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*Where Minds Pollinate*

## Class 12
## Chemistry

# Chapter 6
# Transition Elements
## Handwritten Notes

# CH#6 TRANSITION METALS

Transition elements:-

Elements in which outermost orbital is d or f which is partially filled are called Transition elements.

e.g:- Cobalt $_{27}Co = 1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^2, 3d^7$

d-block elements are also called outer transition element
f-block elements are also called inner transition element.

Why are they called Transition metal?

They are called transition metal bcz they exist in blw s and p block element and their properties are in blw s and p block element.

Series of Transition element:

d block element are divided into foor series.

i) 3d series
ii) 4d series
iii) 5d series
ir) 6d series

General electronic confrigation of d block element is

$ns^{1\to2}, (n-1)d^{1-10}$

f-block elements are divided into two series

i) 4f series (Lanthanides)
ii) 5f series (Actinides)

Zn-Group :- (II-B)

Zn-group consist of Zn, Cd, Hg

$Zn = 4s^2, 3d^{10}$

$Cd = 5s^2, 4d^{10}$

$Hg = 6s^2, 5d^{10}$

They are also called Transition element bcz they maked stable complexes with $Cl^-$, amine, $NH_3$ doe to which they are called transition element but they are not pure transition element

Typical & Non-Typical Transition elements

Typical Transition element :-

Element which shows all the propelty of Transition element.

e.g I-B, IVB, VB, VIB, VIII-B, VIII B

Non-Typical Transition element :-

Elements which shows some propelty of Transition element due to completly filled d orbital or emply d-orbital are called non-Typical transition element.

e.g II-B, III-B

# Electronic Configuration of d-Block elements:

$_{21}Sc = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^1$

$_{22}Ti = [Ar], 4s^2, 3d^2$

$_{23}V = [Ar] 4s^2, 3d^3$

$\star_{24}Cr = [Ar] 4s^1 3d^5$

$_{25}Mn = [Ar] 4s^2 3d^5$

$_{26}Fe = [Ar] 4s^2 3d^6$

$_{27}Co = [Ar] 4s^2, 3d^7$

$_{28}Ni = [Ar] 4s^2, 3d^8$

$\star_{29}Cu = [Ar] 4s^1, 3d^{10}$

$_{30}Zn = [Ar] 4s^2, 3d^{10}$

## Why the Electronic Configuration of Cu and Cr are unsual

Chromium and copper breaks Aufbau principle. The reason is that atoms or lonepair with half filled 3d or filled 3d sub shell are ~~reactively~~ stable avoiding the inter electronic repulsion in 4s orbital that occur with the $4s^2$ configuration.

## Properties of Transition Element.

### Physical Properties

1) They have high melting point because of strong mettalic bond
2) They have high density
3) They are good thermal conductors
4) They have a shiny metallic luster
5) They are malleable and ductile.
6)

Physical Characteristics:

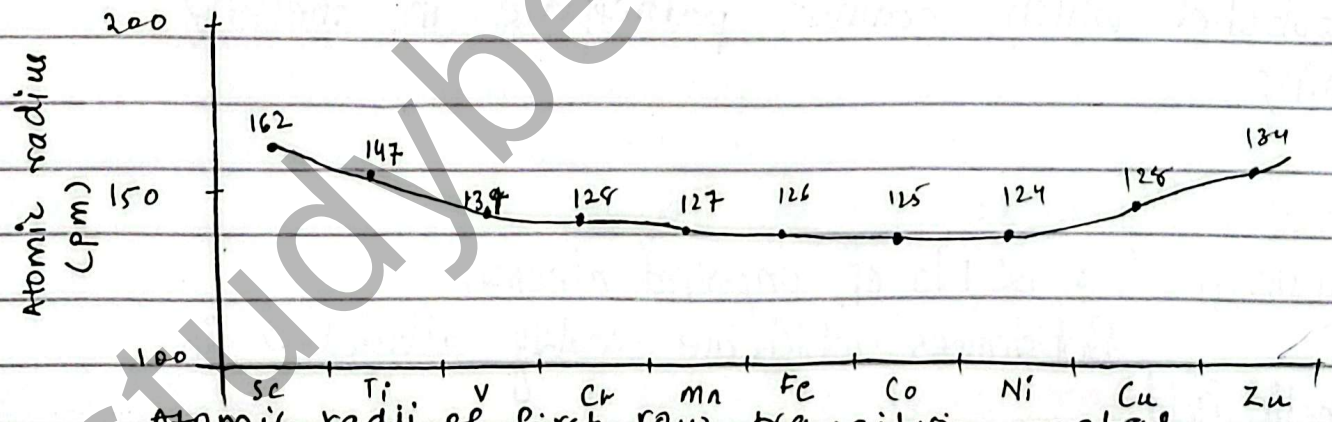
Density:-

"Density is the ratio of mass and volume"

Trends of Density across Period:

The density of Transistion element increases across period because of 1) decrease in atomic radius due to increase in nuclear charge which pulls the electron cloud closer there by reducing the size (volume) of the atoms. 2) The atomic mass of the metal increased, making their nuclei progessively heavier as we move to the right across the period.

Atomic Radii:-




Atomic radii of first row transition metal

The atomic radii decreases across the period bcz the nuclear charge increases, polling electron closer to the nucleus.

Atomic radii increases from nickel to copper and zinc. The reason is that the 3d sub-shell become full which causes shielding effect, pushing 4s sub-shell away from nucleus.

Melting Points and Boiling Points:

The melting and boiling point of transition element are generally much higher than those of s- and p-block element bcz of strong metallic bonding.

M.P & B.P $\propto$ No of binding electron

Zinc has lowest m.p and b.p because of full 3d and 4s subshell which cannot participate in melting bonding.

Magnetic Properties:

1) Paramagnetic: $\propto$ No of unpaired electron

Substances which are weakly attracted in magnetic field.

e.g aluminium and Sodium, Fe, Mn

2) Diamagnetic:

Substances which are weakly ~~attracted~~ reppelled by magnets

e.g zinc

Ferromagnetic:

Substances which are strongly attracted in magnetic field

e.g iron, Cobalt and nickel.

Alloy Formation:

Mixture of two or more than two metal is called alloy. Transistion metal can form alloy because of similar atomic size.

e.g Brass, Bronze and steel etc

Steel is the combination of iron, nickel

## Chemical Properties:

Variable oxidation state:

Energy gap between ns and (n-1)d is very small due to electron are easily removable due to transition element shows variable oxidation state.

Oxidation state ∝ No of unpaired electron

Maghese with e.c is $[Ar]\,3d^5 4s$ have maximum oxidation state of +7.

Catalytic Activity:

Transition elements or their compounds can be used as catalysts bcz of two reasons

- They show variable oxidation state
- They have vacant d-orbital capable of forming temporary dative bond with ligand.

① Haber Process:

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

② Contact Process:

$$2SO_2 + O_2 \overset{V_2O_5}{\rightleftharpoons} 2SO_3$$

③ Hydrogenation:

Ni, pt and $H_2$.

Show that Transition element as Catalyst

$$SO_2 + \frac{1}{2}O_2 \xrightarrow{V_2O_5} SO_3$$

$$SO_2 + V_2O_5 \longrightarrow SO_3 + V_2O_4$$

$$V_2O_4 + \frac{1}{2}O_2 \longrightarrow V_2O_5$$

Here $V_2O_5$ is used as catalysts.

## Ligands:

Substances which donate pair of electron to central metal is called ligand.

e.g $OH^-$, $Cl^-$, $CN^-$, $NH_3$, $H_2O$

There are four types of Ligand

1) Mondentate ligand

e.g $H_2O$, $NH_3$, $CN^-$

2) Didenate ligand

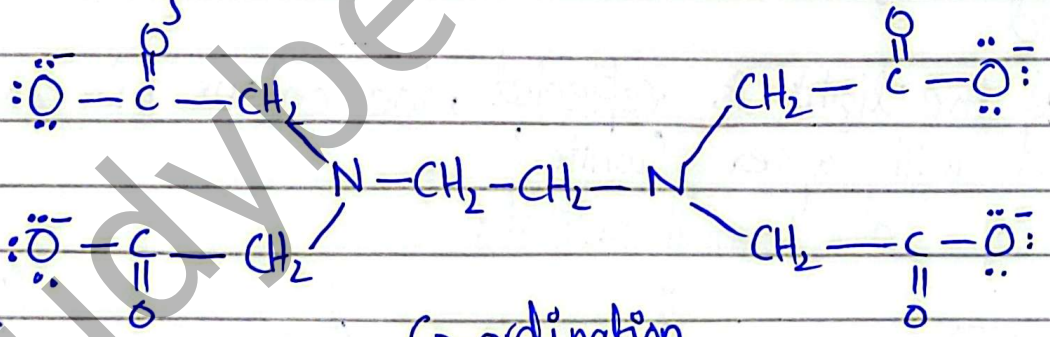
e.g $PO_4^{-3}$, $NH_2$, $-CH_2-CH_2-NH-CH_2-CH_2-NH_2$

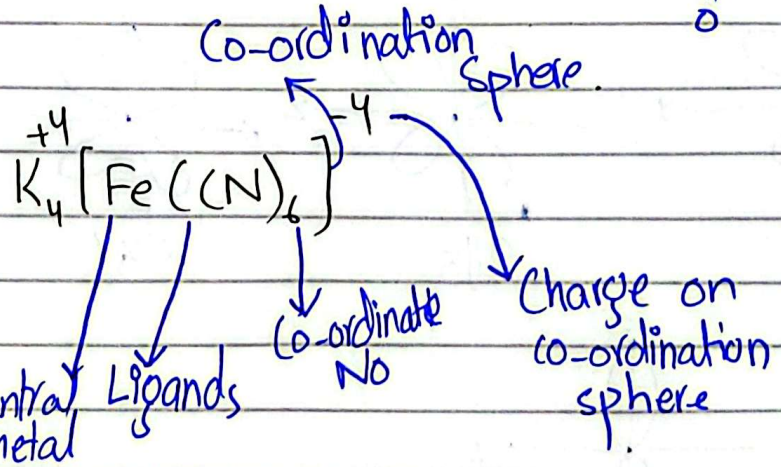
3) Tridentate ligand

e.g $PO_4^{-3}$, $NH_2$, $-(CH_2)_2-NH-(CH_2)_2-NH$

4) Hexadentate ligand

e.g EDTA (Ethanediaminetetraethanoic acid)





## Colored Complexes:

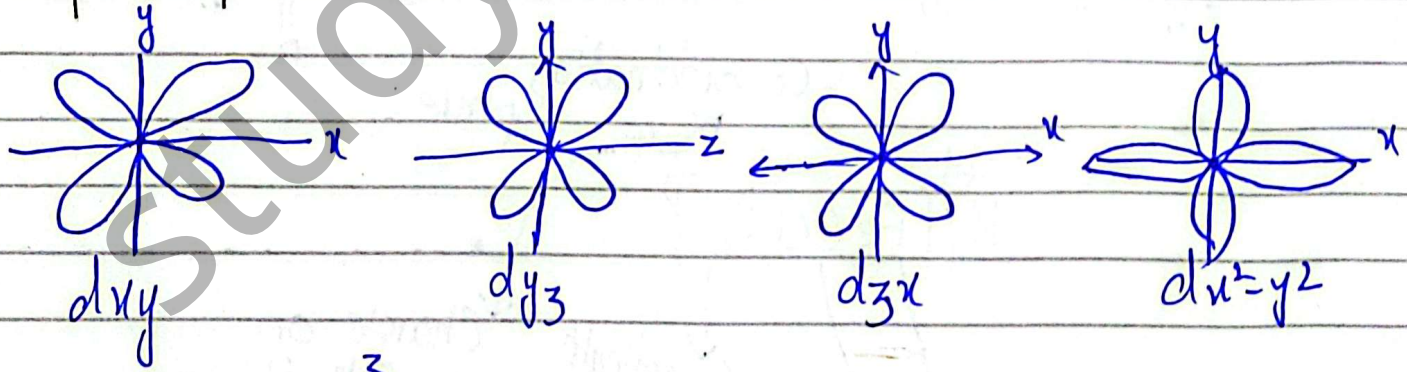
Solid or solution forms of complexes shows colored complexes because it absorb a part of visible light and the remaining part is transmitted.

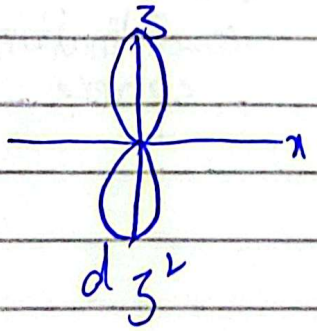
for example

copper complex has incomplete d subshell so it has colored compound whereas zinc has completely fill d subshell so it do not show colored complexes.

- If all the light is absorbed, the compound appears 'black'
- If some light is absorbed, the compound will appear colored
- If all the light is reflected, the colour of complex compound will appear 'white'

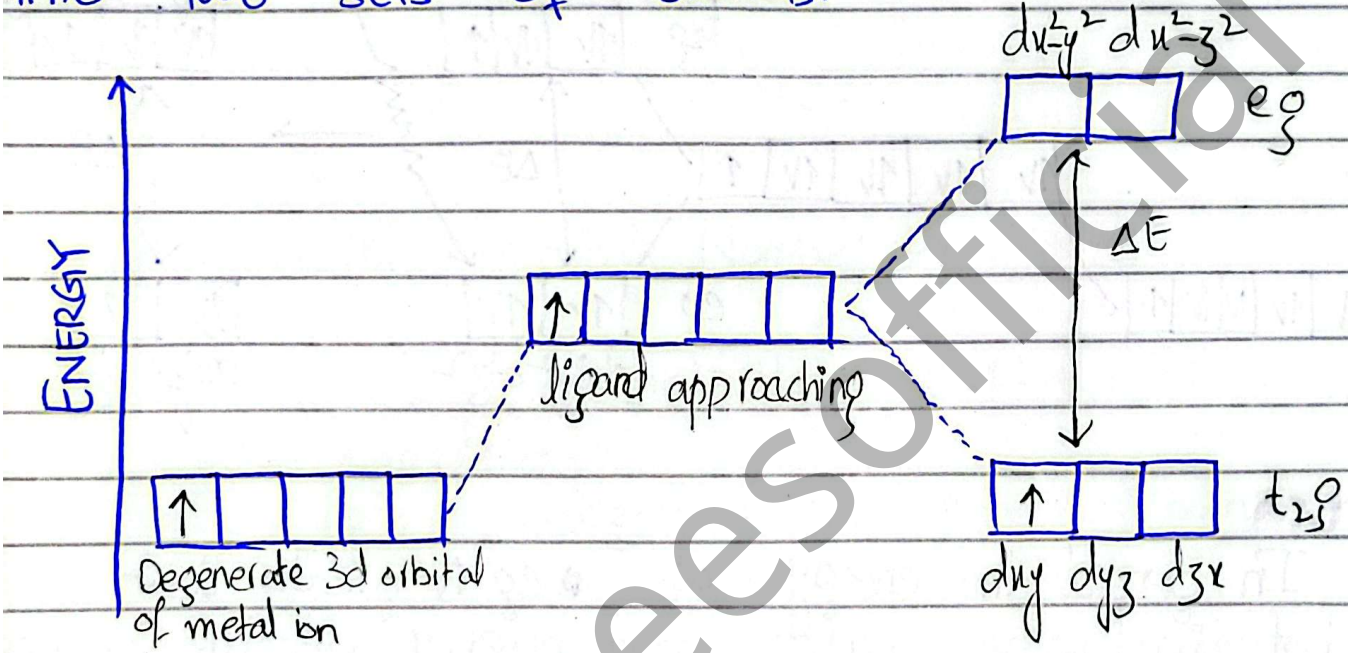
Shapes of d subshell orbital:



## d-d Spliting:

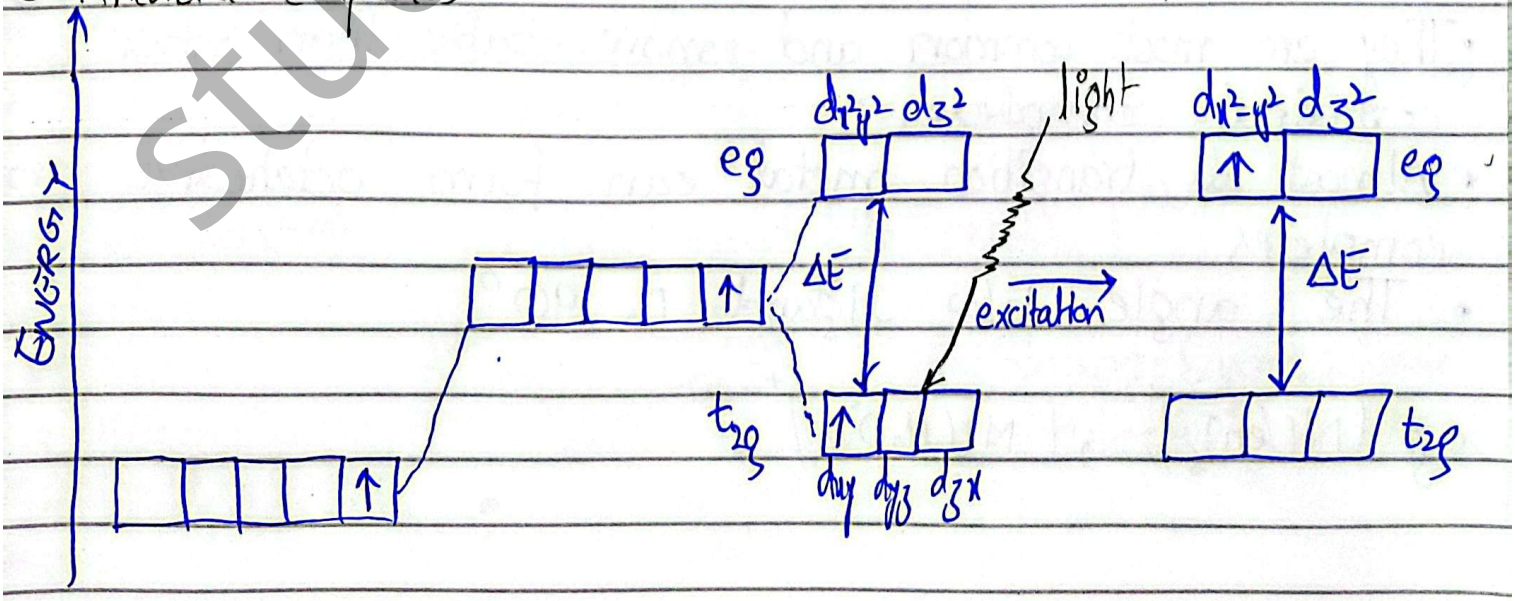
"The interaction b/w ligands and central metal ion causes spliting of d subshell into two sets of orbitals."



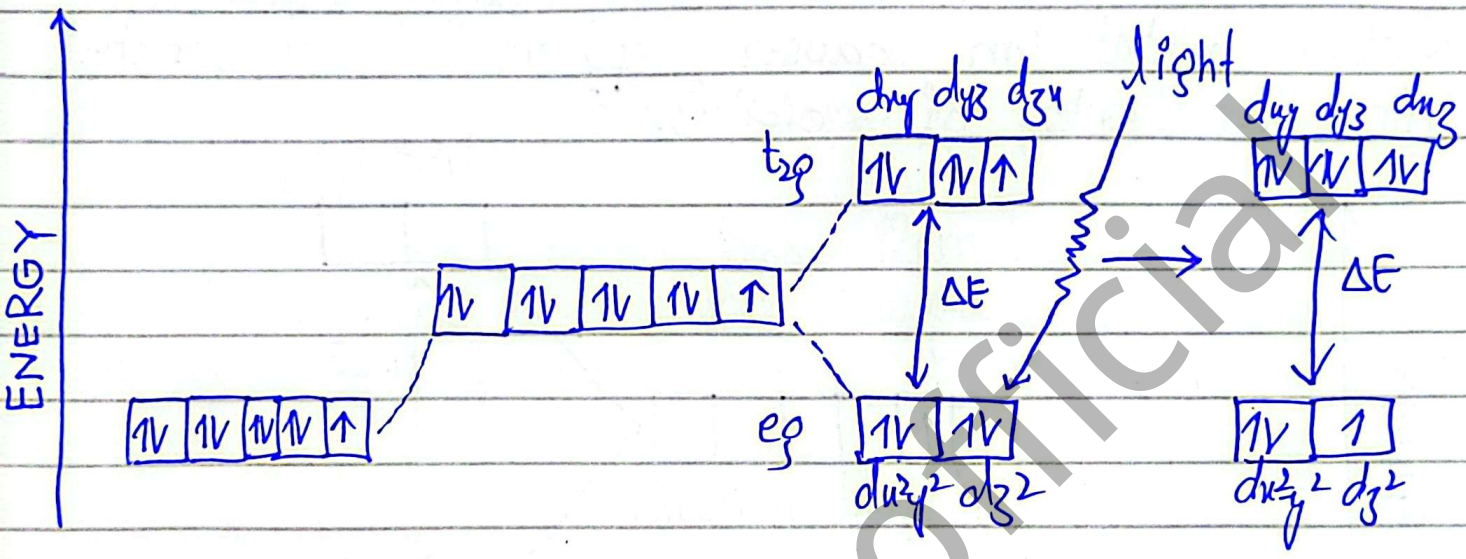

## d-d Transition:

"The shift of electron b/w the two sets of orbitals is called d-d electronic transition"

Octahederal Complexes:-



# Tetrahedral Complexes:




**Note:**

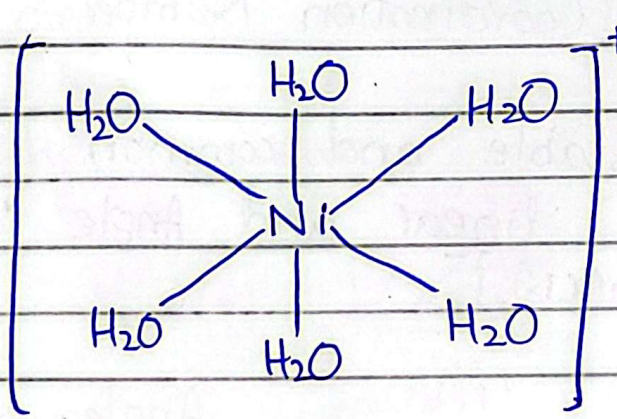
In general the energy of eg is greater than $t_{2g}$ bot in some cases $t_{2g}$ energy become greater than eg..

Geometric of Complexes:-

. Complexes with Coordinate Number 6:-

- They are most common and more stable than other cordinate complexes
- Almost all transition metal can form octahedral complexes
- The angle b/w ligand is 90°

e.g $[Ni(en)_6]^{+2}$, $[Ni(H_2O)_6]^{+2}$




Shape: Octahedral
Angle: 90°

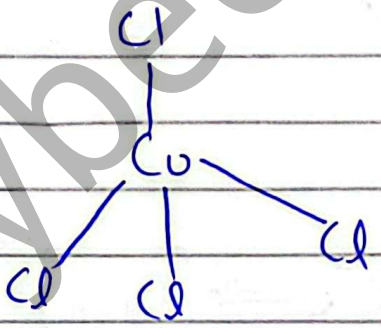
2 Complexes with Coordinate Number 4:

- stable and less common than C.N 6

a) Tetrahedral Complexes:-

- Usually $sp^3$ hybridized forms tetrahedral complexes

e.g $[CuCl_4]^{-2}$

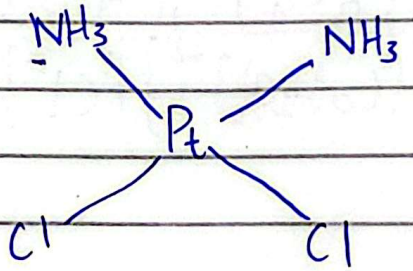



Shape: Tetrahedral
Angle: 109.5°

b) Square Planar Complexes:- $sp^2d \longrightarrow d^8$ e.g $Ni^{+2}$

- Usually $sp^2d$ hybridized forms square planar complexes

e.g $[Ni(CN)_4]^{-2}$, $[AuCl_4]^{-1}$ and $[Pt^{+2}(NH_3)_4]^{+2}$




Shape: Square planar.
Angle: 90°

## 3. Complexes with Coordination Number

- They are least stable and common
- Have shape of linear and Angle is 180°
  e.g $[CuCl_2]^{-1}$ , $[Au(CN)_2]^-$

$[H_3N — Ag — NH_3]^+$ Angle : 180°
Shape : Linear.

### Stability of Complexes and Stability Constant ($K_{stab}$)

"The equilibrium constant obtained from ligand exchange reactions in a solvent is called stability constant"

Denoted by ($K_{stab}$)

$$[Co(H_2O)_6]^{+2} + 4Cl^- \rightleftharpoons [CoCl_4]^{-2} + 6H_2O$$

pink solution — blue solution

If we add water reverse reaction will take place if we add conc HCl forward reaction will take place

$$K_c = \frac{[[CoCl_4]^{-2}][H_2O]^6}{[[Co(H_2O)_6]^{+2}][Cl^-]^4}$$

Water is solvent so it is in large excess and it is treated as constant and not shown in stability constant

$$K_{stab} = \frac{[Co(I_4)]^{-2}}{[Co(H_2O)_6]^{+2}[I^-]^4}$$

Note

Poly Dentate stability ($K_{stab}$) > Mono dentate stability ($K_{stab}$)

Redox Reaction:-

"A reaction in which oxidation and reduction take place those reaction is known as redox reaction"

Oxidizing Agent:

Substances which oxides other and reduces itself is called oxidizing agent.

Reducing Agent:

Substances which reduces other and oxides itself is called reducing agent

e.g

$$KMnO_4 + H_2SO_4 + Fe^{+2}SO_4 \longrightarrow K_2SO_4 + Mn^{+2}SO_4 + Fe_2^{+3}(SO_4)_3$$

Oxidizing Agent — Reducing agent.

## i) Reaction B/w Copper (II) ion and Iodide Ion:

$CuSO_{4(aq)}$ ⟶ Blue
$KI_{(aq)}$ ⟶ colourless

$$2Cu^{+2} + 4I^- \longrightarrow 2CuI + I_2$$

white ppt. — red-brown solution.

$$Cu^{+2} + 1\bar{e} \longrightarrow Cu^+ \qquad E^\circ_{red} = +0.15V$$
$$\frac{1}{2} I_2 + 1\bar{e} \longrightarrow I^- \qquad E^\circ_{red} = +0.54$$

This reaction proceed in forward direction bcz of continous precipitation of copper(I) iodide in the reaction, although the overall standard potential value is negative

$$2I^- \longrightarrow I_2 + 2\bar{e} \qquad E^\circ_{red} = -0.54V$$
$$2Cu^{+2} + 2\bar{e} \longrightarrow 2Cu^+ \qquad E^\circ_{red} = +0.15V$$

$$2Cu^{+2} + 2I^- \longrightarrow 2Cu^+ + I_2 \qquad E^\circ_{red} = -0.39$$

# Worked Example 1:

a) $[Cu(H_2O)_6]^{+2}_{(aq)} + 4Cl^-_{(aq)} \longrightarrow [CuCl_4]^{-2} + 6H_2O$

$$K_c = \frac{[[CuCl_4]^{-2}]\,[H_2O]^6}{[[Cu(H_2O)_6]^{+2}]\,[Cl^-]^4}$$

$$K_{stab} = \frac{[[CuCl_4]^{-2}]}{[[Cu(H_2O)_6]^{+2}]\,[Cl^-]^4}$$

b) Units

$$K_{stab} = \frac{[\cancel{mol\,dm^{-3}}]}{[\cancel{mol\,dm^{-3}}]\,[mol\,dm^{-3}]^4}$$

$$K_{stab} = mol^{-4}\,dm^{+12}$$