

Chapter 4 · d- and f-Block Elements

CBSE Class 12 Chemistry (043) · Inorganic · Unit 4 = 7 marks · Ultimate Revision Sheet

60-SECOND RECALL

Transition element	Has a partially filled d subshell in its ground state or in a common oxidation state
Not transition	Zn, Cd, Hg — d^{10} , completely filled
Exceptions	Cr = $3d^5 4s^1$ · Cu = $3d^{10} 4s^1$ (half/fully filled stability)
Highest O.S.	Mn = +7 · strongest reducing Sc , most stable +2 Mn
Colour	d-d transition — needs partially filled d
Magnetic moment	$\mu = \sqrt{n(n+2)}$ BM, n = unpaired electrons
Lanthanoid contraction	Poor shielding by 4f → steady size decrease

1. Position and Electronic Configuration

THE BASICS d-block: groups 3–12, general configuration $(n-1)d^{1-10} ns^{1-2}$.

Two exceptions to remember: **Cr** = $3d^5 4s^1$ and **Cu** = $3d^{10} 4s^1$, because half-filled and fully filled d subshells are extra stable (symmetry + exchange energy).

Zn, Cd, Hg are NOT transition elements — their d subshell is full in both the atom and all their common ions.

2. General Properties

THE PROPERTIES AND THEIR ONE-LINE REASONS

Property	Reason — this is the mark
High melting points	Strong metallic bonding from unpaired d electrons . Maximum in the middle of the series; Zn, Cd, Hg are low (no unpaired d electrons).
Variable oxidation states	(n-1)d and ns have similar energies , so both can take part in bonding.
Coloured ions	d-d transition — an electron absorbs visible light and jumps between split d orbitals. Sc³⁺ (d⁰) and Zn²⁺ (d¹⁰) are colourless .
Paramagnetism	Due to unpaired electrons ; $\mu = \sqrt{n(n+2)}$ BM.
Catalytic activity	Variable oxidation states and the ability to form intermediates , plus large surface area. Eg V_2O_5 , Fe, Ni.
Complex formation	Small size, high charge density, vacant d orbitals .
Alloy formation	Similar atomic radii , so one metal can replace another in the lattice.
Interstitial compounds	Small atoms (H, C, N) occupy interstitial sites → harder, higher melting, chemically inert.

THE FACTS MOST OFTEN ASKED

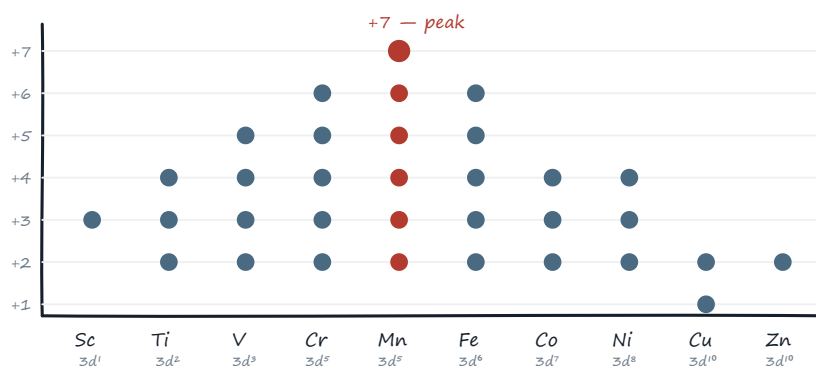
Mn shows the maximum oxidation state (+7) because it has the most unpaired electrons available ($3d^5 4s^2$).

Cu is the only 3d metal with a positive E° value — so it does **not** liberate H_2 from acids. The reason is its **high sublimation and ionisation enthalpy** not being compensated by hydration enthalpy.

Zn, Cd, Hg are not paramagnetic and their compounds are **white/colourless**.

Cr^{2+} is a strong reducing agent (changes to the stable d^3 Cr^{3+}), while Mn^{3+} is a strong oxidising agent (changes to the stable d^5 Mn^{2+}).

Oxidation states across the 3d series — why the maximum sits at manganese



Mn has 5 unpaired 3d + 2 4s electrons = 7 available, so +7 is its maximum.

Zn ($3d^{10}$) shows only +2, so it is not a transition element at all.

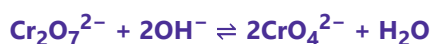
States rise to Mn then fall, because after d^5 the 3d electrons pair up and are held too tightly to be lost. **Sc^{3+} (d^0) and Zn^{2+} (d^{10}) are colourless** for the same reason — no d-d transition is possible.

3. Important Compounds

POTASSIUM DICHROMATE $K_2Cr_2O_7$ Colour: orange. Oxidation state of Cr: +6.



The equilibrium asked every year: in alkali, orange dichromate turns yellow chromate; on acidifying, the yellow turns back orange.



Structure: both ions are tetrahedral about each Cr; the dichromate has a Cr-O-Cr bridge.

POTASSIUM PERMANGANATE $KMnO_4$ Colour: deep purple. Oxidation state of Mn: +7. It is diamagnetic and its colour is due to charge transfer, not d-d transition (Mn is d^0).



Structure: tetrahedral.

4. Lanthanoids and Actinoids

LANTHANOID CONTRACTION — guaranteed question

What: the steady decrease in atomic and ionic radii across the lanthanoid series.

Why: each added electron goes into the 4f subshell, which shields poorly, so the effective nuclear charge felt by the outer electrons rises steadily.

Consequences: (1) Zr and Hf have almost identical radii and are very hard to separate; (2) the second and third transition series have similar sizes and properties; (3) basicity of hydroxides decreases across the series.

LANTHANOIDS vs ACTINOIDS

Basis	LANTHANOIDS	ACTINOIDS
Filling	4f	5f
Common O.S.	Mainly +3	Wide range, +3 to +7
Radioactivity	Only promethium	All are radioactive
Complex formation	Less	Greater (smaller size, higher charge)

Uses: mischmetall (lanthanoid alloy) in lighter flints and tracer bullets; lanthanoid oxides as catalysts and in glass; uranium and plutonium as nuclear fuel.

5. Question Triggers

what the wording wants

If the question says...	The answer is...
"why is Zn not a transition element"	d^{10} in atom and ion — no partially filled d
"why are Zn^{2+} and Sc^{3+} colourless"	d^{10} and d^0 — no d-d transition possible
"why does Cr have $3d^5 4s^1$ "	Half-filled stability
"orange solution turns yellow on adding alkali"	Dichromate → chromate
"why is Cu^{2+} coloured but Cu^+ colourless"	Cu^{2+} is d^9 , Cu^+ is d^{10}
"Zr and Hf are difficult to separate"	Lanthanoid contraction
"calculate the magnetic moment"	$\mu = \sqrt{n(n+2)}$ BM
"why are transition metals good catalysts"	Variable oxidation states + intermediate formation

MOST-ASKED BOARD QUESTIONS

- [3M] Explain variable oxidation states, colour and catalytic activity of transition elements.
- [3M] Write the preparation / oxidising reactions of $KMnO_4$ or $K_2Cr_2O_7$, with the ionic equations.
- [3M] What is lanthanoid contraction? Give its cause and two consequences.
- [2M] Calculate the spin-only magnetic moment of a given ion.
- [2M] Compare lanthanoids and actinoids.
- [1M] Which 3d element has the highest oxidation state? → Mn (+7)

THE HABIT THAT SCORES — Every "why" question in this chapter is answered by one of four things: **number of unpaired electrons**, **half/fully filled stability**, **similar energy of $(n-1)d$ and ns** , or **poor shielding by f electrons**. Name the reason explicitly — describing the observation again earns nothing.