FREE NOTES · NCERT + JEE/NEET LEVEL

The d- and f-Block Elements

Transition metals: configuration aur general trends (size, ionisation enthalpy, oxidation states, E°, magnetic moment, colour, catalysis, complexes, alloys), $K_2Cr_2O_7$ aur $KMnO_4$, lanthanoids, lanthanoid contraction aur actinoids.

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01 Position & electronic configuration

d-block = groups 3–12, aakhri electron (n-1)d orbital me jaata. Chaar series: 3d (Sc–Zn), 4d (Y–Cd), 5d (La, Hf–Hg), 6d (Ac, Rf–Cn). General configuration: $(n-1)d^{1-10}\ ns^{1-2}$.

Transition element wo jiska d subshell atom me ya kisi common ion me adhoora bhara ho. Isliye **Zn, Cd, Hg transition elements nahi** (atom aur ion dono me d^{10}). Cu hai (Cu^{2+} d^9 hai).

YE EXCEPTIONS YAAD KARO

Cr: $3d^5\ 4s^1$ ($3d^4 4s^2$ nahi) aur Cu: $3d^{10}\ 4s^1$ ($3d^9 4s^2$ nahi), kyunki half-filled aur full d subshell extra stable hote (exchange energy).

02 Physical properties & atomic size

- Sakht, high melting aur boiling point (bahut se unpaired d electrons se strong metallic bonding). M.p. beech me (d^5 ke paas) sabse zyada; Mn aur Tc irregular; Zn, Cd, Hg naram aur kam melting (Hg liquid hai).
- Enthalpy of atomisation zyada. Bhaari series (4d, 5d) me aur zyada.
- **Size:** series me dheere dheere ghatta (d electrons ki kamzor shielding), phir lagbhag constant. Ek group ke 4d aur 5d ka radius **lagbhag same** (Zr 160 pm ≈ Hf 159 pm), **lanthanoid contraction** ki wajah se.
- Series me density badhti (Sc se Cu).

03 Ionisation enthalpy & oxidation states

Series me IE dheere badhti. 3d/4s energy paas hone se irregular: jaise Cr aur Cu ki IE_2 zyada (d^5, d^{10} tootta), Mn (Mn^{2+} d^5) aur Zn ki IE_3 zyada.

Variable oxidation states kyunki 3d aur 4s electrons ki energy milti-julti hai. Beech me sabse zyada states: **Mn +2 se +7 tak**.

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

PATTERNS

- Sabse oonchi states oxides aur fluorides me (Mn_2O_7, CrO_3, VF_5): O multiple bonds bana sakta.
- CO wale complexes me neechi states ($Ni(CO)_4$, oxidation state 0).
- Oonche oxides acidic (Mn_2O_7), neeche wale basic (MnO).

04 E° values & stability

- **Cu** ka $E°(M^{2+}/M)$ = +0.34 V positive hai, isliye acids se H_2 nahi nikalta. Iski wajah zyada atomisation energy aur kam hydration energy.
- **Mn^{2+} (d^5), Zn^{2+} (d^{10}), Ni^{2+}** (zyada hydration energy) ka E° expected se zyada negative ⇒ ye ions bahut stable.
- $E°(Mn^{3+}/Mn^{2+})$ bahut zyada (+1.57): Mn^{3+} strong oxidant kyunki Mn^{2+} d^5 stable hai. $E°(Fe^{3+}/Fe^{2+})$ kam kyunki Fe^{3+} (d^5) stable hai.
- **Cr^{2+} reducing** hai (Cr^{3+} banta, t_2g^3) jabki **Mn^{3+} oxidising** (Mn^{2+} banta, d^5), dono d^4 hone ke bawajood.
- Paani me Cu^+ disproportionate hota: $2Cu^+ \rightarrow Cu^{2+} + Cu$ (Cu^{2+} ki hydration energy bahut zyada).

05 Magnetism, colour, catalysis, complexes, alloys

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

n = unpaired electrons. Unpaired ⇒ **paramagnetic**; sab paired ⇒ diamagnetic. n = 1, 2, 3, 4, 5 ⇒ μ = 1.73, 2.83, 3.87, 4.90, 5.92 BM.

- **Colour:** d–d transition. Ek rang ki light absorb hoti, complementary rang dikhta. d^0 (Sc^{3+}, Ti^{4+}) aur d^{10} (Zn^{2+}, Cu^+) ions rangheen. Cu^{2+} neela, Ni^{2+} hara, Mn^{2+} halka gulabi, Fe^{3+} peela.
- **Catalysts:** variable oxidation states aur adsorption ke liye surface. V_2O_5 (Contact process), Fe (Haber), Ni (hydrogenation), $TiCl_4 + Al(CH_3)_3$ (Ziegler-Natta).
- **Complexes:** chhota size, zyada charge, khaali d orbitals.
- **Interstitial compounds:** chhote atoms (H, C, N) metal lattice me fanse (TiC, Fe_3H). Sakht, high melting, chemically inert.
- **Alloys:** atoms ka size milta-julta (brass Cu-Zn, bronze Cu-Sn, stainless steel).

06 Potassium dichromate & permanganate

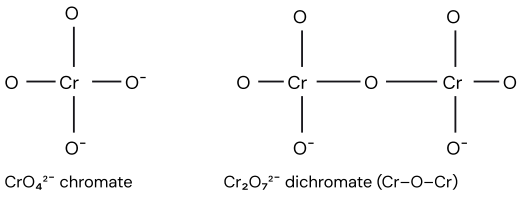
$K_2Cr_2O_7$ banana (chromite ore $FeCr_2O_4$ se):

$$4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$$
$$2Na_2CrO_4 + 2H^+ \rightarrow Na_2Cr_2O_7 + 2Na^+ + H_2O$$
$$Na_2Cr_2O_7 + 2KCl \rightarrow K_2Cr_2O_7 + 2NaCl$$

Chromate (peela) ⇌ dichromate (orange) pH pe depend: acid → dichromate, base → chromate.

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O \ (E^\circ = 1.33\ V)$$

$I^- \rightarrow I_2$, $Fe^{2+} \rightarrow Fe^{3+}$, $H_2S \rightarrow S$, $Sn^{2+} \rightarrow Sn^{4+}$ oxidise karta



Chromate aur dichromate ions ki structure

$KMnO_4$

Pyrolusite MnO_2 se: KOH + O_2 ke saath fuse → K_2MnO_4 (hara) → disproportionation/oxidation → $KMnO_4$ (purple). Diamagnetic; rang charge transfer se.

Acidic: $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ $(5\ e^-)$

Neutral/weakly basic: $MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$ $(3\ e^-)$

Acidic $KMnO_4$ Fe^{2+}, oxalate, I^- → I_2, H_2S, SO_2 ko oxidise karta. Acidic banane ke liye HCl nahi (Cl^- oxidise ho jaata); dilute H_2SO_4 use hota.

07 Lanthanoids & lanthanoid contraction

La ke baad ke 14 elements (Ce se Lu), 4f bharta. Configuration [Xe] $4f^{1-14}$ $5d^{0-1}$ $6s^2$. Common oxidation state **+3**. Ce^{4+} (f^0) achha oxidant; Eu^{2+}, Yb^{2+} (f^7, f^{14}) reductants.

LANTHANOID CONTRACTION

La se Lu tak size lagatar ghatta kyunki 4f electrons kamzor shielding karte. Nateeje: (1) group ke 4d aur 5d elements ka size lagbhag same (Zr/Hf, Nb/Ta), alag karna mushkil; (2) $Ln(OH)_3$ ki basicity $La(OH)_3$ se $Lu(OH)_3$ tak ghatti; (3) lanthanoids ko aapas me alag karna mushkil.

Uses: **misch metal** (Ln 95% + Fe 5%, lighter ke flint), petroleum cracking me catalyst, TV screen ke phosphors.

08 Actinoids

- Ac ke baad ke 14 elements (Th se Lr), 5f bharta. Sab **radioactive**; U ke baad wale insaan ne banaye.
- Lanthanoids se **zyada oxidation states** (+3 se +7; U, Np, Pu) kyunki 5f, 6d, 7s ki energy milti-julti.
- **Actinoid contraction** lanthanoid contraction se zyada (5f aur bhi kamzor shielding).
- Reactive metals, bareek powder pyrophoric hota.

09 JEE Extra + Tricks

JEE LEVEL

- d–d transition se rang: d^0 (Sc^{3+}, Ti^{4+}) aur d^{10} (Zn^{2+}, Cu^{+}) rangheen.
- Lanthanoid contraction ⇒ Zr aur Hf lagbhag same size (alag karna mushkil); La → Lu $Ln(OH)_3$ ki basicity ghatti.
- $KMnO_4$ aur $K_2Cr_2O_7$: chromate (peela) ⇌ dichromate (orange) pH se; MnO_4^- baingani. Banana: pyrolusite (MnO_2) KOH ke saath → K_2MnO_4 (hara) → $KMnO_4$.
- Sabse zyada oxidation state: Mn +7 ($KMnO_4$), Os +8 (OsO_4). Ln ka aam state +3; Ce^{4+} (oxidant), Eu^{2+} (reductant).
- Interstitial compounds, catalyst (Haber me Fe, contact process me V_2O_5, hydrogenation me Ni) aur alloys.

10 Solved questions

Q1. Fe^{2+} (Z = 26) ka μ nikalo.

Fe^{2+}: $3d^6$ ⇒ 4 unpaired ⇒ μ = √(4×6) = √24 = **4.90 BM**.

Q2. Sc^{3+} rangheen kyun aur Ti^{3+} rangeen kyun?

Sc^{3+} $3d^0$ hai: d–d transition ke liye koi d electron nahi. Ti^{3+} $3d^1$ hai: d–d transition visible light absorb karta (purple rang).

Q3. Zr aur Hf ka radius lagbhag same kyun?

Lanthanoid contraction: Hf se pehle ke 14 4f elements uska size ghata dete, jo extra shell se badhna chahiye tha wo cancel ho jaata.

Q4. Acid me 1 mol Fe^{2+} ko kitne mol $KMnO_4$ oxidise karega?

MnO_4^- $5e^-$ leta, har Fe^{2+} $1e^-$ deta ⇒ **1/5 mol**.

11 Mistakes & practice

- Zn ko transition element kehna.
- Cr ko $3d^4 4s^2$ ya Cu ko $3d^9 4s^2$ likhna.
- Kehna ki $KMnO_4$ ka rang d–d transition se hai (Mn^{7+} d^0 hai: ye charge transfer hai).
- $KMnO_4$ ko HCl se acidic banana.

1. Kaun sa 3d metal sabse zyada oxidation states dikhata?
2. Paani me Cu^+ unstable kyun?
3. Peele chromate me acid dalne pe rang?
4. Cu^{2+} ka μ?
5. Lanthanoid contraction ka ek nateeja batao.

ANSWERS

1) Mn · 2) Disproportionate hota; Cu^{2+} ki hydration energy bahut zyada · 3) Peela → orange (dichromate) · 4) 1.73 BM · 5) Zr aur Hf ka size lagbhag barabar

12 Quick revision: exam se 5 minute pehle

BASICS

- $(n-1)d^{1-10}\ ns^{1-2}$.
- Cr $3d^5 4s^1$, Cu $3d^{10} 4s^1$.
- Zn, Cd, Hg: transition nahi.

PROPERTIES

- $\mu = \sqrt{n(n+2)}$ BM.
- Rang: d–d; d^0, d^{10} rangheen.
- Mn: +2 se +7.

REAGENTS

- $Cr_2O_7^{2-} \rightarrow Cr^{3+}$ ($6e^-$).
- $MnO_4^- \rightarrow Mn^{2+}$ acid ($5e^-$), MnO_2 neutral ($3e^-$).
- Chromate peela $\rightleftharpoons$ dichromate orange.

F-BLOCK

- Lanthanoids: +3, contraction.
- Zr ≈ Hf size.
- Actinoids: radioactive, kai states.

Koi doubt? padhaiadda.netlify.app pe AI Doubt Solver se poocho, ya is chapter ka mock test do.