

THE d- & f-BLOCK ELEMENTS

General electronic configuration of d block elements. \Rightarrow [Noble gas] $(n-1)d^{1-10} ns^{1-2}$

\Rightarrow Transition Series :-

① 1st Transition Series (3d Series) :-

10 elements from Scandium (Sc) to Zinc (Zn)

② IInd Transition Series (4d Series) :-

10 elements from Yttrium (Y) to Cadmium (Cd)

③ IIIrd Transition Series (5d Series) :-

10 elements from Lanthanum (La) to Mercury (Hg)

④ IVth Transition Series (6d Series) :-

10 elements from Actinium (Ac) to Ununbium (Uub)

\Rightarrow 3d Series :-

Symbol	Atomic No.	Electronic Config.
Sc	21	[Ar] $3d^1 4s^2$
Ti	22	[Ar] $3d^2 4s^2$
V	23	[Ar] $3d^3 4s^2$
Cr	24	* [Ar] $3d^5 4s^1$
Mn	25	* [Ar] $3d^5 4s^2$
Fe	26	[Ar] $3d^6 4s^2$
Co	27	[Ar] $3d^7 4s^2$

Ni	28	$[Ar] 3d^8 4s^2$
Cu	29	$[Ar] 3d^{10} 4s^1$
Zn	30	$[Ar] 3d^{10} 4s^2$

⇒ 4d Series :-

Symbol	Atomic No.	Electronic Configuration
Y	39	$[Kr] 4d^1 5s^2$
Zr	40	$[Kr] 4d^2 5s^2$
Nb	41	$[Kr] 4d^4 5s^1$
Mo	42	$[Kr] 4d^5 5s^1$
Tc	43	$[Kr] 4d^5 5s^1$
Ru	44	$[Kr] 4d^7 5s^1$
Rh	45	$[Kr] 4d^8 5s^1$
Pd	46	$[Kr] 4d^{10} 5s^0$
Ag	47	$[Kr] 4d^{10} 5s^1$
Cd	48	$[Kr] 4d^{10} 5s^2$

⇒ 5d Series :-

Symbol	Atomic No.	Electronic Configuration
La	57	$[Xe] 4f^0 5d^1 6s^2$
Hf	72	$[Xe] 4f^{14} 5d^2 6s^2$
Ta	73	$[Xe] 4f^{14} 5d^3 6s^2$
W	74	$[Xe] 4f^{14} 5d^4 6s^2$
Re	75	$[Xe] 4f^{14} 5d^5 6s^2$
Os	76	$[Xe] 4f^{14} 5d^6 6s^2$
Ir	77	$[Xe] 4f^{14} 5d^7 6s^2$
Pt	78	$[Xe] 4f^{14} 5d^9 6s^1$
Au	79	$[Xe] 4f^{14} 5d^{10} 6s^1$
Hg	80	$[Xe] 4f^{14} 5d^{10} 6s^2$

⇒ Physical properties of d-block elements

- All are metals
- Malleable & Ductile (except Hg)
- High thermal & electrical Conductivity
- Sonorous (except - Zn, Cd, Hg, Mn)

⇒ Atomic radii :- Atomic radii first decrease to the middle, become constant & finally increase across a period.

Ex. $Sc > Ti > V > Cr < Mn > Fe \approx Co \approx Ni < Cu < Zn$

→ $3d < 4d \approx 5d$ (except 3rd group)

The size of 4d & 5d orbital has to be similar because of Lanthanoid Contraction

⇒ Lanthanoid Contraction :- The filling of electron in 4f orbital before 5d orbital results regularly decrease atomic radii

Ques. Ionic radii why Zr & Hf has similar size?

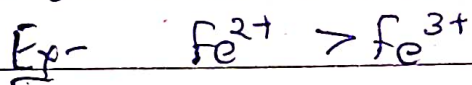
Ans. because of Lanthanoid Contraction.

⇒ Ionic radii :-

- Ionic radii increase with decrease oxidation Number.
- Ionic radii is different for different oxidation State.

→ Ionic Radii of d block is smaller than s & p block.

→ Ionic Radii regularly decreased for same oxidation state.



⇒ Metallic character:

→ Hard Metals except Zn, Cd & Hg

→ Cr, Mo, W are hardest metal because of presence of greater no. of balance e

→ Cu, Ag, Au are ductile.

⇒ Density: The density of d-block elements is higher because of low atomic volume.

→ Os & Ir has higher density.

→ Density increase from 3d to 4d series & just double from 4d to 5d series.

⇒ Melting & Boiling point:

→ Chromium (Cr), Molybdenum (Mo) & Tungsten (W) has higher boiling point because of greater no. of valence electron.

→ Zinc (Zn), Cd, Hg has very low melting point because of presence of stable electrons.

→ Mn & Fe has low boiling point because of high enthalpy of atomisation.

⇒ Ionisation Enthalpy: The first Ionisation Enthalpy of d block is greater than s block but lower than p block. element.

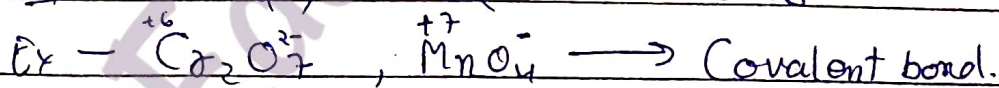
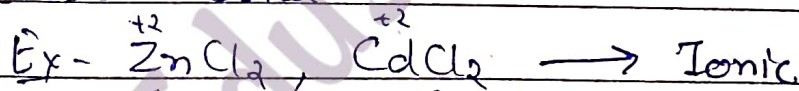
$$s < d < p$$

→ Successive Ionisation Enthalpy of d-block is lower than s & p block. because electrons enter in $(n-1)$ d orbital provide Screening effect.

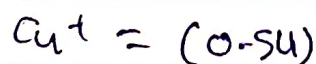
→ Second Ionisation Enthalpy of Cr & Cu has higher

⇒ Oxidation State:

- They show variable oxidation state
- Most Common oxidation State of first Series is +2 (except Sc) → Scandium
- The metal in lower oxidation state form ionic bond & in higher oxidation state form covalent bond.



- Metal in higher oxidation state form Oxo Acid.
- Osmium has highest oxidation state (+8)
- Metal exist more than 1 oxidation state then the relative stability is known as standard Reduction potential
- Cu^{2+} is more stable in aq. solⁿ than Cu^{+} because of their low value of E_0



⇒ Standard Reduction potential :- The E_0 value depends on enthalpy of Sublimation, Ionisation & hydration enthalpy.

- More (ve) E_0 Value, greater Stable Compound
- Zn has low E_0 Value because of these higher their ionisation enthalpy.

⇒ Trends of M^{+2}/M & M^{3+}/M^{2+} :-

- Cu has positive E_0 Value because of high enthalpy of Atomisation & low enthalpy of hydration hence large amount of energy required for the conversion of Cu to Cu^{2+} is not balanced by hydration energy.

→ M^{3+}/M^{2+} has positive E_0 Value because Mn^{2+} is in $3d^5$ stable electronic configuration & their Ionisation enthalpy of Mn^{3+} is very high.

⇒ Magnetic property :- The compound having unpaired electron is known as paramagnetic. Compound

→ The Compound having

→ The magnetic property can be calculated by

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

$n = \text{no. of unpaired } e^-$

⇒ Coloured Ions :- Most of the d-block metal ions are coloured in both solid as well as aqueous state.

→ Coloured is due to d-d Transition [More than 1 unpaired e⁻]

ex - Sc^{3+} , Ti^{4+} , Zn^{2+} , Cu^{+} ← colourless.
 V^{4+} , Cr^{2+} , Fe^{2+} ← Coloured.

⇒ Complex formation :- Most of the d-block elements form complex because of small size, high charge & availability of vacant d-orbital.

Ex:- $[Fe(CN)_6]^{3-}$, $[Fe(CN)_6]^{4-}$, $[Cu(NH_3)_4]^{2+}$ etc.

⇒ Catalytic property :-

→ Most of the d-block elements and their compounds are used as catalyst.

Ex - Pt, Pd, Ni, Mo, W, Co etc.

① V_2O_5 :- Manufacture of H_2SO_4 by contact process.

V_2O_5/Pt :- Oxidation of SO_2 to SO_3 by contact process.

② Fe + Mo :- Manufacture by NH_3 :- Haber's process

③ Ni :- Hydrogenation of unsaturated organic compound.

④ MnO_2 :- decomposition of H_2O_2

⑤ Co salt :- Decomposition of bleaching powder

⑥ $[(\text{Ph}_3\text{P})_3\text{RhCl}]$:- Wilkinson Catalyst used for hydrogenation of Alkene.

⑦ $\text{FeSO}_4 + \text{H}_2\text{O}_2$:- Fenton's reagent used for alcohol to Aldehyde.

⑧ $\text{TiCl}_4 + \text{Al}(\text{C}_2\text{H}_5)_3$:- Ziegler-Natta Catalyst used for polymerisation of ethylene.

⇒ Interstitial Compound :-

→ d-block elements form a large no. of interstitial compound in which small atom such as H, C, B, N etc. occupied at their interstitial site.

→ These compounds are generally non-stoichiometric in nature.

Ex - TiC , TiH , TiH_2 , Wc , Mn_xN etc.

⇒ Alloy formation :-

→ Most of the alloys of d-block are very hard & at high melting points.

→ They are solid substitutional

Ex - Bronze (Cu + Sn)

Brass (Cu + Zn)

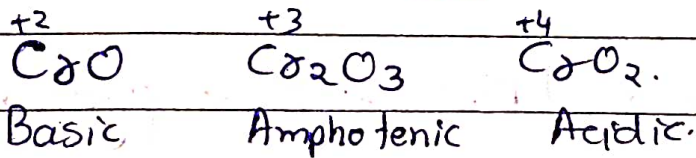
Dental Alloys (Ag + Hg + Cu + Zn + Sn)

Stainless steel (Fe + Cr)

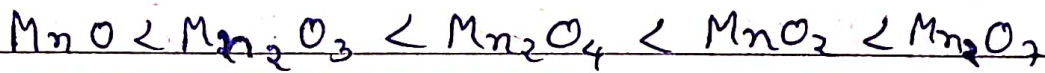
Nickel Steel (i) Ni + C - Used for Shaving

(ii) Fe + Ni in drilling Machine

⇒ Oxides & Oxoacids:



Covalent ↑

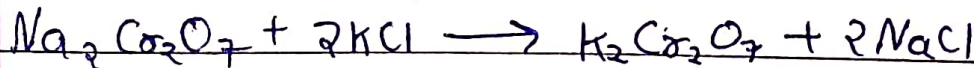
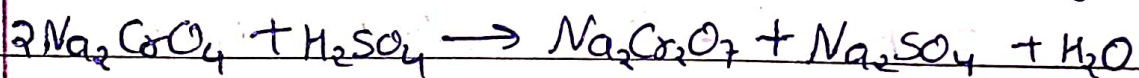
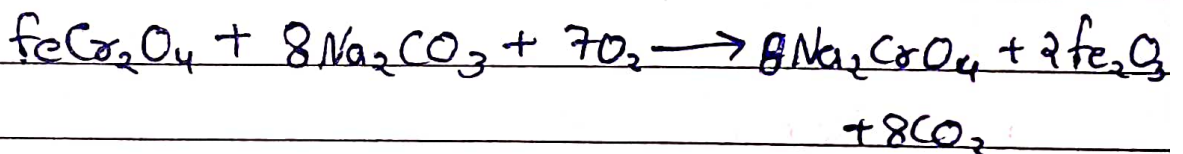


Acidic character ↑

Imp.

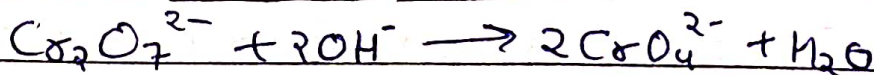
⇒ Potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$)

Preparation of $\text{K}_2\text{Cr}_2\text{O}_7$ - from chromite are

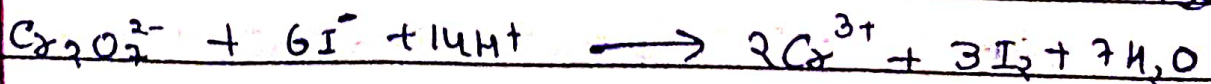
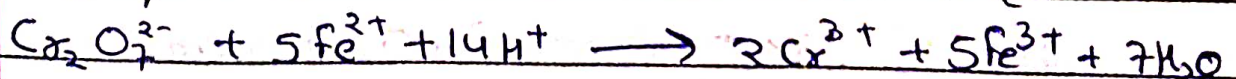
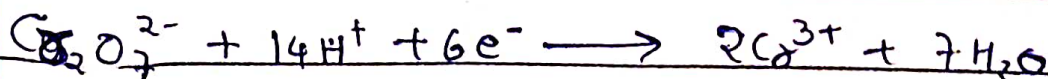


Chemical properties:

① Action with acid & base.

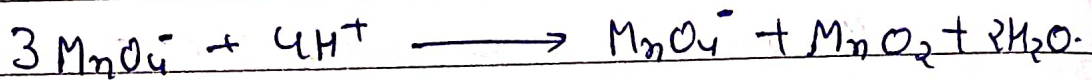
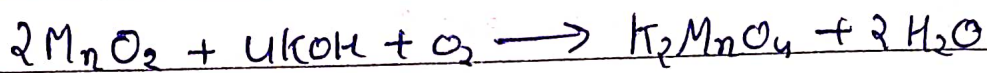


② Oxidising property:

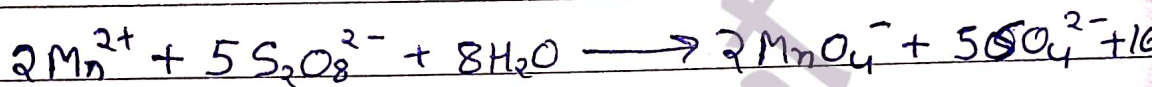


⇒ Potassium permanganate (KMnO₄)

Preparation of KMnO₄ from pyrolusite ore

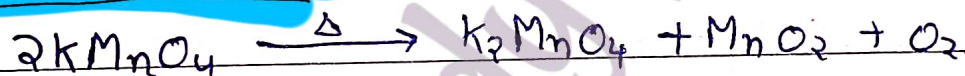


Laboratory preparation

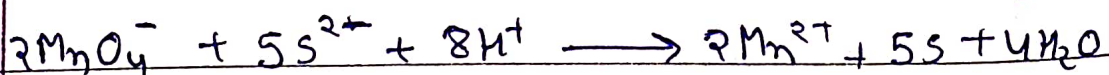
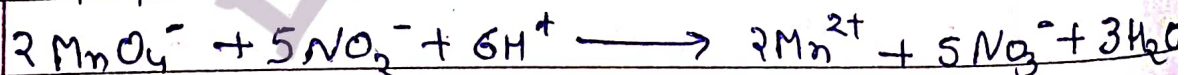
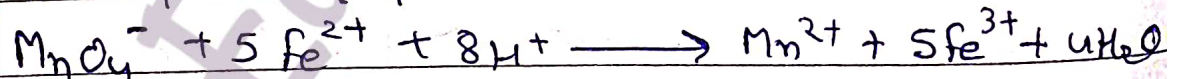
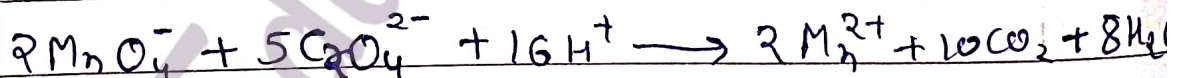
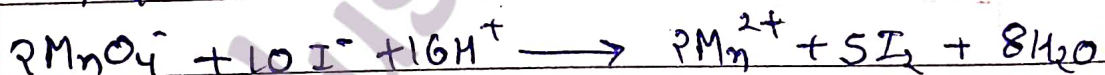
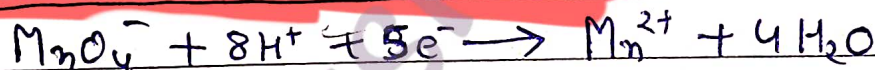


Chemical properties:-

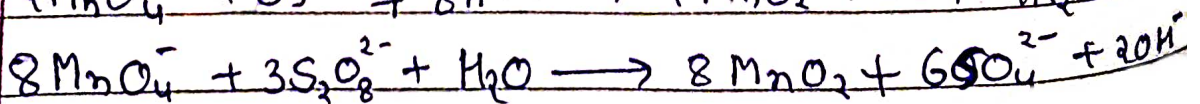
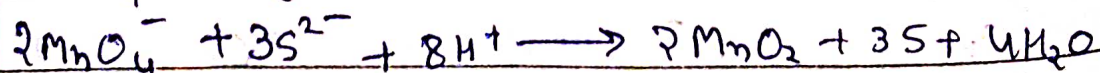
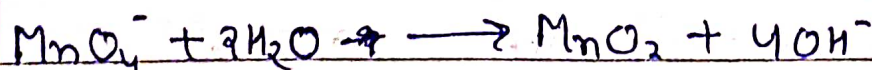
(1) Action of Heat



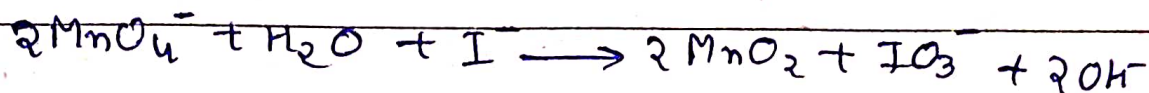
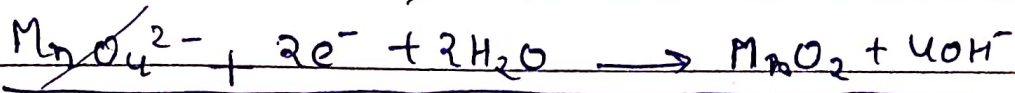
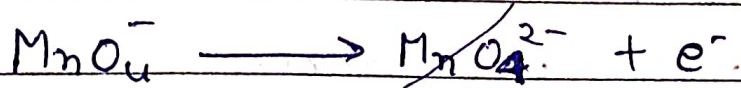
(2) Reaction in Acidic medium



(3) In Neutral Medium:-



(4) In Basic Medium:-



F-Block Elements

⇒ Lanthanoids: Lanthanum $_{57}(\text{La})$

It has 14 elements from Cerium $_{58}(\text{Ce})$ to Lutetium $_{71}(\text{Lu})$

general configuration: $[\text{Xe}] 4f^{1-14} 5d^{0-1} 6s^2$

General properties-

- they are highly dense metal.
- They have high melting point.
- They form Alloys with metal.
- They are Soft Malleable & Ductile.

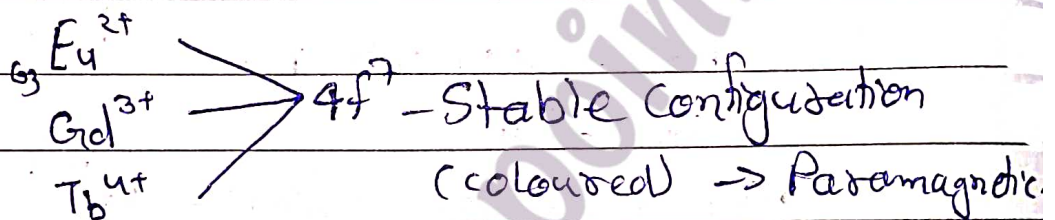
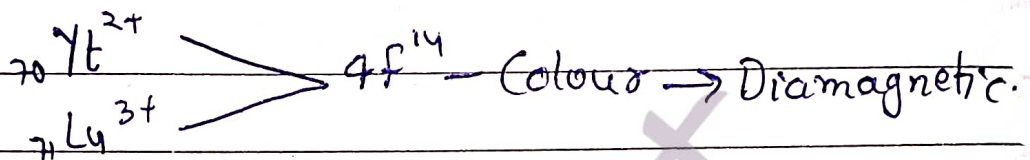
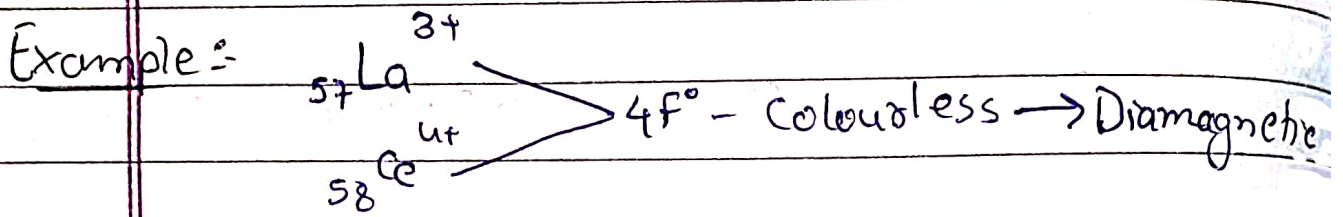
⇒ Oxidation State: Most Common oxidation

State of Lanthanoid is +3. Some of the element also exhibit +2 & +4 Oxidation State.

Colour: La^{3+} & Lu^{3+} are colourless and other
($4f^0$) ($4f^{14}$)

are trivalent lanthanoid ions are coloured due to f-f transition.

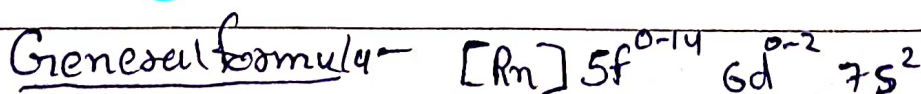
⇒ Magnetic property :- La^{3+} & Lu^{3+} are generally diamagnetic & other lanthanoid ion are paramagnetic in nature.



⇒ Reactivity :- Lanthanoids are highly electropositive & they have almost similar chemical reactivity.

Lanthanoid Contraction :- The filling of e^- in $4f$ orbital before $5d$ orbital results regular decrease atomic radii.

⇒ Actinoids :- Actinium $_{89}(\text{Ac})$ to Lawrencium $_{103}(\text{Lr})$



General properties

→ They are highly dense metal with high melting point & form alloys with other metals.

→ They are silvery white metal which are highly reactive.

Actinoid Contraction - The filling of e^- in 5f before 6d series, result attraction towards nucleus & valence e^- ↓ tends to atomic size ↓.

Oxidation State:- Common oxidation state of Actinoids is +3. The max. oxidation state increase from +4 in ${}_{90}\text{Th}$ to +5, +6 & +7
 ${}_{91}\text{Pa}$ ${}_{92}\text{U}$ ${}_{93}\text{Np}$

→ The most of the Actinoid ions are coloured

Magnetic property:- Many of the Actinoids are paramagnetic except ${}_{84}\text{Ac}$ & ${}_{103}\text{Lu}$

Reactivity:-

→ They are also highly electro. +ve & form oxides as well as complex.

→ Many of these elements are radioactive.

Uses:-

→ ${}_{90}\text{Th}$ is used in treatment of Cancer

→ ${}_{91}\text{U}$ is used in textile & glass industry nuclear & in Medicine

→ ${}_{94}\text{Pu}$ is used in Atomic Reactor & in atomic bond.

Uses of Lanthanoids:

- Ce Salt is used in dyeing cotton and also as Catalyst.
- Lanthanoid Compounds are used as Catalyst for dehydrogenation & petroleum trading.
- Lanthanoid oxide are used as polishing of glass.

Difference b/w Lanthanoid & Actinoid

- ① Except Pm Lanthanoids are non-radio active except while actinoids are radio Active.
- ② Lanthanoid do not form of oxocation. where as Actinoid form oxocation.
- ③ Lanthanoid has less tendency toward Complex formation where as actinoid has greater tendency toward Complex formation.

Similarity b/w Lanthanoid & Actinoid.

- Both show +3 oxidation State.
- Actinoid show Actinoid Contraction as like Lanthanoid Contraction.
- Both are electro +ve & very Reactive.