D and F Block

→ last e⁻ → (n-1) d orbital → penultimate shell.

→ General Electronic Configuration.

$(n-1)d^{1-10}\,ns^{0-2}$

→ Transition Elements → d block having incompletely filled d orbital (either in ground state or in any other oxidation state)

Zn, Cd, Hg ☆ $(n-1)d^{10}\,ns^{2}$ — $Zn^{+2} \rightarrow (n-1)d^{10}$

(these are not transition metals)

Cu → $3d^{10}\,4s^{1}$

$Cu^{+1} \rightarrow 3d^{10}$

$Cu^{+2} \rightarrow 3d^{9}$ → transition element

D Block → Group 3 - Group 12

Transition Metal → Group 3 - Group 11

n=4	4th period	3d Series	21 Sc – Zn 30
n=5	5th period	4d Series	39 Y – Cd 48
n=6	6th period	5d series	57 La, 72 Hf – Hg 80
n=7	7th period	6d series	89 Ac, 104 Rf – Cn 112

General Electronic Configurations

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
21	22								
$3d^1\,4s^2$	$3d^2\,4s^2$	$3d^3\,4s^2$	$3d^5\,4s^1$	$3d^5\,4s^2$	$3d^6\,4s^2$	$3d^7\,4s^2$	$3d^8\,4s^2$	$3d^{10}\,4s^1$	$3d^{10}\,4s^2$

Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd
$4d^1\,5s^2$	$4d^2\,5s^2$	$4d^4\,5s^1$	$4d^5\,5s^1$	$4d^6\,5s^1$	$4d^7\,5s^1$	$4d^8\,5s^1$	$4d^{10}\,5s^0$	$4d^{10}\,5s^1$	$4d^{10}\,5s^2$

La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg
$5d^1\,6s^2$	$5d^2\,6s^2$	$5d^3\,6s^2$	$5d^4\,6s^2$	$5d^5\,6s^2$	$5d^6\,6s^2$	$5d^7\,6s^2$	$5d^9\,6s^1$	$5d^{10}\,6s^1$	$5d^{10}\,6s^2$

(Transition Metals) General properties

→ Shows metallic property

→ High Tensile

→ Malleable and ductile – (mercury - exception)

→ High Thermal and electrical conductivity.

→ Metallic lustre

→ Hard

→ Less Volatile

Except Zn, Cd, Hg, all have metallic lattice. (Mn) ①

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
hcp	hcp	bcc	bcc	X	bcc	ccp	ccp	ccp	X

Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd
hcp	hcp	bcc	bcc	hcp	hcp	ccp	ccp	ccp	X

La	Hf	Ta	W	Re	Os	Ir	Pt	Ag	Hg
hcp	hcp	bcc	bcc	hcp	hcp	ccp	ccp	ccp	X

② Melting and Boiling point →

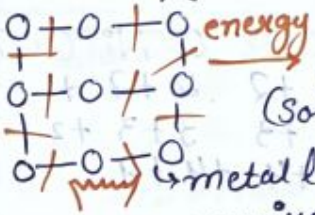
more no. of Valence e⁻, more strong bonding.

Cr, Mo, W → Highest MP and BP (6 Valence e⁻)

Volatile Metals: Zn, Cd, Hg → lowest MP and BP.

Mn, Tc, Re → exception, low MP and BP

③ Enthalpy of atomization → high upto middle and then less in a series



→ energy required to break all bonds of lattice and then convert to gaseous bond.

max → V

④ Atomic Size →

Period →

Sc > Ti > V > Cr > Mn >

Zeff > Screening effect

Fe ≈ Co ≈ Ni

Zeff = Screening effect

< Cu < Zn

Zeff < Screening effect

Group →

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd
↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg
↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
Ac									

Lanthanide Contraction

④ Ionisation Energy →

Sc < Ti > V < Cr < Mn < Fe > Co > Ni < Cu < Zn

General → Left → Right, I.E ↑ (change at 2, 6, 7)

IE_1 of Zn, Cd, Hg → fully filled → Highest

IE_2 of Cr, Cu → full/half filled → High
(Cr: $3d^5$, Cu: $3d^{10}$)

IE_3 of Mn → $3d^5$ → High

⑤ Oxidation State → all d block elements show Variable Oxidation State

(Sc and Zn) – exception

Very less energy gap b/w (n-1)d and ns orbital

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
+3	+2	+2	+2	+2	+2	+2	+2	+1	+2
	+3	+3	+3			+3	+3	+2	
	+4	+4	+4	+4	+4	+4	+4		
		+5	+5	+5					
			+6	+6	+6				
				+7					

Maximum O.S. = +8 = Ru, Os (OSO_4)

⑥ M^{+2}/M electrode potential →

Mn, Ni, Zn → Electrode potential
- Mn: $3d^5$
- Zn: $3d^{10}$ → High Hydration Energy
- → Highly negative

Cu → (+ve) Value → electrode potential
- Cu can't liberate H_2 from acid
- low hydration enthalpy

⑦ M^{+3}/M^{+2} Electrode potential →

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

$Zn^{+2} \rightarrow Zn^{+3}$ → positive electrode potential (High)

$Mn^{+2} \rightarrow Mn^{+3}$ → positive electrode potential (High)

$Fe^{+2} \rightarrow Fe^{+3}$ (stable) → negative electrode potential (low)

Higher Oxidation State in Halide and Oxide →

Ti	V	Cr	Mn	Fe	Co
TiX_2	VX_2	CrX_2	MnX_2	FeX_2	CoX_2
TiX_3	VX_3	CrX_3	MnF_3	FeX_3	CoF_3
TiX_4	VX_4	CrX_4	MnF_4		
	VF_5	CrF_5			
		CrF_6	MnO_3F		

only VF_5 is known

On hydrolysis → VOF_3

In aq. sol^n → Cu^{+2} is more stable than Cu^+
↳ bcoz Hydration Energy is more in Cu^{+2}

Ni	Cu	Zn
NiX_2	CuX	ZnX_2
	CuX_2	

CuX_2 is formed except CuI_2.

$Cu^{+2} + I^- \rightarrow Cu_2I_2 + I_2$

I_2 → good Reducing agent

⑧ Oxide →

Sc	Ti	V	Cr	Mn	Fe
Sc_2O_3	TiO	VO	CrO	MnO	FeO
	Ti_2O_3	V_2O_3	Cr_2O_3	Mn_2O_3	Fe_2O_3
	TiO_2	V_2O_4	CrO_2	MnO_2	Fe_3O_4
		V_2O_5	---	Mn_3O_4	
			CrO_3	Mn_2O_7	

Co	Ni	Cu	Zn
CoO	NiO	CuO	ZnO
Co_3O_4		Cu_2O	

⑨ Magnetic property →

Diamagnetic	paramagnetic	Ferro-magnetic
repelled by M.F.	attracted by MF.	Very strong attracted by MF.
→ 0 unpaired e$^-$	→ presense of upaired e$^-$	
→ all e$^-$ are paired	→ magnetic moment	

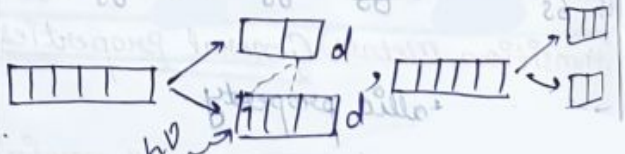
$\mu = \sqrt{n(n+2)}$ B.M

n = no. of upaired e$^-$

⑩ Formation of Coloured ions →

→ unpaired electron is present and it shows colour

→ Colour shows due to d-d-transition



Sc^{+3} → no colour

Zn^{+2} → no colour

Cu^+ → Colourless

Ti^{+4} → Colourless

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(13) Alloy formation →

Due to similar size of d block elements these elements form alloy.

alloy of Copper →

Brass → Cu (70-80%) + Zn (20-30%)

Bronze → Cu (80-90%) + Sn (10-20%)

Gun metal → Cu (85%) + Zn (10%) + Sn (5%)

Bell Metal → Cu (72-80%) + Zn (20-28%)

Some Imp Compounds of Transition Elements

Oxides → Low Oxidation State Oxide → Basic
High Oxidation State Oxide → Acidic
Intermediate Oxidation State Oxide → Amphoteric

V_2O_3 → Basic

V_2O_5 → Amphoteric
- $V_2O_5 + HCl \longrightarrow VO_2Cl + H_2O$
- $V_2O_5 + NaOH \longrightarrow Na_3VO_4 + H_2O$

CrO → Basic

Cr_2O_3 → Amphoteric

CrO_3 → Acidic

$Cr_2^{+6}O_3 + H_2O \longrightarrow H_2Cr^{+6}O_4$

$Mn_2^{+7}O_7 + H_2O \longrightarrow HMn^{+7}O_4$

$2CrO_3 + H_2O \longrightarrow H_2Cr_2O_7$

Catalytic Property →

Due to Variable Oxidation state it shows catalytic property.

Contact process → V_2O_5

Haber's process → Fe (finely divided)

Catalytic Hydrogenation → Ni, Pt, Pd.

$Fe^{+3} + I^- \longrightarrow Fe^{+2} + I_2$

$Fe^{+2} + S_2O_8^{-2} \longrightarrow Fe^{+3} + SO_4^{-2}$

Potassium Dichromate ($K_2Cr_2O_7$)

Pprn → Chromite ore + dhe lo.

$(FeO.Cr_2O_3)$ $FeCr_2O_4$

① $FeCr_2O_4 + Na_2CO_3 + O_2 \longrightarrow Na_2Cr_2O_4 + Fe_2O_3 + CO_2$

$Fe^{+2}Cr_2O_4^{-2}$ Na^+ — Sodium chromate

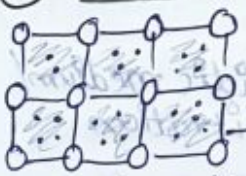
② $Na_2Cr_2O_4 + H_2SO_4 \longrightarrow Na_2SO_4 + Na_2Cr_2O_7$

Sodium dichromate

③ $Na_2Cr_2O_7 + KCl \longrightarrow K_2Cr_2O_7 + NaCl$

potassium dichromate

(12) Interstitial Compound →



H, C, N, B ↳ small size elements

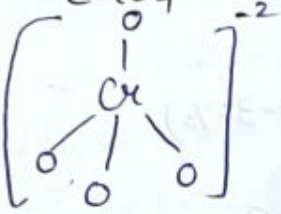
→ Transition elements are metal, and hence form metallic lattice, (Voids)

Small size elements like H, C, N, B are accomodated in these empty spaces (Voids) and form interstitial compounds.

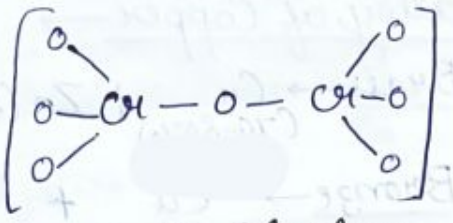
→ High melting point
→ Very Hard.
→ Chemically inert.
→ Have metallic conductivity.

structure →

chromate CrO_4^{-2}



dichromate $Cr_2O_7^{-2}$



Chromate-dichromate Equilibrium

$Cr^{+6}O_4^{-2} \rightleftharpoons Cr_2^{+6}O_7^{-2}$

Acidic → pH < 7 → Rx.n forward

Basic → pH > 7 → Rx.n Backward.

$Cr^{+6}O_4^{-2}$ → Yellow

$Cr_2^{+6}O_7^{-2}$ → Orange

Strong Oxidizing agent in acidic medium →

$Cr_2^{+6}O_7^{-2} + H^+ \longrightarrow Cr^{+3}$

$I^- \rightarrow I_2$	$Cr_2O_7^{-2} + H^+ + I^- \rightarrow Cr^{+3} + I_2 + H_2O$
$H_2S \rightarrow S$	$Cr_2O_7^{-2} + H^+ + H_2S \rightarrow Cr^{+3} + S + H_2O$
$Sn^{+2} \rightarrow Sn^{+4}$	
$Fe^{+2} \rightarrow Fe^{+3}$	

Chromyl Chloride Test →

metal chloride + conc H_2SO_4 + $K_2Cr_2O_7$ → CrO_2Cl_2 + $KHSO_4$ + H_2O

(red vapour)

② Potassium P.e r magnate ($KMnO_4$) →

ppr.n → MnO_2 (pyrolusite ore)

$MnO_2 + KOH + O_2 \rightarrow K_2MnO_4 + H_2O$

magnate ion (green)

$Mn^{+6}O_4^{-2} \xrightarrow{H^+} Mn^{+7}O_4^- + MnO_2 + H_2O$

(green) permagnate (purple)

Commercial ppr.n →

$MnO_2 \xrightarrow[\text{and oxidise with air or } KNO_3]{\text{Fused with KOH}} MnO_4^{-2}$

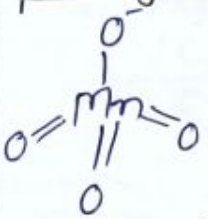
$MnO_4^{-2} \xrightarrow[\text{oxidation}]{\text{electrolytic}} MnO_4^-$

Lab →

$Mn^{+2} + S_2O_8^{-2} \longrightarrow MnO_4^- + SO_4^{-2}$

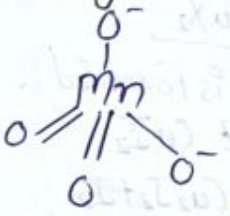
Structure →

permagnate



diamagnetic purple

magnate



paramagnatic green

potassium permagnate in acidic medium →

$Mn^{+7} \rightarrow Mn^{+2}$

① $C_2^{+3}O_4^{-2} \rightarrow CO_2^{+4}$

② $Fe^{+2} \rightarrow Fe^{+3}$

③ Nitrite → Nitrate

$NO_2^- \rightarrow NO_3^-$

④ Iodide → Iodine

$I^- \rightarrow I_2$

⑤ $S^{-2} \rightarrow S$

⑥ $SO_3^{-2} \rightarrow SO_4^{-2}$

eg → $KMnO_4 + H^+ + C_2O_4^{-2} \rightarrow Mn^{+2} + CO_2$

Neutral / faintly alkaline Sol.n →

$Mn^{+7}O_4^- + I^- \longrightarrow Mn^{+4}O_2 + IO_3^-$

$Mn^{+7}O_4^- + S_2O_3^{-2} \longrightarrow Mn^{+4}O_2 + SO_4^{-2}$

$MnO_4^- + Mn^{+2} \longrightarrow MnO_2$

We don't use HCl in acidic medium/ titration

$HCl + KMn^{+7}O_4 \rightarrow Mn^{+2} + Cl_2$

F-Block → Inner transition metals.

→ Those in which 4F and 5F Orbitals are progressively filled.

Group 3 → Biggest → 32

Group ③ ① Lanthanoids → 1st inner transition metals

period ⑥ La(57) | Ce(58) Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu(71)

Group ③ ② Actenoids → 2nd inner transition

Period ⑥ Ac(89) | Th(90) Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr(103)

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

Lanthanoids → $4f^{1-14}5d^{0-1}6s^2$

	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
4f	0	1	3	4	5	6	7	7	9	10	11	12	13	14	14
5d	1	1	0	0	0	0	0	1	0	0	0	0	0	0	1
6s	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

② Oxidation Number →

(+2) Eu^{+2}, Yb^{+2} → Reducing agents

(+3) Most common Ln^{+3}

(+4) Ce^{+4} → good analytical agent; Pr Nd Tb Dy → MO_2 Oxidizing agent

③ Ionic Radii →

Ln^{+3} $La^{+3} > Ce^{+3} > Pr^{+3} \dots\dots > Lu^{+3}$

Left to right decreases, due to increase in Effective Nuclear Charge due to Lanthanoid Contraction.

(poor screening of 4f e⊖s)

Screening effect → s > p > d > f

④ Chemical Reactions →

$Ln + O_2 \xrightarrow{\Delta} Ln_2O_3$

$Ln + acid \rightarrow H_2$ realeased ↑

$Ln + X_2 \rightarrow LnX_3$

$Ln + N_2 \xrightarrow{\Delta} LnN$

$Ln + H_2O \rightarrow Ln(OH_3) + H_2$

$Ln + C \xrightarrow[2773\,K]{\Delta} LnC_2$

$Ln + S \xrightarrow{\Delta} Ln_2S_3$

⑤ General properties →

① All Ln are silvery white soft metals (exception – Sm is steel hard) due to strong metallic bond.

② Except La^{+3} and Lu^{+3} all are coloured.

③ Except f^0 type (La^{+3} and Ce^{+4}) and f^{14} type (Yb^{+2} and Lu^{+3}) } diamagnetic all are paramagnetic

④ Basicity of Ln decreases from left to right due to decrease in Size.

$La(OH)_3 > \dots\dots > Lu(OH)_3$

Basicity Decreases →

⑤ Hardness ∝ Atomic number

⑥ Alloys of Lanthanoids are called Mischmetalls.

95% Ln, 5% Fe with some traces of S, C, Ca etc...

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② Actinoids → Radioactive metals, (U → Lr = Trans Uranic Elements)

	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
							7	7	9	10	11	12	13	14	14
(5f)	0	0	2	3	4	6									
6d	1	2	1	1	1	0	0	1	0	0	0	0	0	0	1
7s	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Oxidat^{n} no.	3	–	3	3	3	3	3	3	3	3	3	3	3	3	3
		4	4	4	4	4	4	4	4						
			5	5	5	5	5								
				6	6	6	6								
					7	7									

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

Actenoids → $5f^{1-14}6d^{0-1}7s^2$

① Size →

Left to Right, size decreases due to increase in Effective Nuclear Charge. due to Actinoid Contraction, (poor screening of 5fe$^{\ominus}$s.)

② General Characteristics →

1. All are paramagnetic.
2. They are silvery white metal.
3. They get tarnished on exposure to alkali.
4. All are radioactive (and atomic no. 92 onwards all elements are called transuranic elements)
5. They react with boiling water to form mix. of oxides and hydrides.
6. All are reacted with non metals at moderate temp.
7. All are reacted with HCl but effect with HNO_3 is small due to the formation of Oxide layer.