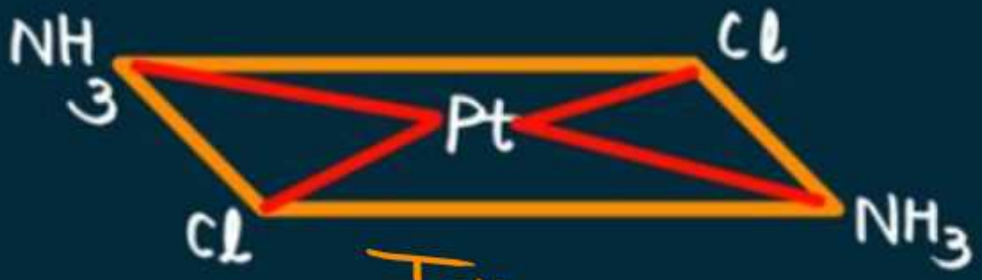
Square planar complexes

Square Planar ✓
Tetra ×
C.N= 6
↓
Octahedral

(a) Ma_2b_2, Where a and b both are monodentate.

PYQ** $[Pt(NH_3)_2(Cl_2)]$

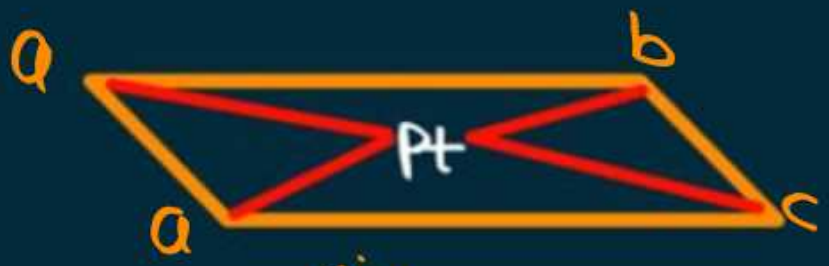
Cis



Trans

(b) Ma_2bc, where a, b, c are monodentate

$[Pt(NH_3)_2(Cl)NO_2]$

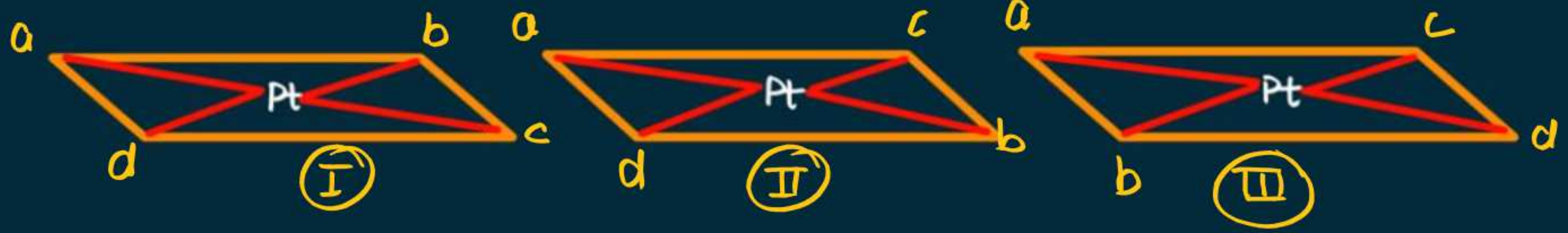


Cis

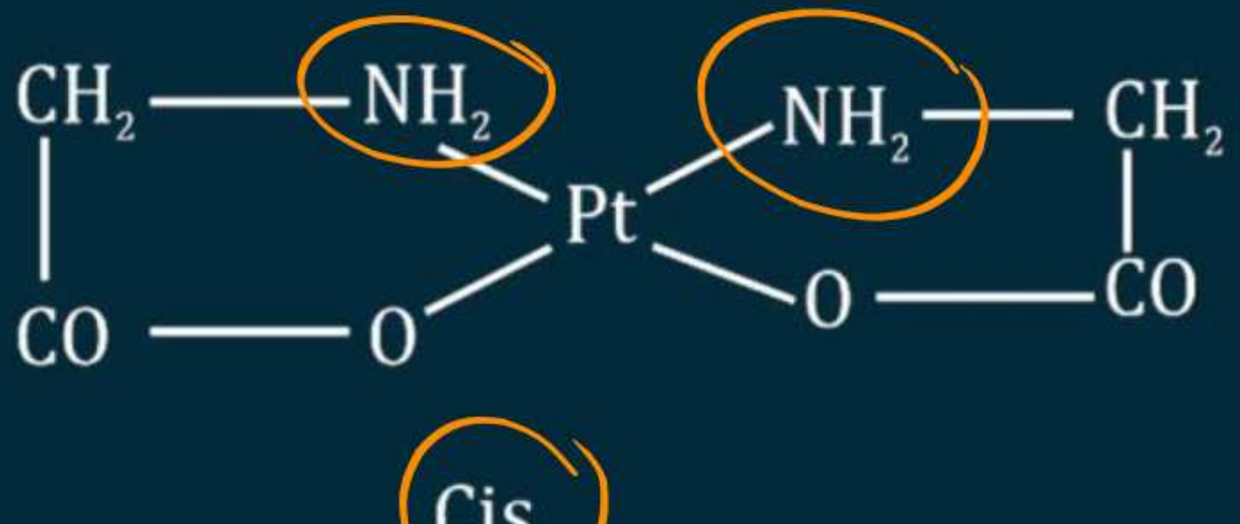
Trans

(c) Mabcd, Where a, b, c, d are monodentate

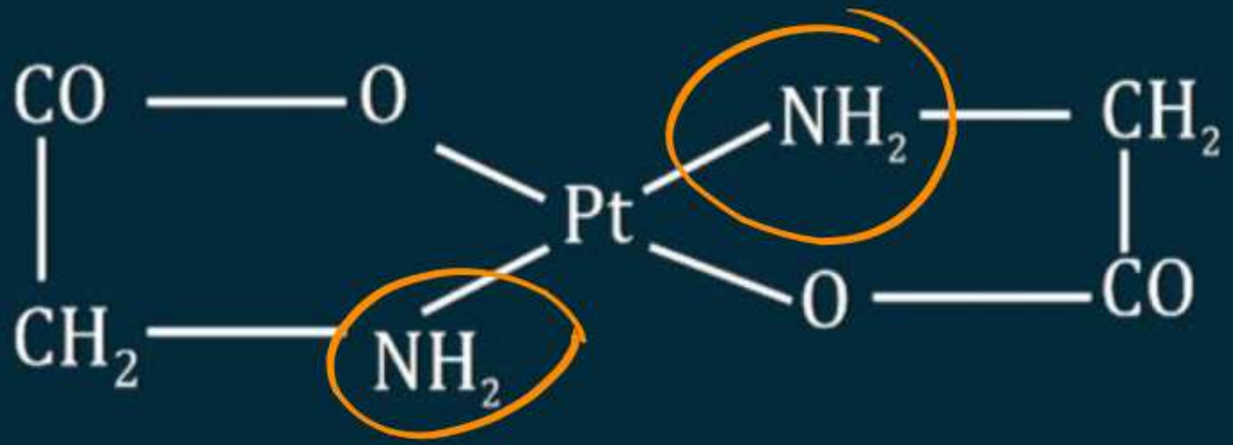
$[Pt(NH_3)(NH_2OH)(NO_2)(Py)]NO_2$



(d) Square planar complexes having unsymmetrical bidentate ligands can also show geometrical isomerism



Cis

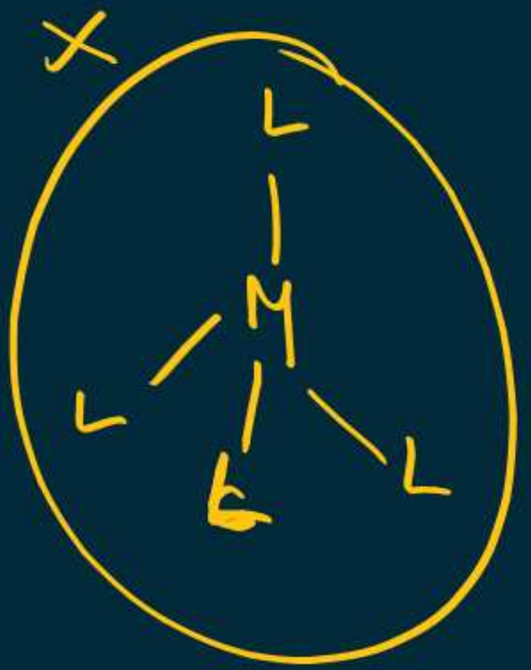


Trans.

Important notes

square planar

1. Geometrical isomerism is not observed in complexes of C.No. 2 and 3
2. Square planner of type Ma_4, Ma_3b and Mab_3 do not show geometrical isomerism ✓
3. Geometrical isomerism is not observed in complex of C.NO. 4 of tetrahedral geometry. All positions are adjacent to one another.



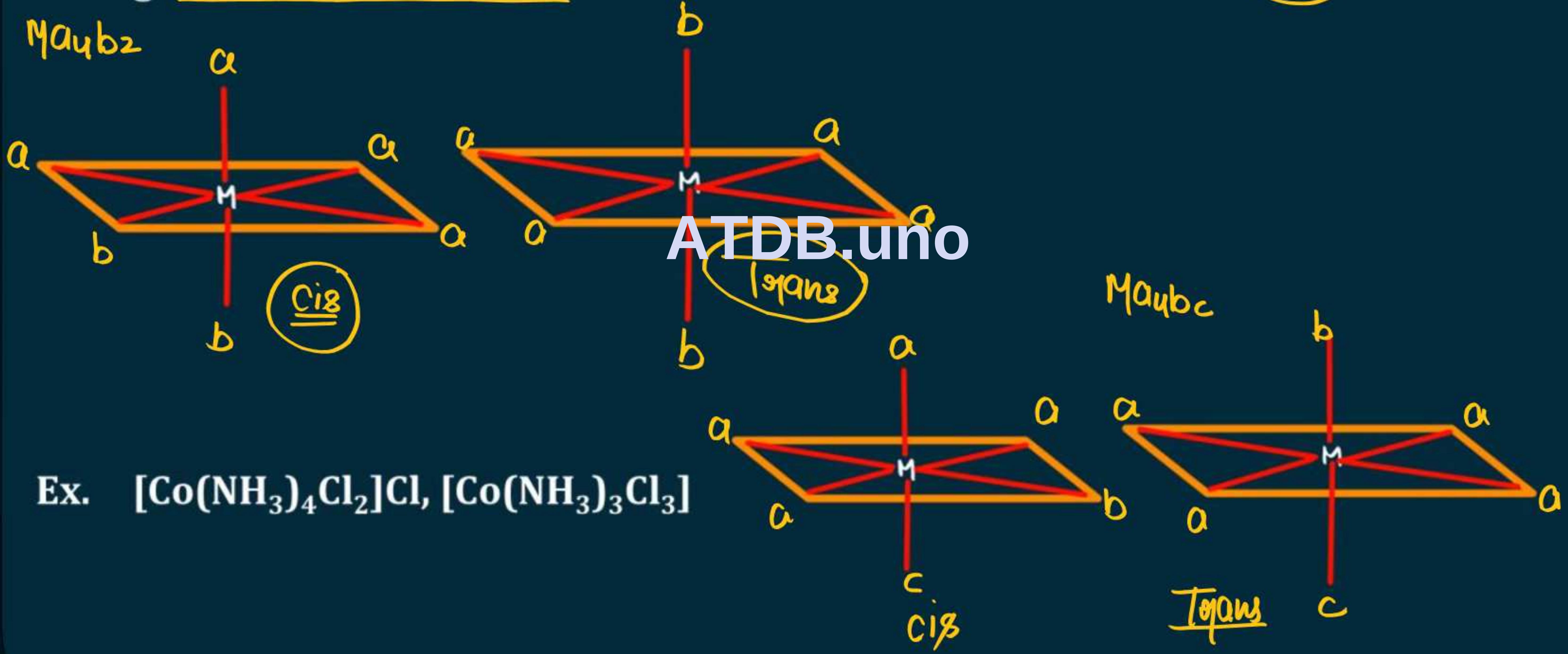
CN=2 X
CN=3 X
C.N=4
S.P ✓
T.H X

$Ma_2bc \rightarrow 2$
$Ma_2b_2 \rightarrow 2$
$Mabcd \rightarrow 3$
$Ma_4 \rightarrow 0$
$Ma_3b \rightarrow 0$
$Mab_3 \rightarrow 0$

Octahedral Complexes (C.No = 6)

(a) Octahedral complexes of the type Ma_4B_2, Ma_2B_4, Ma_4bc and Ma_3b_3 exhibit geometrical isomerism

✓ ✓ ✓ ✓ **



Ex. $[Co(NH_3)_4Cl_2]Cl$, $[Co(NH_3)_3Cl_3]$

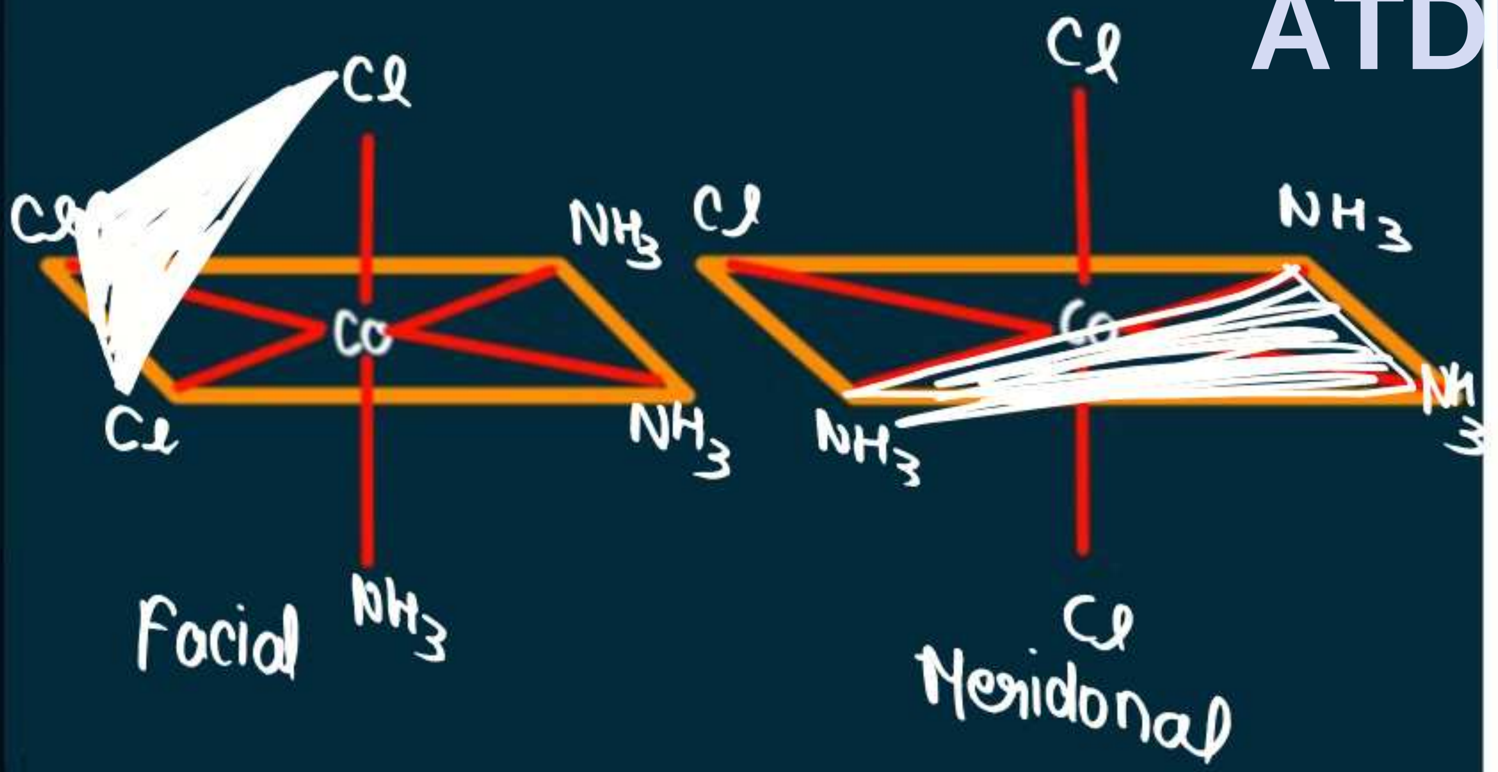
Note :

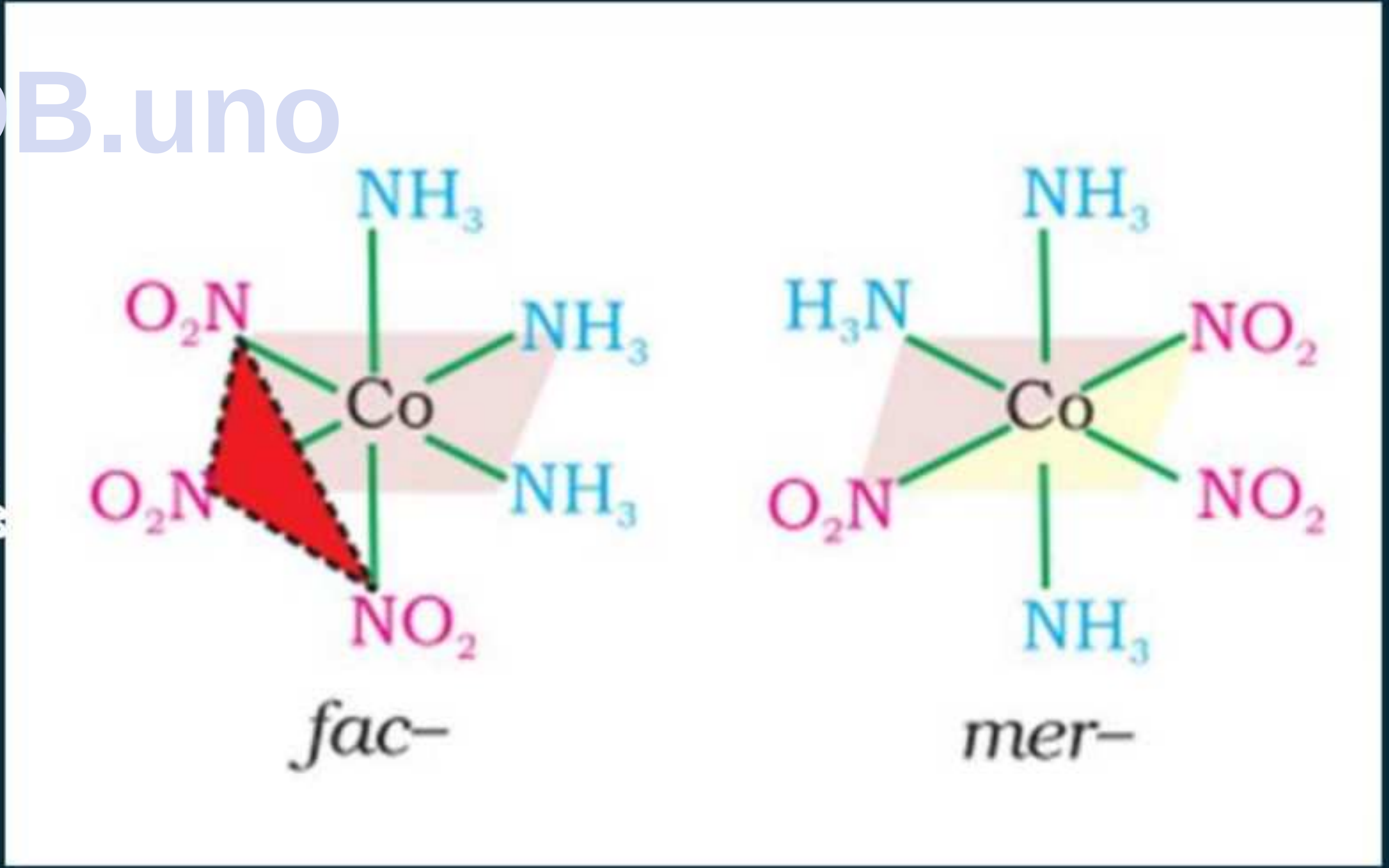
Cis-Trans

** Ma_3b_3 type octahedral complex do not exhibit cis and trans isomerism, they exhibit facial and meridional isomerism.

Example

$[CO(NH_3)_3Cl_3]$ and $[CO(NH_3)_3(NO_3)_3]$





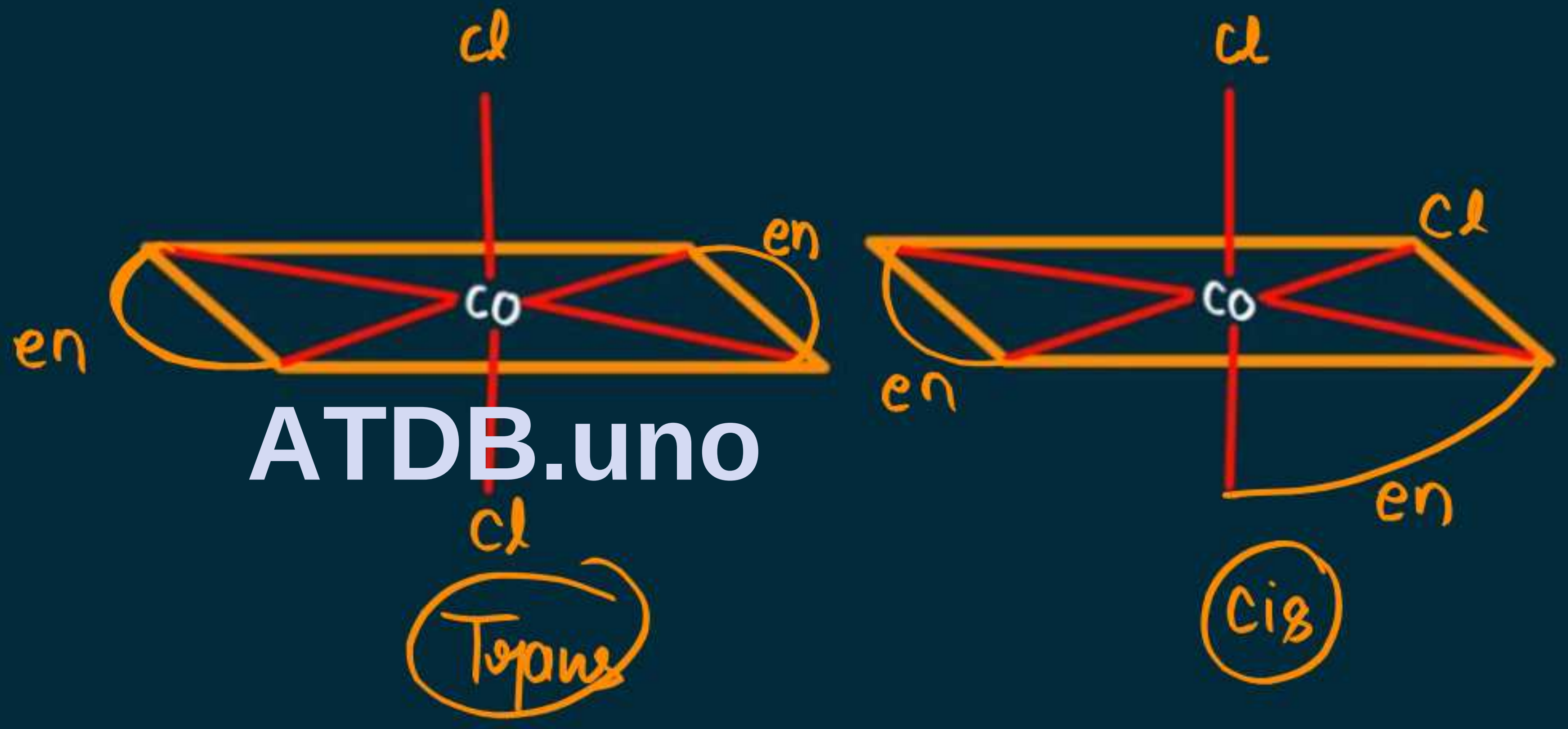
fac– *mer–*

APM ♥

(b) Octahedral complexes having bidentate ligands of the type $M(aa)_2b_2$ or $M(aa)_2bc$ can also exist in cis-trans isomers where aa is symmetrical bidendate ligands

Example

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



QUESTIONS

(2019)

Write IUPAC name of the complex $[Pt(en)_2Cl_2]$.

Draw structures of geometrical isomers for this complex.

Optical Isomerism

- A coordination compound which can rotate the plane of polarized light is said to be optically active.
- When the coordination compounds have same formula but differ in their abilities to rotate directions of the plane of polarized light are said to be exhibit optical isomers and molecules are optical isomers.
- The optical isomers are pair of molecules which are non-superimposable mirror images of each other.
- The essential requirement for a substance to be optically active is that the substance should not have a plane of symmetry in its structure.

Axis of Symmetry

Coordination
✓
No POS
No AOS

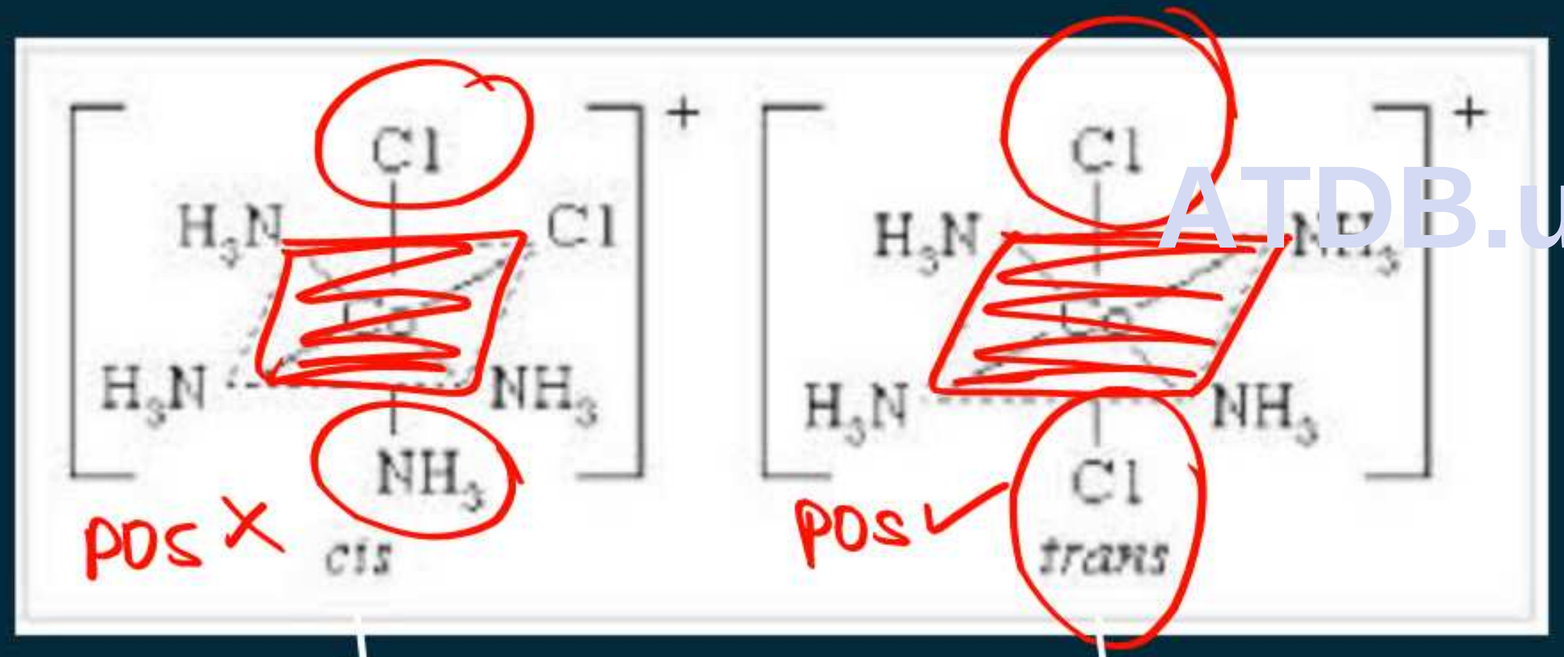
Mirror Image
① Non-superimpo

Laeveo Enantiomer Dextro

Note : -

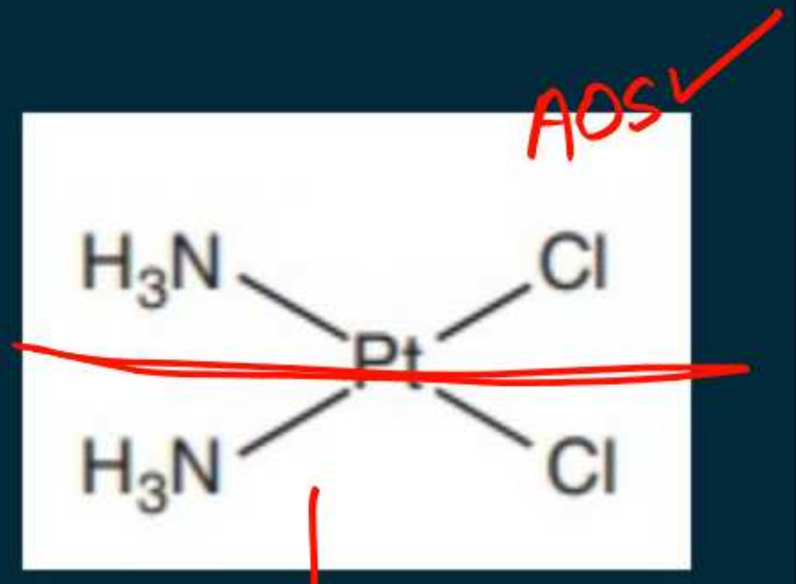
Plane of symmetry → Plane that divides the structure into 2 equal/superimposable /halves or 2 parts are mirror images of each other.

Axis of symmetry → Axis (line) that divides the structure into 2 equal/superimposable structure/halves.



↓ Optical iso.

↓ POS ✓
No optical iso.



↓ square planar
AOS ✓
↓ No optical isomerism.

- **Optical isomers rarely occurs in square planar complexes on account of the presence of axis of symmetry**

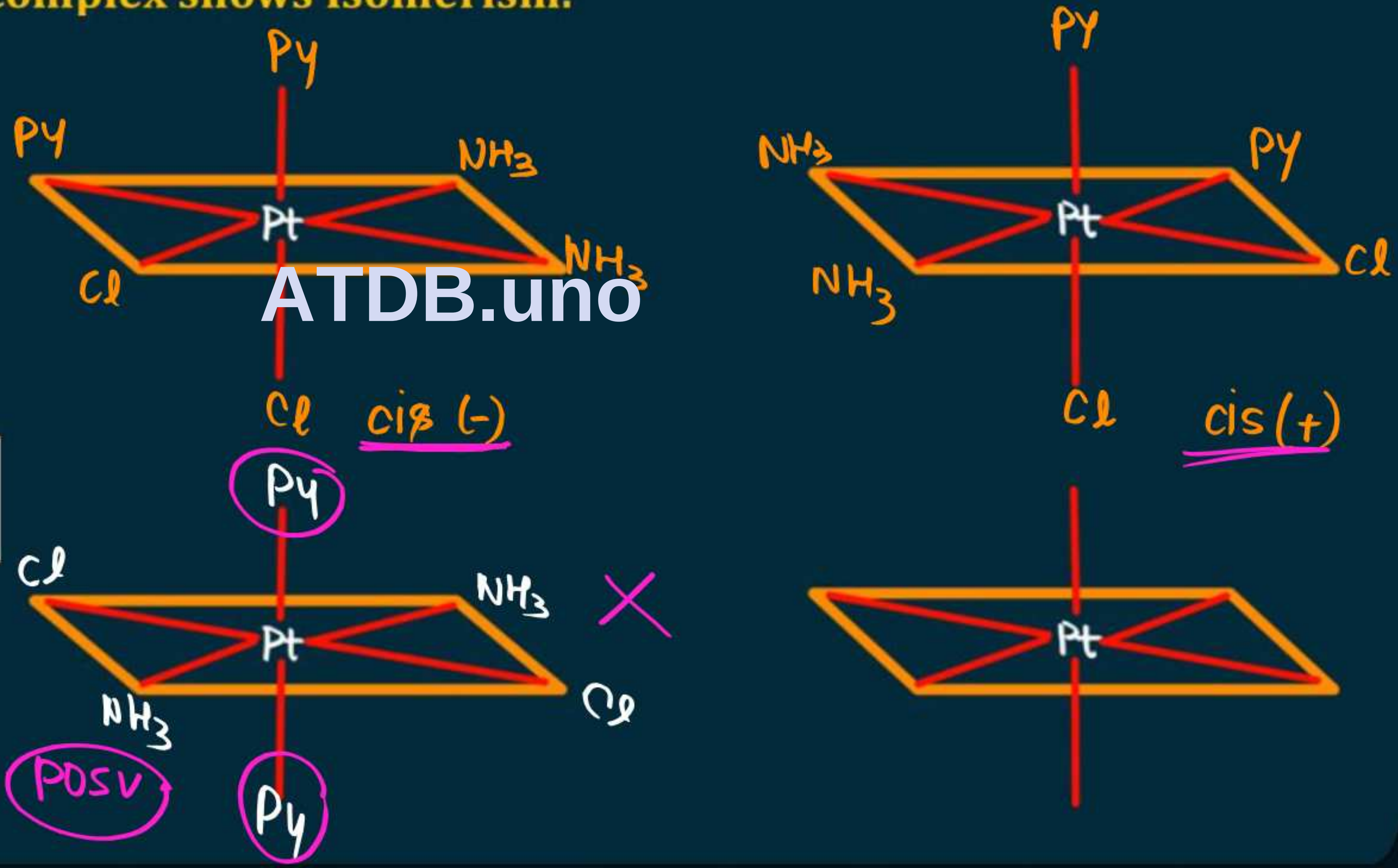
Examples of octahedral complex shows Isomerism.

Ex.

$[Pt(Py)_2(NH_3)_2Cl_2]$

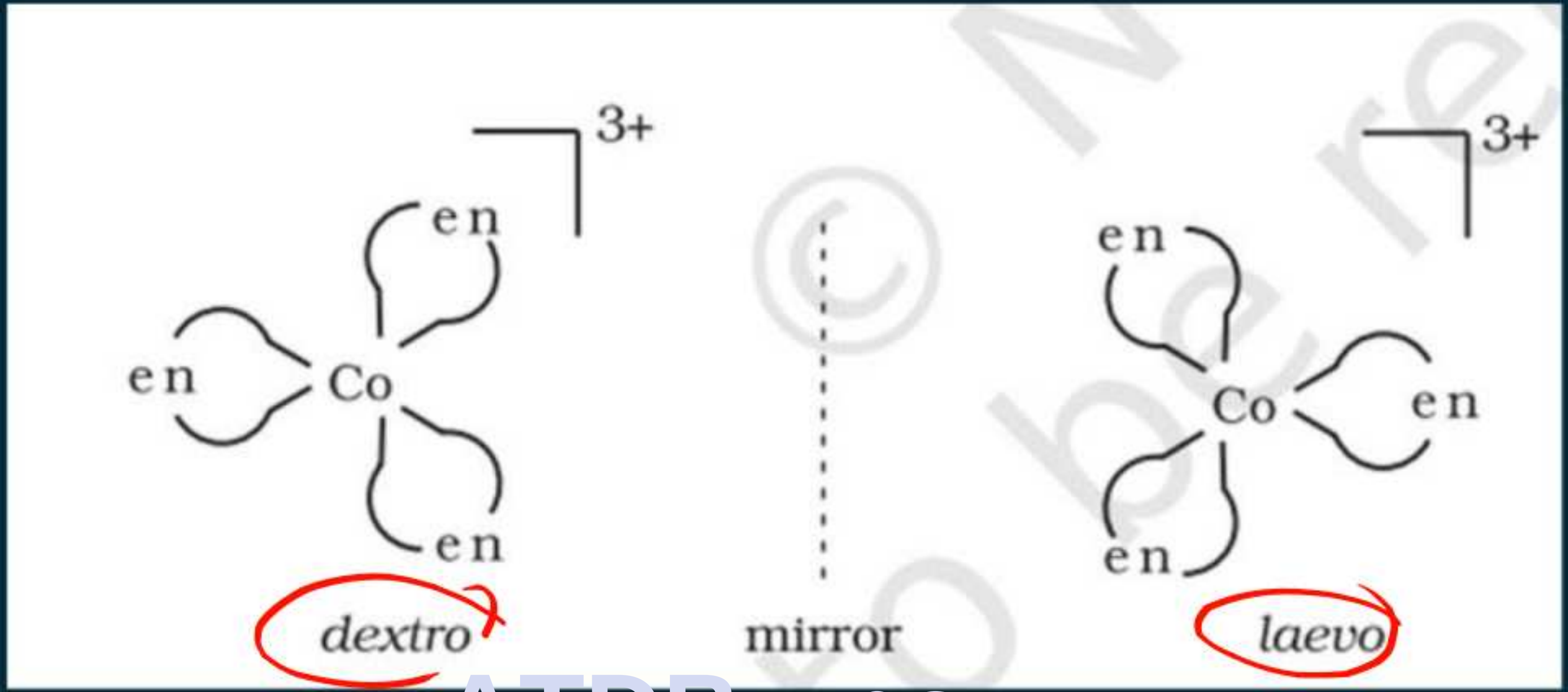
Cis

Trans ×



APM

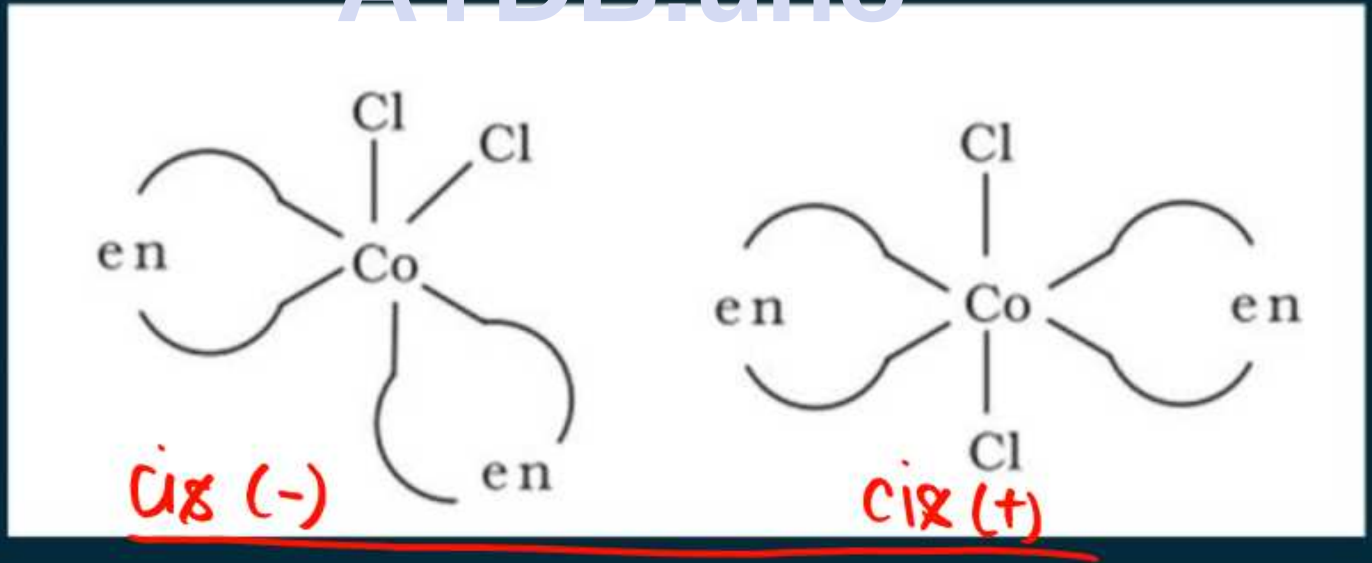
$[Co(en)_3]^{3+}$



$[Co(en)_2Cl_2]^+$

cis

Trans ×



Colour of coordination compound

Some of the visible spectrum is being removed from white light as it passes through the sample, so the light that emerges is no longer white.

The colour of the complex is complementary to that which is absorbed. The complementary colour is the colour generated from the wavelength left over.

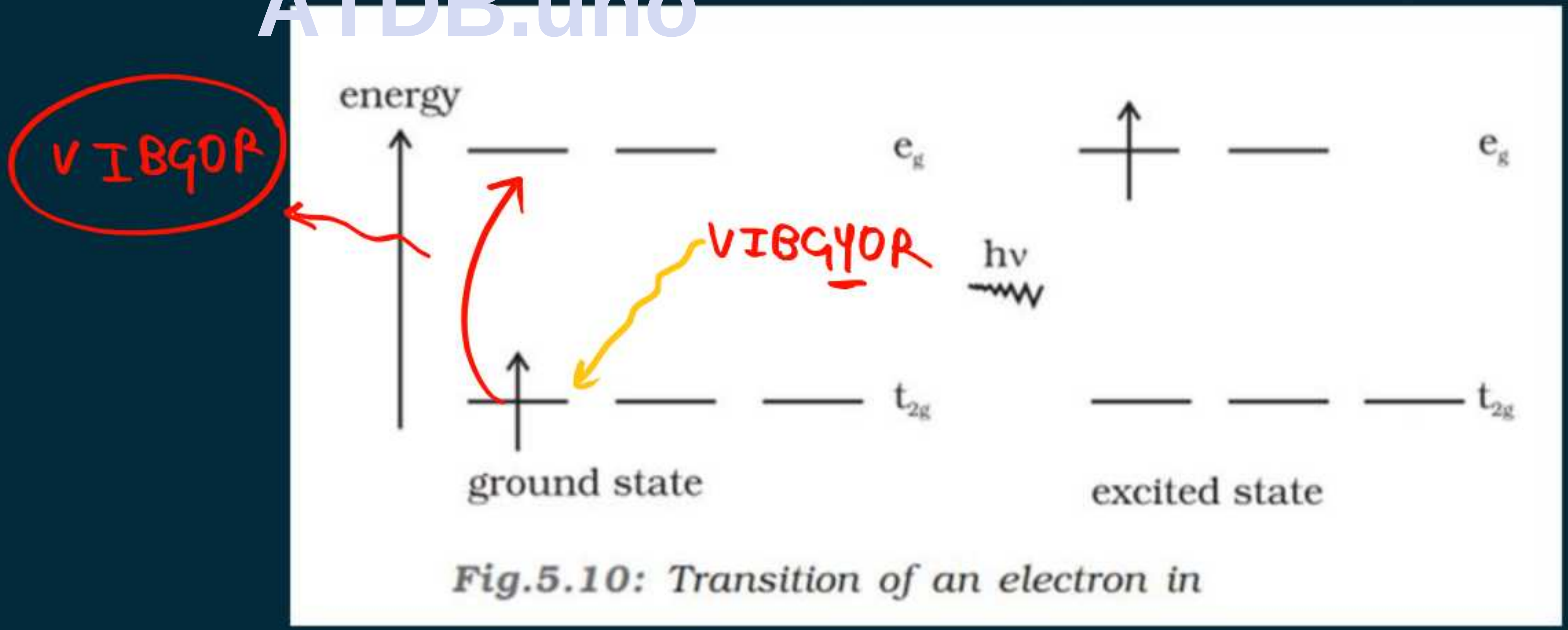
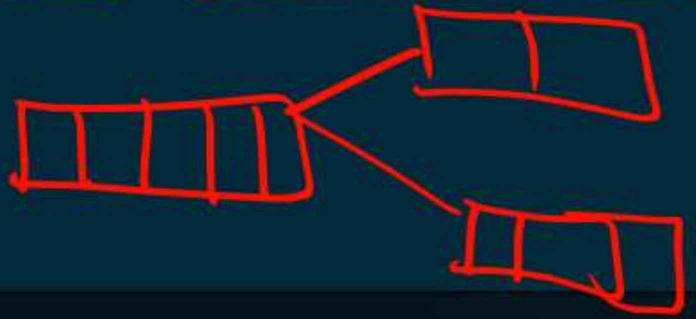


Fig.5.10: Transition of an electron in

Coloured

Coordinaton entity	Wavelength of light absorbed (nm)	Colour of light absorbed		Colour of coordination entity	
$[CoCl(NH_3)_5]^{2+}$	535	Yellow	🟨	Violet	🟪
$[Co(NH_3)_5(H_2O)]^{3+}$	500	Blue Green	🟩	Red	🟥
$[Co(NH_3)_6]^{3+}$	475	Blue	🟦	Yellow Orange	🟧
$[Co(CN)_6]^{3-}$	310	Ultraviolet	Not in visible region	Pale Yellow	🟨
$[Cu(H_2O)_4]^{2+}$	600	Red	🟥	Blue	🟦
$[Ti(H_2O)_6]^{3+}$	498	Blue Green	🟩	Violet	🟪

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 $[Ti(H_2O)_6]Cl_3$ on heating renders it colourless. Similarly, anhydrous $CuSO_4$ is white, but $CuSO_4 . 5H_2O$ is blue in colour.



Organometallic compounds

Compounds that contain at least one carbon-metal bond are called organometallic compound.

$R-MgX$

CH_3CH_3-MgX

Ex.

Grignard reagent (RMgx), [Fe(CO)4]

$[Fe(CO)_5]$

$[Ni(CO)_4]$

Organometallic compounds may be classified into 3 classes

(A) Sigma (σ) bonded complexes

(B) Pi (π) bonded complexes

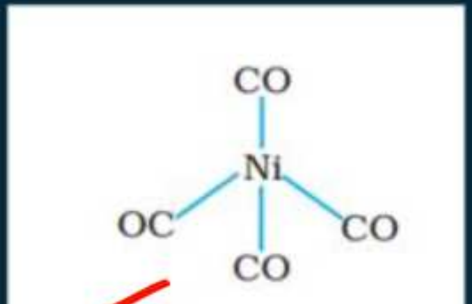
(C) Complex containing both σ and π → Metal carbonyl

Metal carbonyl

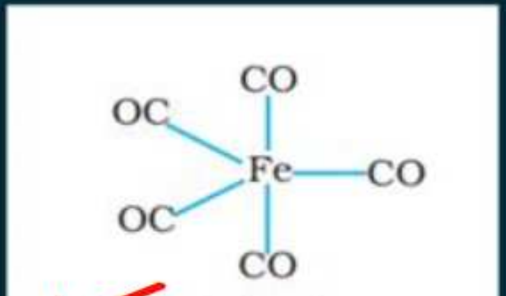
The Homoleptic carbonyls are formed by most of the transition metal

Tetra carbonyl Nickel

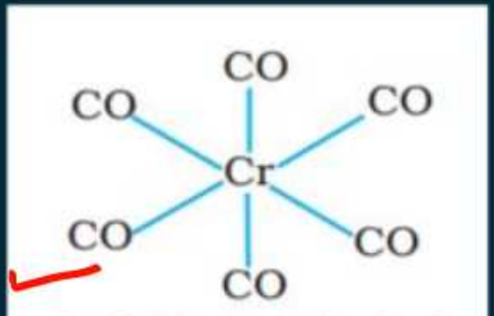
Pentacarbonyl Iron



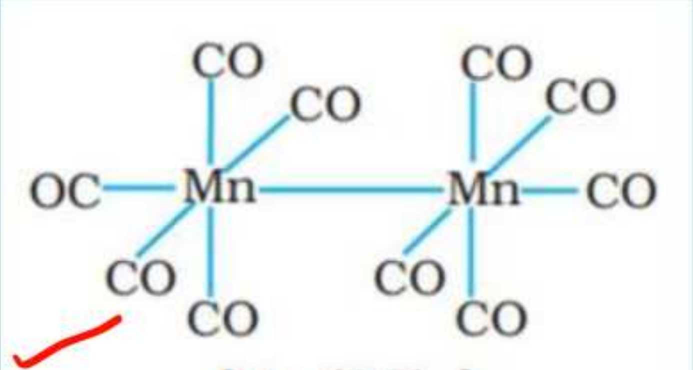
Ni(CO)$_4$
Tetrahedral



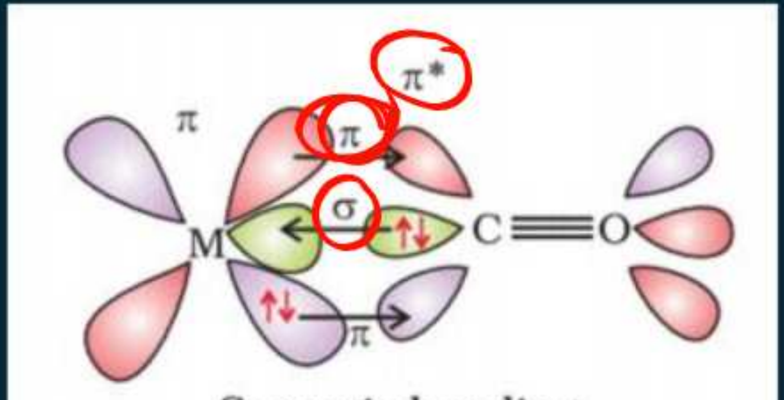
Fe(CO)$_5$
Trigonal bipyramidal



Cr(CO)$_6$ Octahedral



[Mn$_2$(CO)$_{10}$]



Synergic bonding

- The metal –carbon bond in metal carbonyl posses both σ and π character.
- The M-C σ bond is formed by the donation of lone pair of e⁻ of the carbonyl carbon into vacant orbital of the metal
- The M–C π bond is formed by the donation of a pair electron from a filled d-orbital of metal into the vacant antibonding π* orbital of CO.

Samaj Aaya ?

compeut · OC

Sample paper

High weightage

APM

Thank You