

* General properties (Transition metals)

- Metallic property show.
- High Tensile
- malleable & ductile
- High thermal & electrical conductivity
- metallic lustre
- hard
- less volatile

① # Except Zn, Cd, Hg all have metallic lattice

② MP & BP → more no. of valence e⁻
→ more strong bonding.

C ₈	Zn
Mo	→ Highest MP & BP
W	→ Lowest MP & BP

6 valence e⁻

Mn
Tc
Re

→ exception - MP & BP is less

③ Enthalpy of atomization → Energy required to break all bonds of lattice and then convert to gases form maximum is of vanadium (v)

④ Atomic size

$$\text{Sc} > \text{Ti} > \text{V} > \text{Cr} > \text{Mn} > \text{Fe} = \text{Co} = \text{Ni} < \text{Cu} < \text{Zn}$$

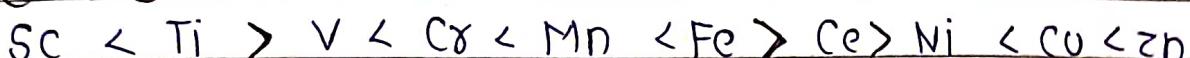
z_{eff} > screening effect z_{eff} = $\frac{z_{eff}}{\text{screening effect}}$



Group -	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
↑										
Y										
↑										
La										
AC										

Lanthanoid
Contractio

(5) IE



general - L to R IE ↑

change at 2, 6, 7

IE₁ of Zn, Cd, Hg → fulfilled - highest

IE₂ of Cr, Cu → High filled - high
 ↳ 3d⁵ → 3d¹⁰

IE₃ of Mn → 3d⁵ → High

6) Oxidation State - All d block elements show

variable oxidation state - (Sc & Zn) → exception

→ very less energy gap betw (n-1) d & ns orbital

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
+3	+2	+2	+2	+2	+2	+2	+2	+1	0
+3	+3	+3	+3	+3	+3	+3	+3	+2	+2
+4	+4	+4	+4	+4	+4	+4	+4	+4	
+5	+5	+5							
+6	+6	+6							

max O.S = +8

RU, OS OSO₄

m^{+2}/m electrode potential

$Mn, Ni, Zn \rightarrow$ electrode potential \rightarrow highly negative
 $\downarrow 3d^5 \quad \downarrow 3d^{10}$

\hookrightarrow High Hydration Enthalpy

$Cu \rightarrow$ +ve value \rightarrow electrode potential

$\hookrightarrow Cu$ can't liberate H_2 from acid
 \hookrightarrow low hydration enthalpy

m^{+3}/m^{+2} Electrode potential

$Sc^{+2} \rightarrow Sc^{+3} \rightarrow$ High negative electrode potential
 (stable) $\quad \quad \quad$ (low)

$Zn^{+2} \rightarrow Zn^{+3} \rightarrow$ Positive electrode potential
 (high)

$Mn^{+2} \rightarrow Mn^{+3} \rightarrow$ Positive
 (high)

$Fe^{+2} \rightarrow Fe^{+3} \rightarrow$ Negative
 Stable $\quad \quad \quad$ (low)

Higher oxidation state in halide & oxide

Halides

Ti	V	$C\gamma$	Mn	Fe	CO	Ni	Cu	Zn
TiX_2	VX_2	$C\gamma X_2$	MnX_2	FeX_2	COX_2	NiX_2	CuX	ZnX
TiX_3	VX_3	$C\gamma X_3$	MnF_3	FeX_3	COF_3		CuX_2	
TiX_4	VX_4	$C\gamma X_4$	MnF_4					
		VFS	$C\gamma F_5$					
			$C\gamma F_6$					
				MnO_3F				

only VF_5 is known \rightarrow on hydrolysis $\rightarrow VOF_3$

CuX_2 is formed except CuI_2 / $Cu^{+2} + I^- \rightarrow Cu_2I_2$



→ In aq. soln Cu^{+2} is more stable than Cu^{+1}
 ↳ because HE is more in Cu^{+2}

Oxide

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Sc_2O_3	TiO	V_2O_3	Cr_2O_3	Mn_2O_3	Fe_2O_3	Co_3O_4	Cu_2O		
	TiO_2	V_2O_4	Cr_2O_2	Mn_2O_2	Fe_3O_4				
		V_2O_5		Mn_3O_4					
				Cr_2O_3	Mn_2O_7				

Magnetic Property

→ diamagnetic, paramagnetic, ferromagnetic

Repelled by MF, attracted by MF, very strongly attracted by MF

MF

MF

attracted by MF

→ 0 unpaired e⁻

→ presence of unpaired e⁻

→ all e⁻ are paired

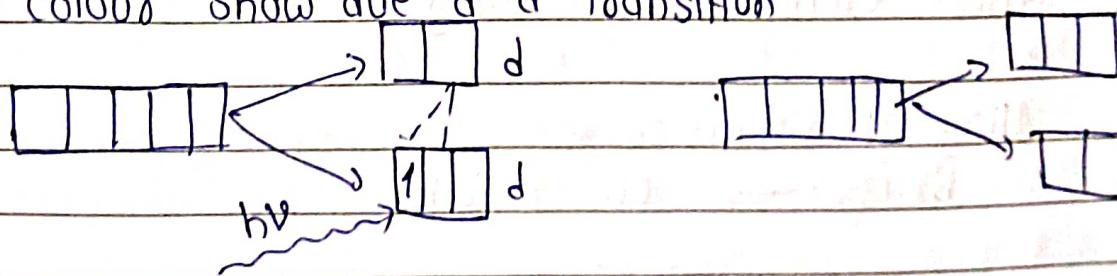
→ magnetic moment $M = \sqrt{n(n+2)} B \cdot M$

$n = n_0 \cdot \text{of unpaired e}^-$

Formation of colored ions

→ unpaired e⁻ is present → it shows colour

→ colour show due to d-d transition



$\text{Sc}^{+3} \rightarrow$ no colour

$\text{Zn}^{+2} \rightarrow$ no colour



- * Catalytic property: due to variable oxidation state it shows catalytic property:
 - contact process - V_2O_5
 - Haber's process \rightarrow Fe (Finely divided)
 - catalytic hydrogenation \rightarrow Ni, Pt, Pd



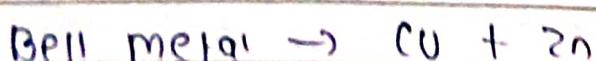
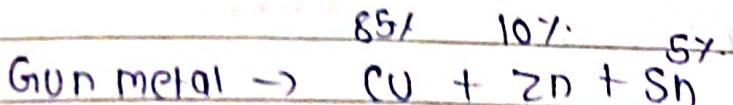
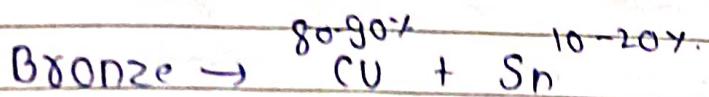
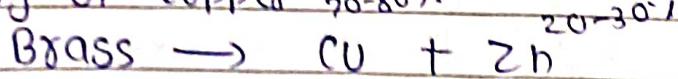
- * Interstitial compound. [H, C, N, B] \rightarrow small size elements
 - \rightarrow transition elements are metal & hence form metallic lattice (voids)

Small size element like B, H, C, N are accommodated in this empty spaces (voids) & form interstitial comp.

- \rightarrow High melting point
- \rightarrow very hard
- \rightarrow chemically inert
- \rightarrow Have metallic conductivity.

- * Alloy Formation Due to similar size of d block elements these elements form alloy.

Alloy of Copper 70-80%



72-80% 20-28%



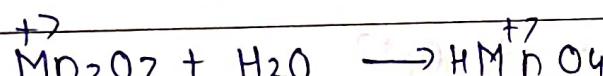
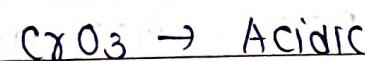
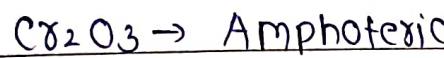
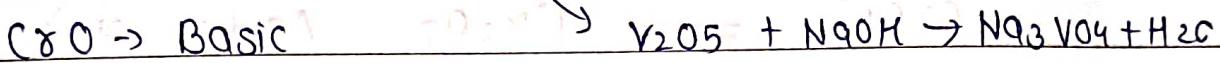
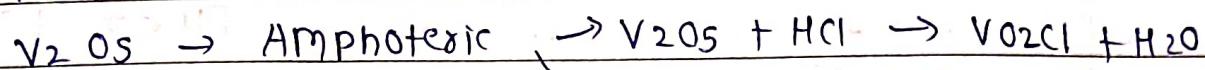
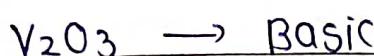
* Some imp compounds of transition elements

Oxides

Low oxidation state oxide \rightarrow Basic

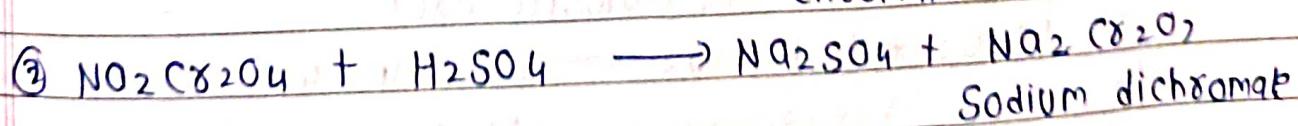
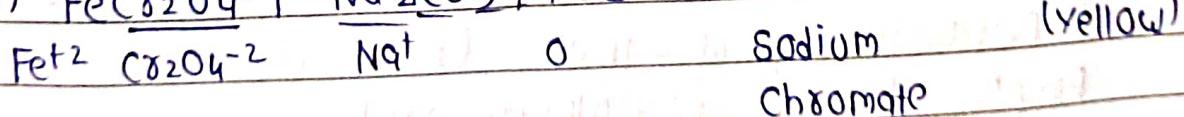
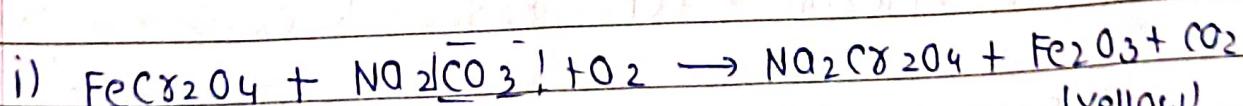
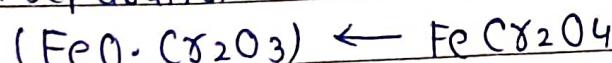
High " " " " " " \rightarrow Acidic

Intermediate " " " " " " \rightarrow Amphoteric



Potassium dichromate ($K_2Cr_2O_7$)

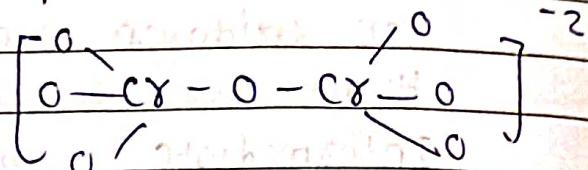
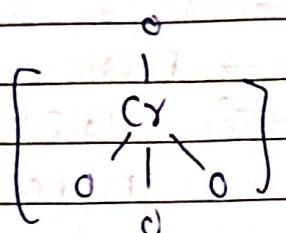
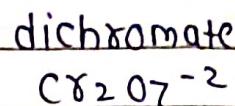
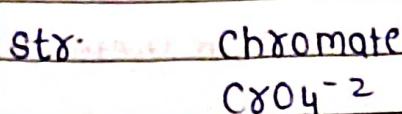
Preparation - Chromite ore + El. heat



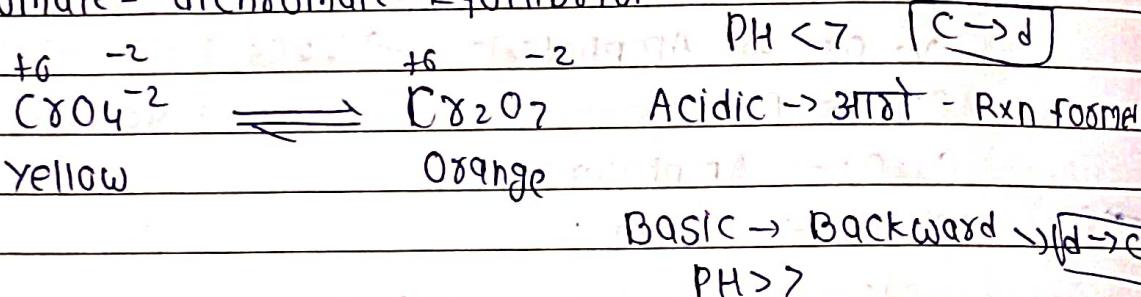
Sodium dichromate



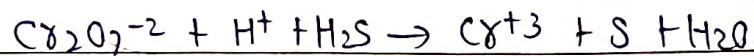
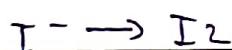
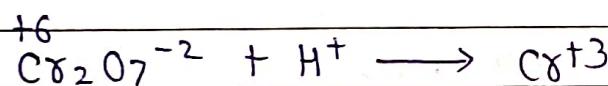
Potassium dichromate



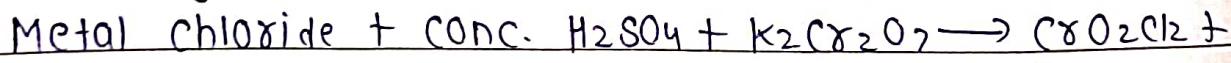
chromate - dichromate Equilibrium



* Strong oxidizing agent in acidic medium



* Chromyl chloride test



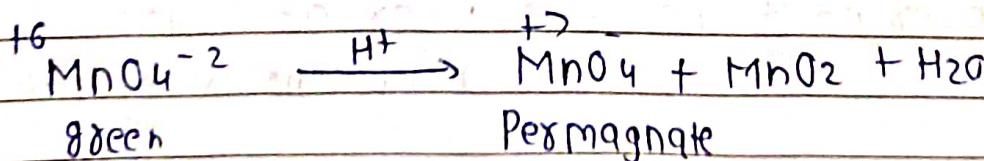
red vapour $\text{KHSO}_4 + \text{H}_2\text{O}$

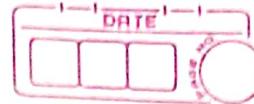
* Potassium permanganate (KMnO_4)

Prepn: MnO_2 (pyrolusite ore)

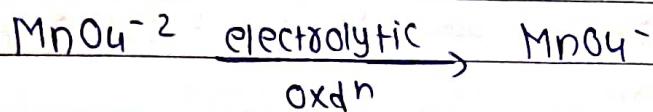


Magnate ion (green)



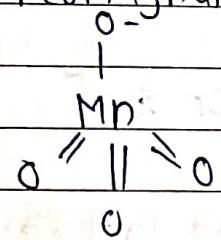


commercial MnO_2 Fused with KOH MnO_4^{-2}
Prepⁿ & oxidise with
air or KNO_3

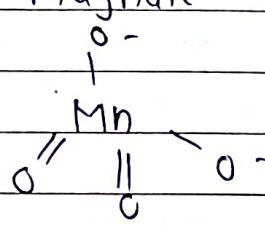


St^r:

Permagnate



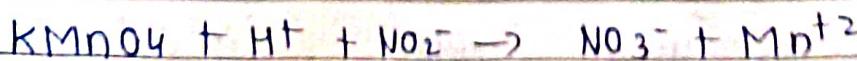
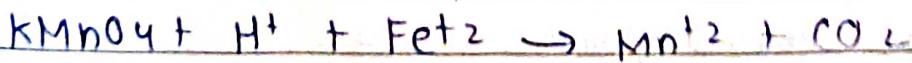
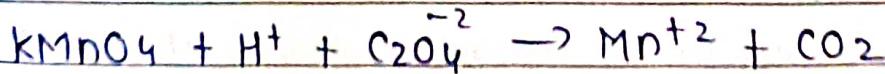
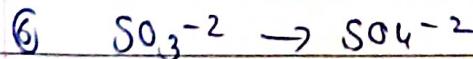
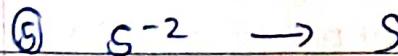
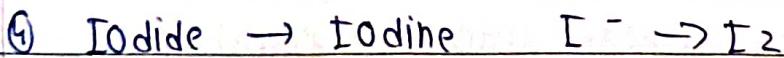
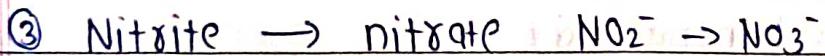
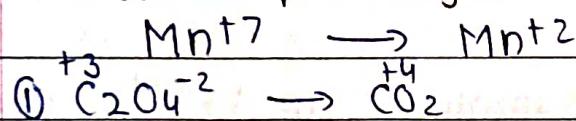
magnate



diamagnetic
(purple)

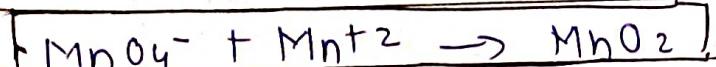
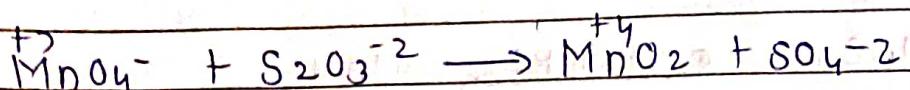
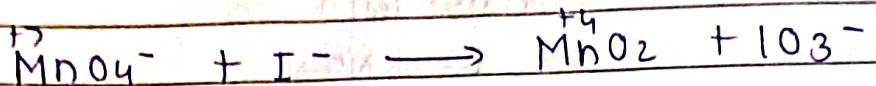
paramagnetic
(Green)

Potassium permagnate in acidic medium

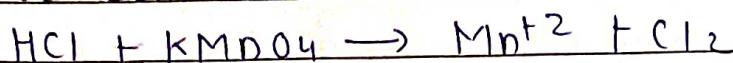




Neutral / faintly alkaline soln



→ we don't use HCl in acidic medium / titration



* F-Block *

The elements in which the last e- enters into f-orbitals of atoms are called f-block elements i.e. antipenultimate shell $(n-2) f$

Also called inner transition elements

Two series of f-block - 4f series and 5f series

General Electronic Configuration $(n-2)f^{1-14}(n-1)d^0-1 ns^2$

4f series (Lanthanoid)

Last electron enters into 4f orbital & properties are almost similar to lanthanum - Exception in $4f = 3, 8$

La 57 Lanthanum

$[\text{Xe}] 6s^2 4s^2 5d^1$

Ce 58 Cerium

सिने $[\text{Xe}] 6s^2 4s^1 5d^1$

Pr 59 Praseodymium

प्रे $[\text{Xe}] 6s^2 4f^3 5d^0$

Nd 60 Neodymium

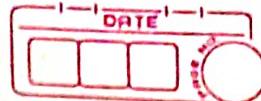
नदियाँ $[\text{Xe}] 6s^2 4f^4 5d^0$

Pm 61 Promethium

प्रेमिक $[\text{Xe}] 6s^2 4f^5 5d^0$

Sm 62 Samarium

समाई $[\text{Xe}] 6s^2 4f^6 5d^0$



Eu	63	Europium	यू	[xe] 6s ² 4f ⁷ 5d ⁰
Gd	64	Gadolinium	गाडोनियम्	[xe] 6s ² 4f ⁷ 5d ¹
Tb	65	Terbium	तर्ब	[xe] 6s ² 4f ⁹ 5d ⁰
Dy	66	Dysprosium	दिप्रोसियम्	[xe] 6s ² 4f ¹⁰ 5d ⁰
Ho	67	Holmium	हुल्मियम्	[xe] 6s ² 4f ¹¹ 5d ⁰
Er	68	Erbium	अर्बे	[xe] 6s ² 4f ¹² 5d ⁰
Tm	69	Thulium	ठुमि	[xe] 6s ² 4f ¹³ 5d ⁰
Yb	70	Ytterbium	यार्टर्बीयम्	[xe] 6s ² 4f ¹⁴ 5d ⁰
Lu	71	Lutetium	लुटेटियम्	[xe] 6s ² 4f ¹⁴ 5d ¹

Position of Elements - 1 ② 3 4 5 6 7 ⑧ 9 10 11 12 13 14
e⁻ in F- Subshell 1 3 4 5 6 7 7 9 10 11 12 13 14 15

Note - half fill (7) & full fill (14) are stable in F subshell

Cerium is 26th most abundant Lanthanoid element on earth and most common occurring lanthanoid.

Monazite sand is most common mineral with contain lanthanoids.
Fractum is only synthetic radioactive element

Oxidation state - All lanthanoid exhibit a common oxidation state of +3

Ce and Tb exhibit +4 oxidation state

Eu and Yb exhibit +2 , , "

La, Gd and Lu exhibit only +3 oxidation state

Eu²⁺ is a strong reducing agent

Colour - colour of lanthanoid ions arises due to absorption in visible region of spectrum resulting in F-F transition because they have partially filled F-orbitals

La^{3+} and Lu^{3+} don't show any colour but other trivalent lanthanoid show colours.

Magnetic properties - Lanthanoids ion other than f^0 type (La^{3+} & Ce^{4+}) and f^{14} type (Yb^{2+} & Lu^{3+}) are all paramagnetic.

Chemical Reactivity

Burns in air, $\text{Ln} + \text{O}_2 \rightarrow \text{Ln}_2\text{O}_3$

Heated with S, $\text{Ln} + \text{S} \rightarrow \text{Ln}_2\text{S}_3$

Heated with N, $\text{Ln} + \text{N} \rightarrow \text{LnN}$

Rxn with C, $\text{Ln} + \text{C} \xrightarrow{\approx 73 \text{ K}} \text{LnC}_2$

Rxn with H_2O , $\text{Ln} + \text{H}_2\text{O} \rightarrow \text{Ln}(\text{OH})_3 + \text{H}_2$

Rxn with halogen, $\text{Ln} + \text{X} \rightarrow \text{LnX}_3$

Rxn with acid, $\text{Ln} + \text{acid} \rightarrow \text{Ln salt} + \text{H}_2$

Similarity among lanthanoids - Because of very small change in radii of Lanthanoids their chemical properties are quite similar. Thus it is very difficult to separate the elements in pure state.

Basicity difference - The basic strength of hydroxides decreases with \uparrow in atomic no.

Thus $\text{Ca}(\text{OH})_3$ is most basic while $\text{Cu}(\text{OH})_3$ is least basic.

Uses - Used in making mischmetal, an alloy of a lanthanoid metal (~95%) with iron (~5%) and traces of S, C, Ca and Al. It is used to make tracer bullet shells.

* 5f-series (Actinoids)

Last e^- enters into 5f orbitals. Their properties are almost similar to actinium, thus they are called actinoids.

Exception in 5f = 6, 8.

Electronic configuration $ns^2 (n-2)f^{1-14} (n-1)d^{0-1} n=7$

Elements position 1 2 3 4 5 6 7 8 9 10 11 12 13 14

e^- in 5f subshell 1 2 3 4 5 7 7 9 10 11 12 13 14 14

Actinoids are radioactive elements and initial members have long life than lower member ranging from a day to 3 min.

Ionic sizes. Just like lanthanoids here is also gradual decrease in size of atom or M^{3+} ions across the series. This is referred as actinoid contraction due to poor shielding of 5f orbitals, the effective nuclear charge \uparrow which results in contraction of size.

Actinoid contraction is greater from element to element than lanthanoid contraction because 5f orbitals have a poor shielding effect than 4f orbitals in lanthanoids. Thus effective nuclear charge experienced by valence e^- in case of actinoids is much more than experienced by lanthanoids.

Oxidn state. Most common O.S is +3

The also shows O.S of +4, +5, +6 & +7 in Th, Pa, U and Np respectively. They have greater range of O.S because 5r, 6d and 7s levels are of comparable energies.



Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No
3	3	3	3	3	3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4	4	4	4	4	4
5	5	5	5	5	5								
6	6	6	6	6	6								
7	7												

Some more characteristics.

- Silvery appearance and highly reactive
- HCl can react with all actinoids
- Most of them are slightly affected by HNO_3 because of protective layer formation (oxide layer)
- Magnetic properties are complex
- IE are less compared to lanthanoid and cannot be accurately known but as 5F orbital is deeply buried due to which it is more effectively shielded by nuclear charge than 4F electron and outer electron can easily removed
- Actinoids are coloured in ionic form & compounds because of f-f transition