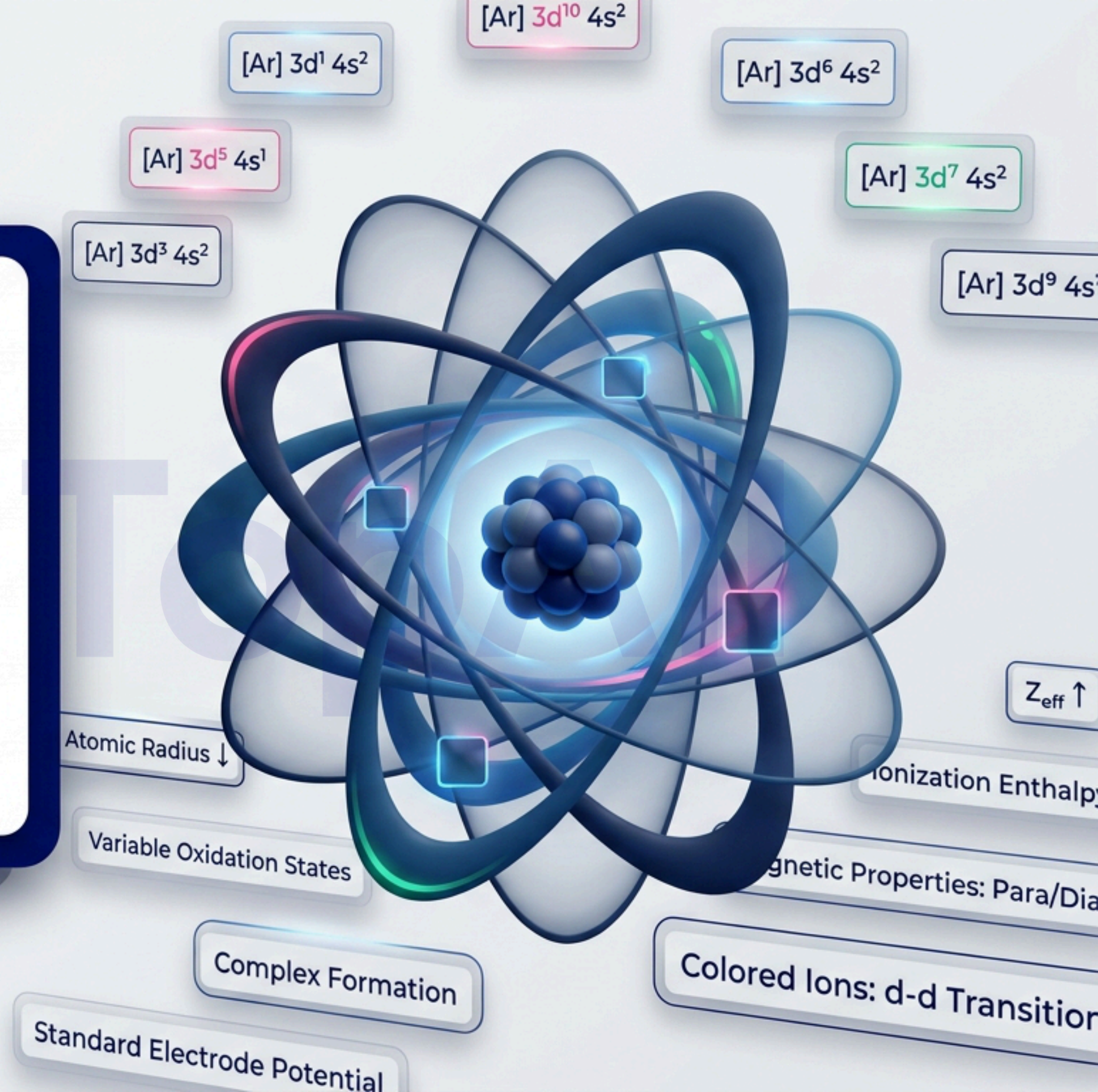
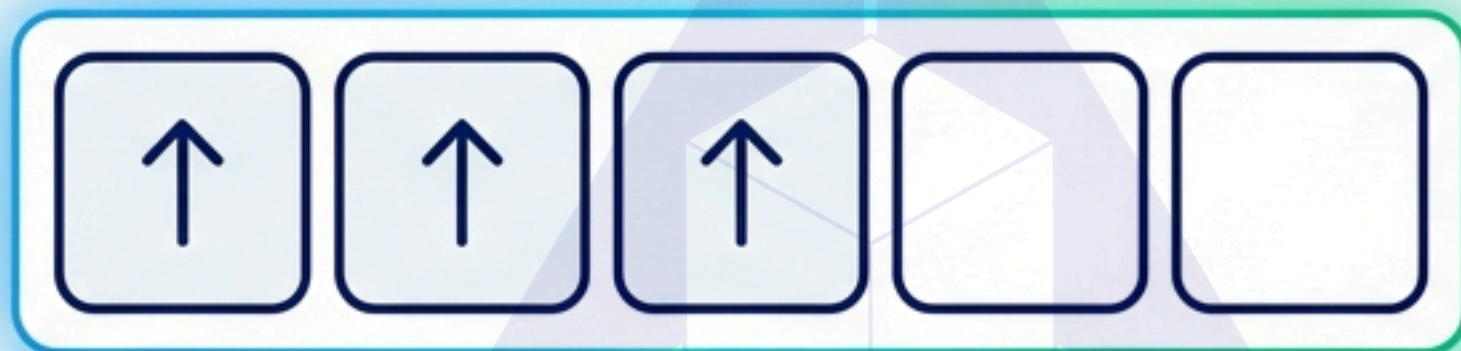


4.3 General Properties of Transition Elements

Decoding the chemical mastery of the d-block.



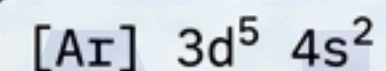
d-orbital infographic



Incomplete d-subshell (e.g., d^3 , d^5 , d^7)

The IUPAC Rule

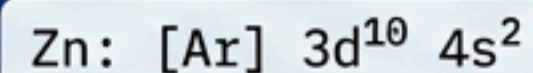
Transition metals are defined by having incomplete d-subshells in their neutral atom or common ions. This incomplete status is the engine driving their unique properties.



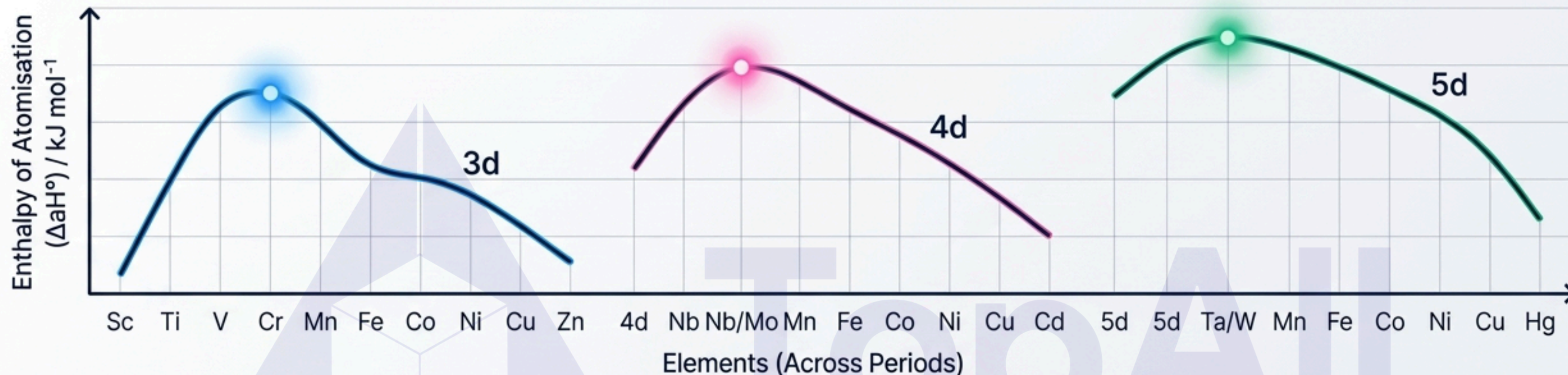
The Exceptions

Excluded Elements: Zinc (Zn), Cadmium (Cd), Mercury (Hg).

Why?: They possess a completely filled $(n-1)d^{10} \ ns^2$ configuration in their ground state and common oxidation states. Fully filled d-orbitals = no transition properties.



Unpaired Electrons Drive Metallic Strength



The Mechanism

Large numbers of unpaired d-electrons participate in interatomic interaction.

More unpaired electrons = stronger metallic bonding, leading to high melting points and extreme atomisation enthalpies.

The Trend Note

Enthalpies rise to a maximum near the middle of each series (d⁵ configurations) and fall as electrons pair up. Heavy transition metals (4d, 5d) have greater atomisation enthalpies than 3d metals, causing frequent metal-metal bonding.

The Valency Heatmap: Variable Oxidation States

Valency Heatmap

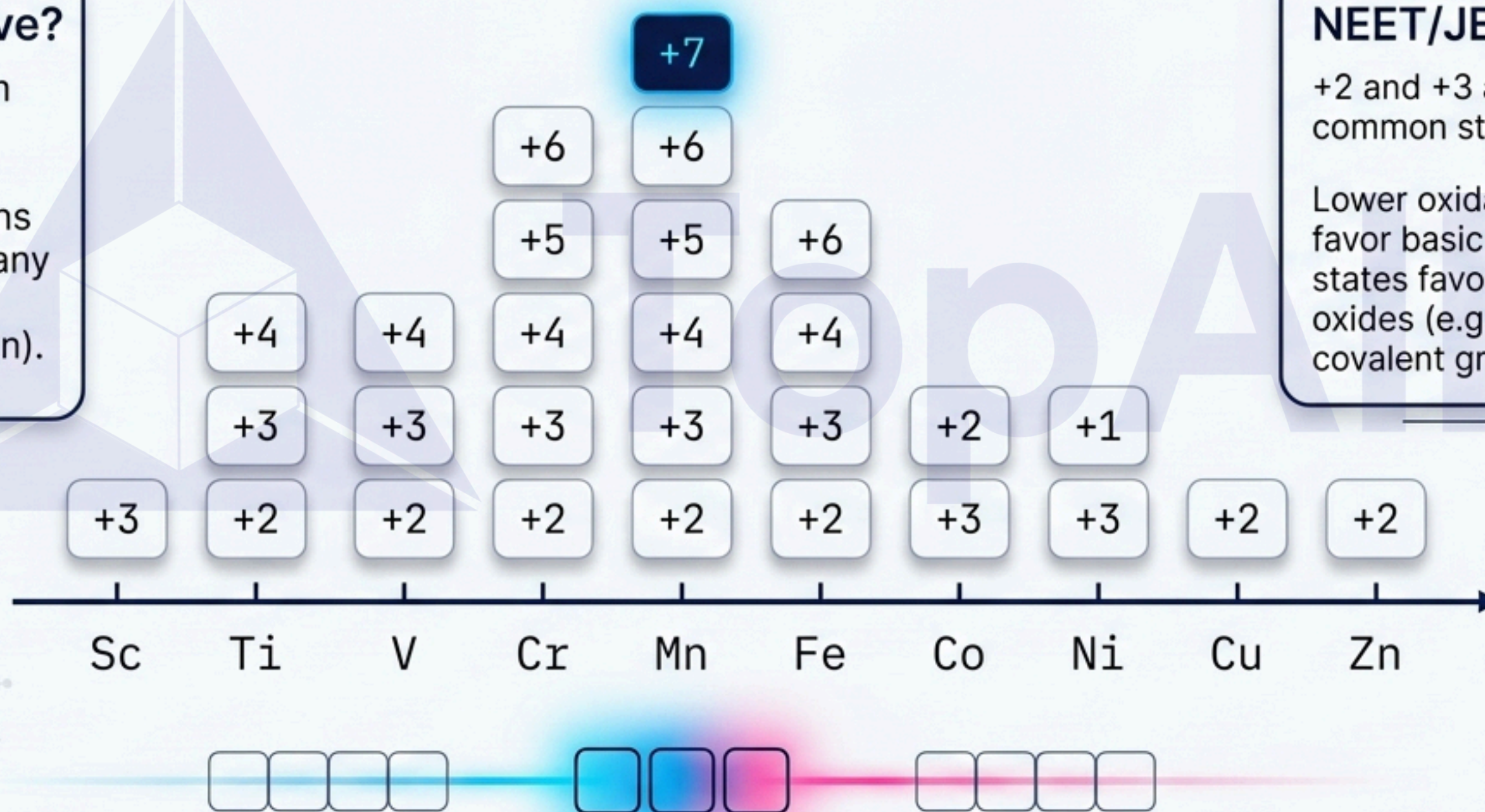
Why the bell curve?

Variability arises from incomplete d-orbital filling. Extreme ends have too few electrons to lose (Sc) or too many d-electrons sharing paired orbitals (Cu, Zn).

NEET/JEE Insight

+2 and +3 are the most common states.

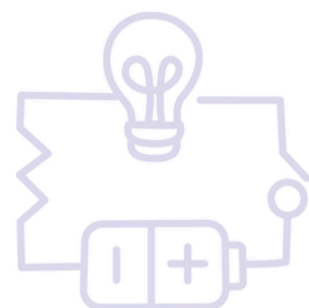
Lower oxidation states favor basic oxides; higher states favor acidic/covalent oxides (e.g., Mn_2O_7 is a covalent green oil).





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Let's Test Them Now.**

$$E=mc^2$$



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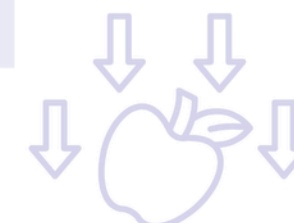
Practice Now



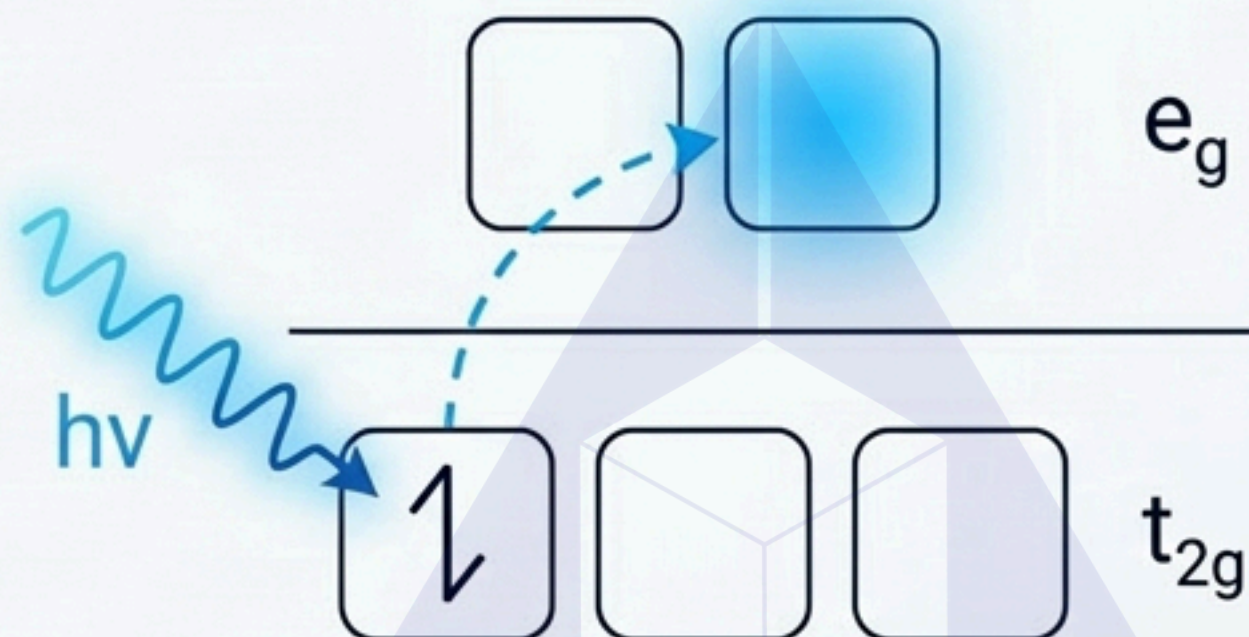
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Key Highlights

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- » Push Your Limits with Level-Based Challenges
- » Climb the Leaderboard Among Fellow Aspirants
- » Practice Unlimited MCQs for NEET & JEE
- » Get Clear Explanations, Not Just Marks
- » Track Your Performance Smarter



Coloured Ions: The d-d Transition Engine

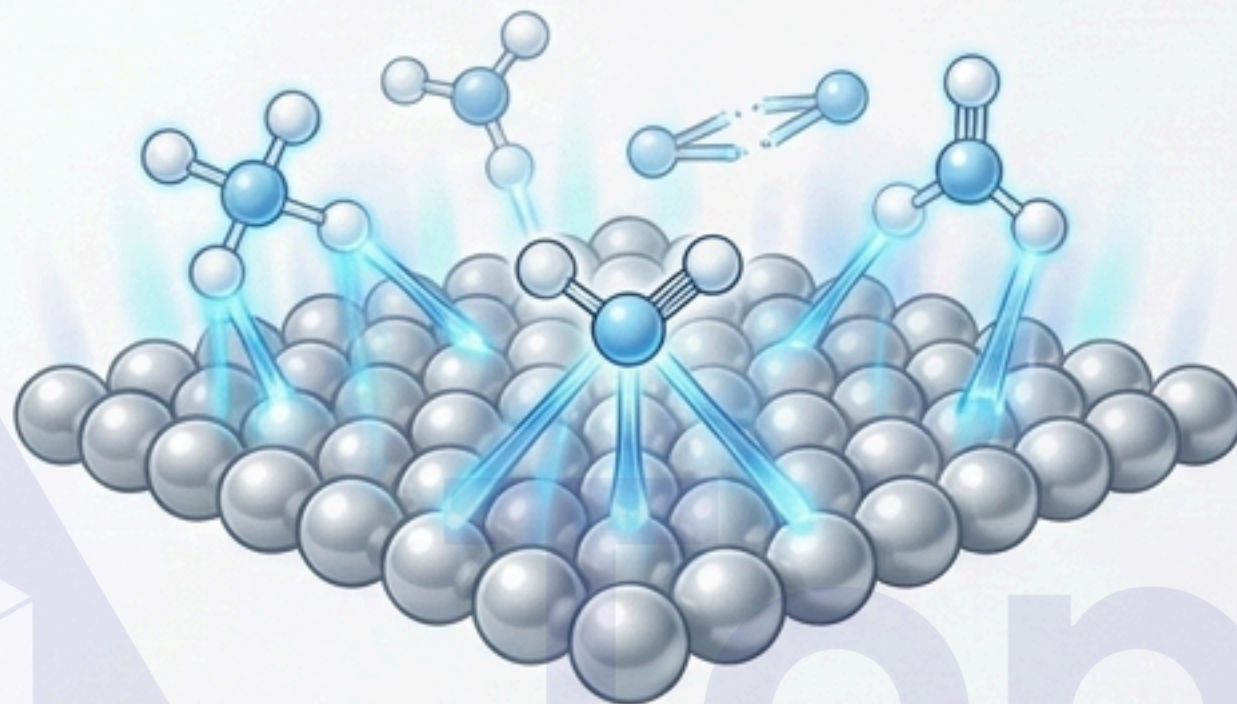


Mechanism: Unpaired d-electrons absorb specific frequencies of visible light to jump to higher-energy d-orbitals. Transmitted light is the complementary colour.



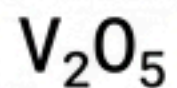
Ion/Example	d-Electron Configuration	Observed Colour
$\text{Ti}^{4+} / \text{Zn}^{2+}$	$3d^0 / 3d^{10}$	Colourless (No transition possible)
Mn^{2+}	$3d^5$	Pink
Cu^{2+}	$3d^9$	Blue

The Chemical Facilitators: Catalytic Behaviour



The Engine of Catalysis

Transition metals use 3d and 4s **electrons** to form **temporary bonds with reactants** at their surface, increasing concentration and lowering activation energy. Their ability to seamlessly change oxidation states allows rapid electron transfer.



Contact Process (Sulphuric Acid)

Finely divided Fe

Haber Process (Ammonia)

Ni

Catalytic Hydrogenation of Fats

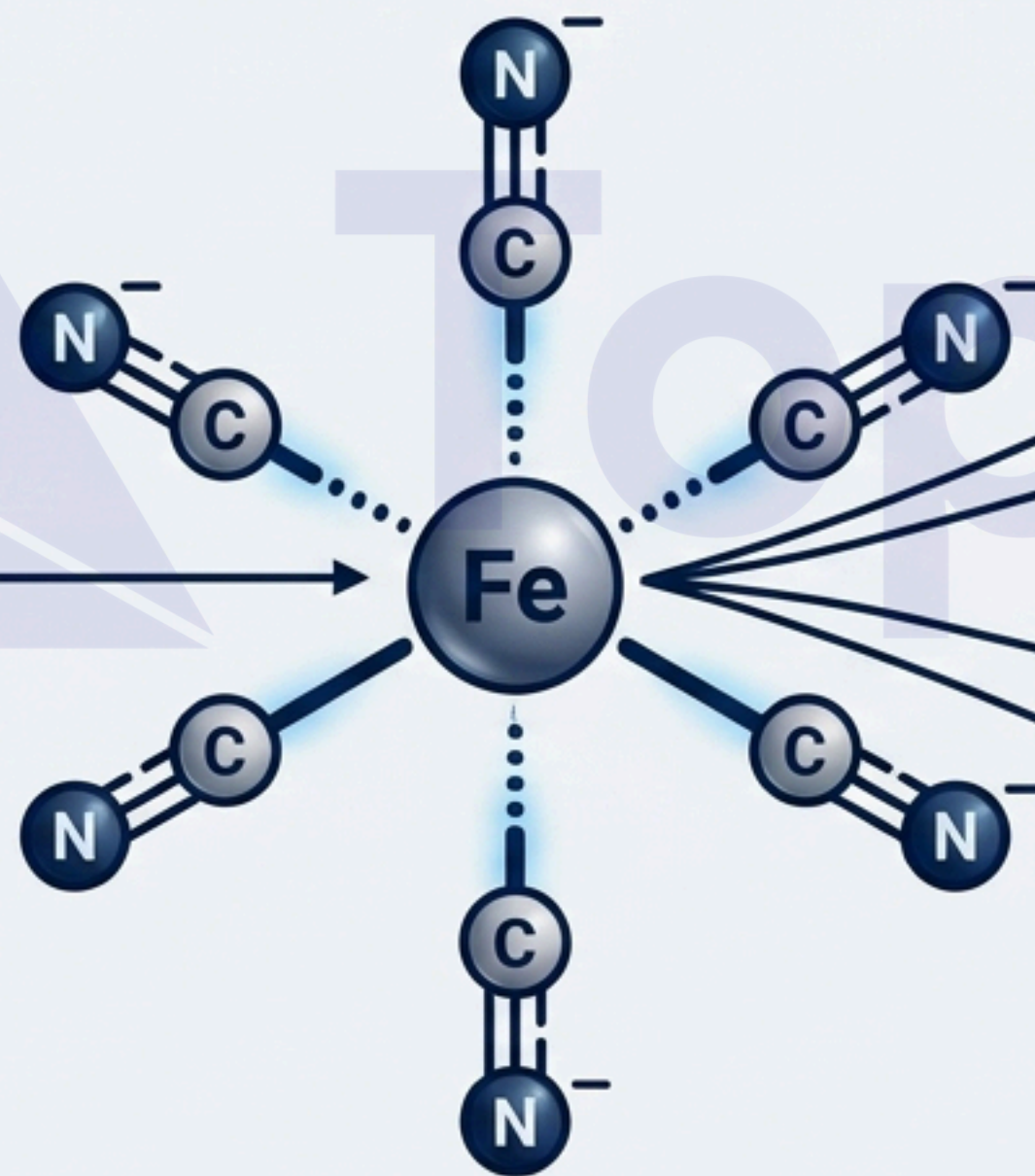
Anatomy of Complex Formation

Definition: Metal ions bind a specific number of anions or neutral molecules (ligands) to form complex species (e.g., $[\text{Fe}(\text{CN})_6]^{3-}$, $[\text{Cu}(\text{NH}_3)_4]^{2+}$).

Three Pillars of Complexation

Small Ionic Size

Comparatively small radius of the metal ion allows tight packing of ligands.



High Charge Density

Strong electrostatic pull created by high ionic charges.

Empty d-orbitals

Availability of empty d-orbitals of appropriate energy to accept lone pairs of electrons donated by ligands.

Magnetic Behaviour



Diamagnetic

All electrons are paired.
Repelled by magnetic fields.

Example: Zn^{2+} ($3d^{10}$) $\uparrow\downarrow \uparrow\downarrow \uparrow\downarrow \uparrow\downarrow \uparrow\downarrow$

Paramagnetic

Contains unpaired electrons.
Attracted to magnetic fields.

Example: Mn^{2+} ($3d^5$) $\uparrow \uparrow \uparrow \uparrow \uparrow$

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

Where n = number of unpaired electrons | BM = Bohr Magnetons

Quick Calc Table

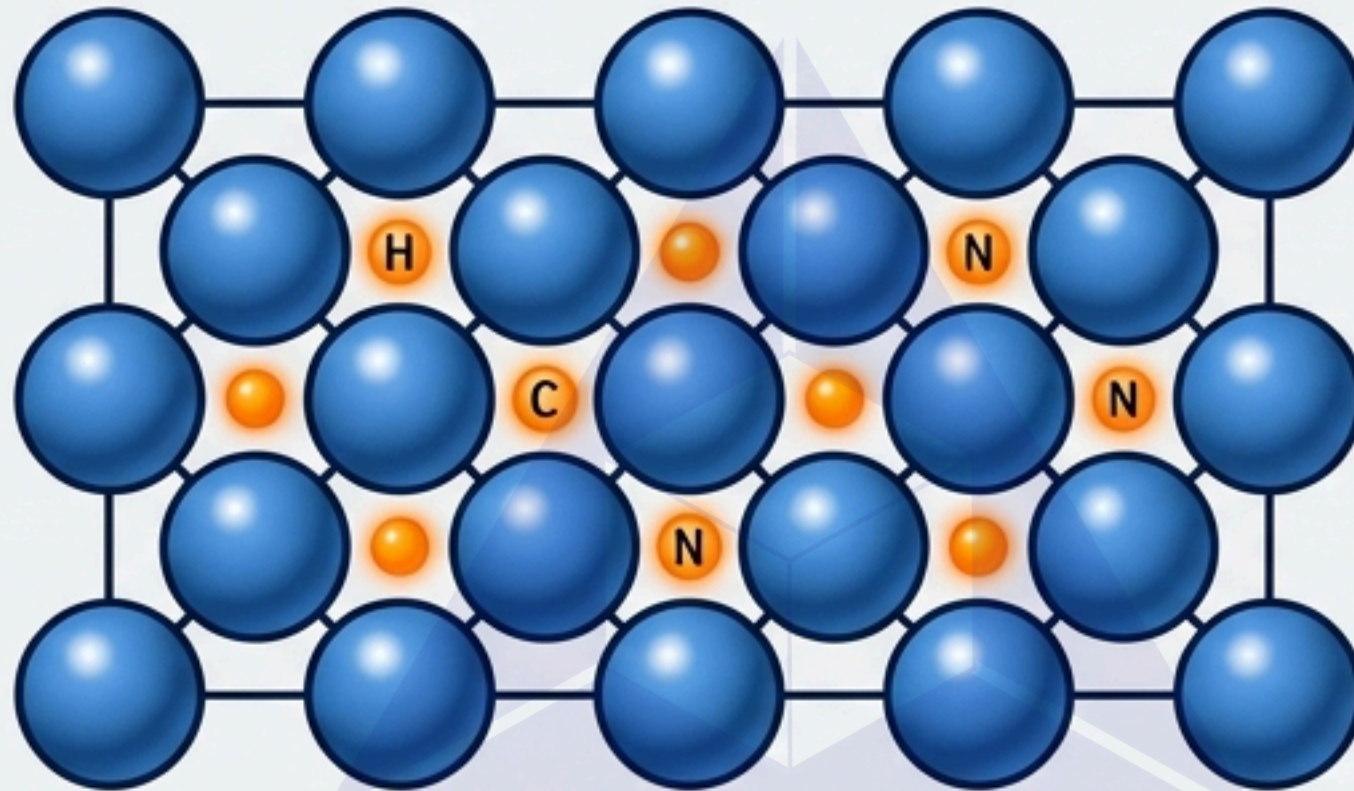
$n=1 \rightarrow \mu = 1.73 \text{ BM}$

$n=3 \rightarrow \mu = 3.87 \text{ BM}$

$n=5 \rightarrow \mu = 5.92 \text{ BM}$

Structural Adaptations: Interstitial Compounds & Alloys

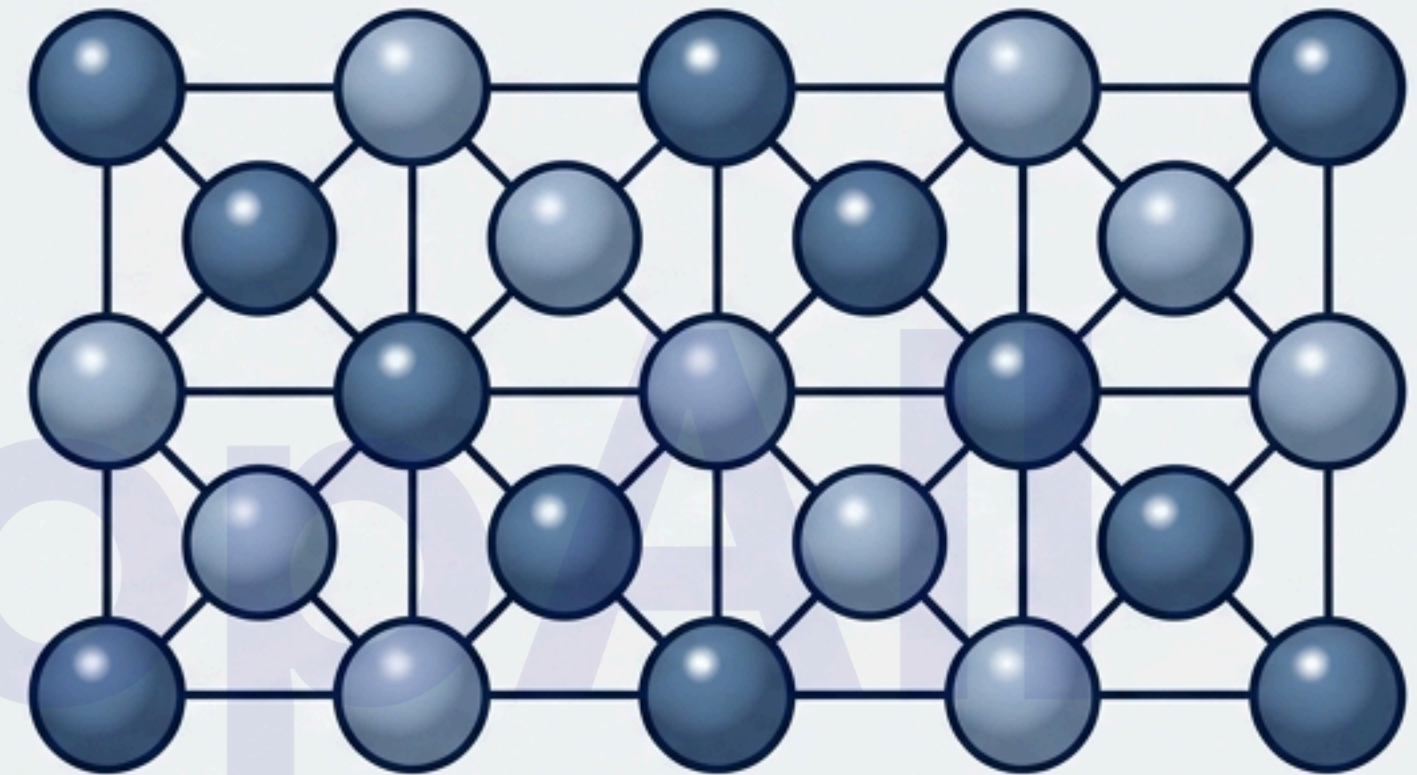
Interstitial Compounds



Small non-metals (H, C, N) are trapped inside the crystal lattices of transition metals.

- **Properties:** Extremely hard (borides approach diamond), retain metallic conductivity, chemically inert, higher melting points than pure metals.

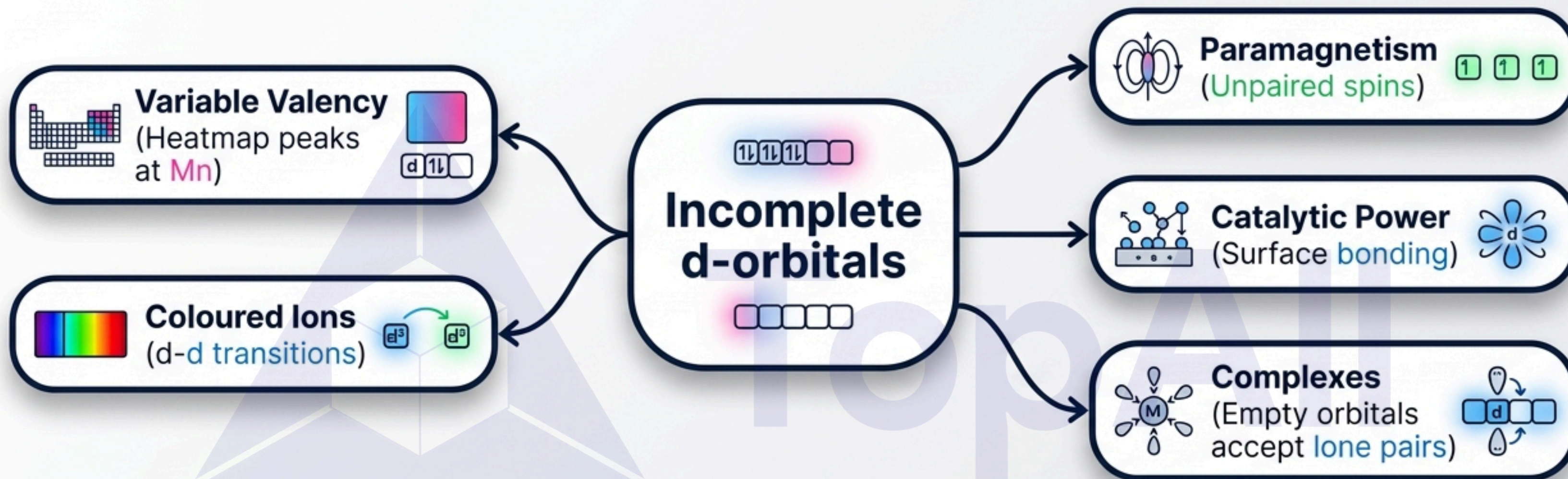
Alloy Formation



Formed because transition metal atomic radii are very similar (within 15% of each other), allowing atoms to easily substitute for one another in the lattice.

Examples: Ferrous alloys (stainless steel), Brass (Cu-Zn), Bronze (Cu-Sn).

The Quantum Dashboard: Final Revision Map



NEET/JEE Exam Tip

Always write the **electronic configuration first!** Most exam traps involve Cu ($[\text{Ar}] 3d^{10} 4s^1$) and Cr ($[\text{Ar}] 3d^5 4s^1$) anomalies, or asking for the color/magnetism of Sc^{3+} and Zn^{2+} . Both are colorless and diamagnetic because $n=0$.



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