

NEET / JEE ADVANCED MASTERY

4.3.7 Stability of Higher Oxidation States

Unlocking the thermodynamic and structural
secrets of d-block extremes.

Reaching the Maximum Oxidation State

Transition metals can exhibit exceptionally high oxidation states (up to **+7** but they require highly electronegative partners to stabilize them. The maximum oxidation number typically coincides with the **Group Number** (from **Sc** to **Mn**).

Oxygen

The Supreme Stabilizer

Can form multiple bonds ($p\pi-d\pi$) with the metal.

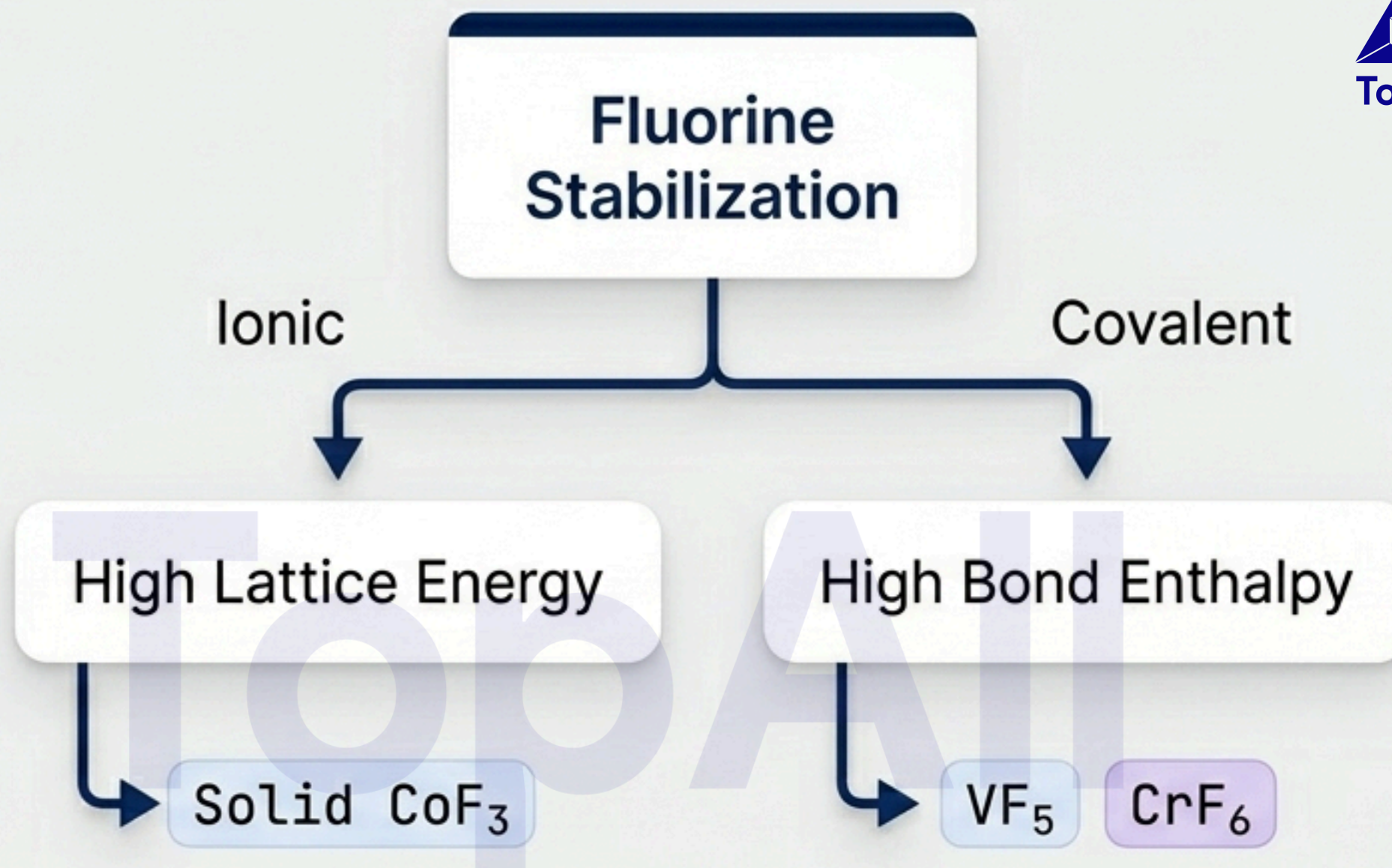
Fluorine

The Halogen Champion

Highest electronegativity; relies on massive lattice or bond enthalpies.

How Fluorine Forces High States

Fluorine stabilizes the highest oxidation states in halides, peaking at $+6$ with CrF_6 . It achieves this through two distinct thermodynamic pathways.



⚠ Instability at the Bottom

Fluorides are remarkably unstable in low oxidation states. Example: VX_2 (where $\text{X} = \text{Cl}, \text{Br}, \text{I}$) is stable, but VF_2 is not. Lower lattice/bond enthalpies cannot compensate for F-F bond breaking.

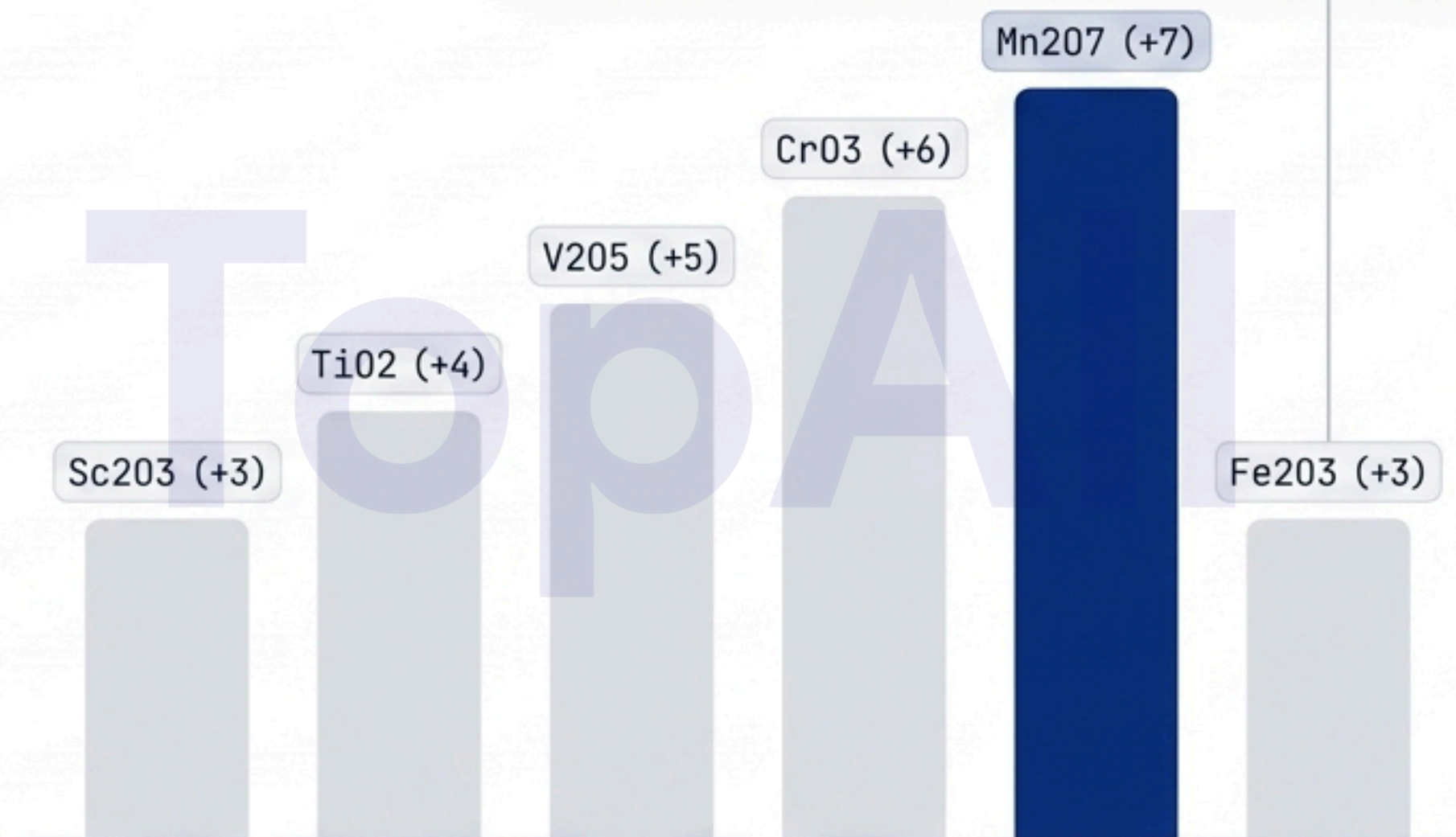
Oxygen's Dominance in Oxides

The ability of oxygen to stabilize high states exceeds that of fluorine.

The highest oxidation number matches the group number, peaking precisely at Manganese.

Peak Mountain

Max Oxidation Number



Beyond Group 7 (Fe), no higher oxides above Fe_2O_3 are known. Ferrates like FeO_4^{2-} exist but readily decompose to Fe_2O_3 and O_2 .

Groups 3 to 8

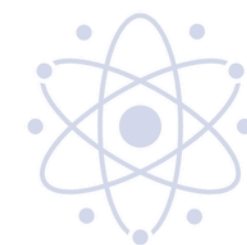
Fluoride vs. Oxide Comparison

Feature	Fluorine	Oxygen (Winner) 
Highest Overall Compound	CrF_6 VF_5	Mn_2O_7 CrO_3 V_2O_5
Highest Mn Compound	MnF_4 (+4)	Mn_2O_7 (+7)
Stabilisation Mechanism	Single bonds (Lattice/Bond Enthalpy)	Multiple bonds (Double bonds to metal via $\text{p}\pi\text{-d}\pi$ overlap)
Mixed Halide Behavior	V^{5+} , forms VF_5 , but easily hydrolyzes to oxohalides like VOX_3	Dominates as the terminal stabilizer



You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



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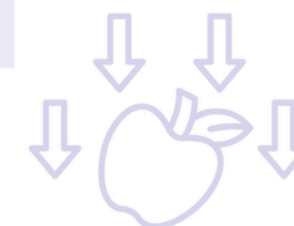
Practice Now



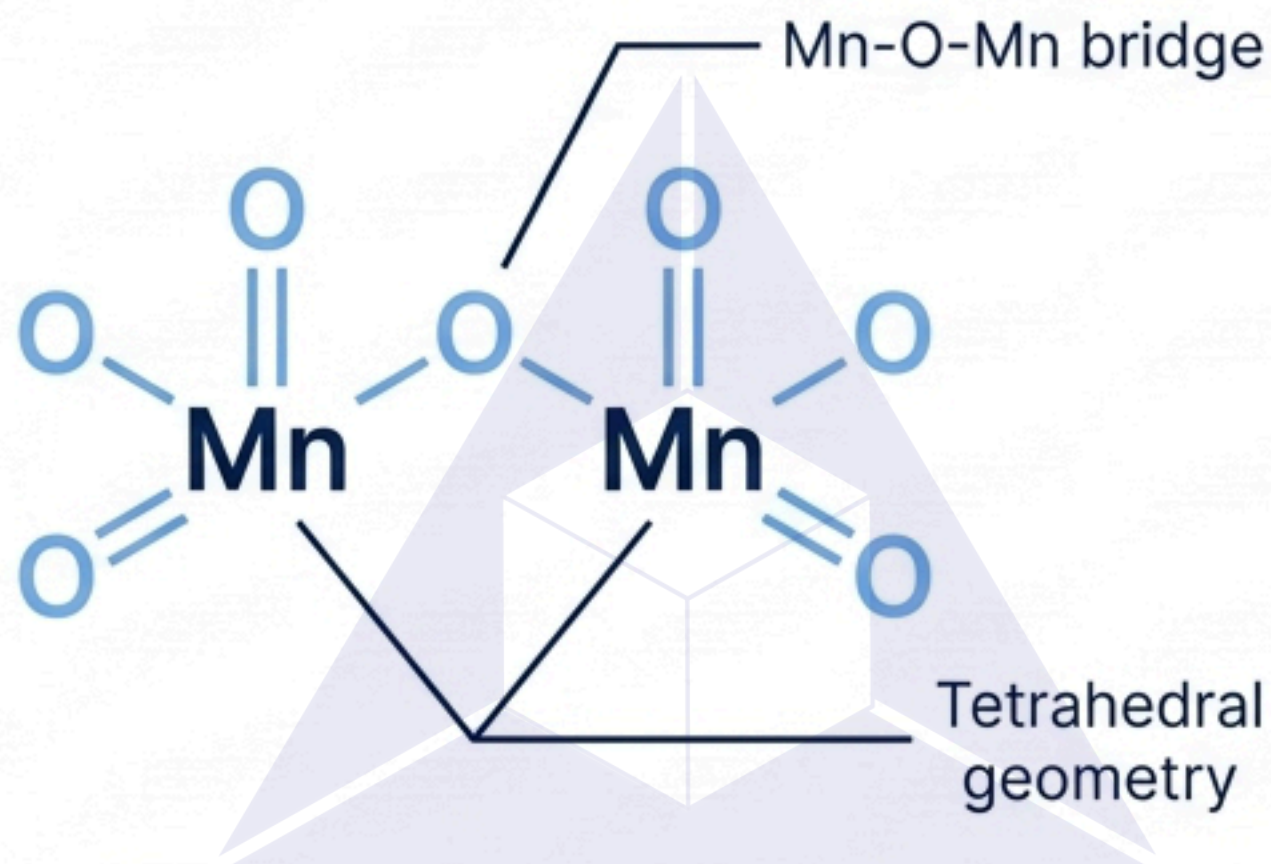
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The Proof: Manganese Extremes



Covalent green oil. Reaches the theoretical maximum of **+7**. Oxygen's multiple bonds easily absorb electron density.



The absolute highest fluoride Manganese can form. Fluorine is restricted to single bonds and cannot stabilize +7.

Beyond Binary Oxides: Oxocations & Oxoanions

Vanadium Oxocations

Vanadium stabilizes in varying high states based on the oxocation formed.

V^{+V} stabilized
as VO_2^{+}

V^{+IV} stabilized
as VO^{2+}

Titanium Oxocations

Titanium stabilizes its maximum +4 state via an oxocation.

Ti^{+IV} stabilized as TiO^{2+}

Tetrahedral Oxoanions

Tetrahedral $[MO_4]^{n-}$ ions are famously known for spanning high oxidation states across multiple metals.

V^{+V}

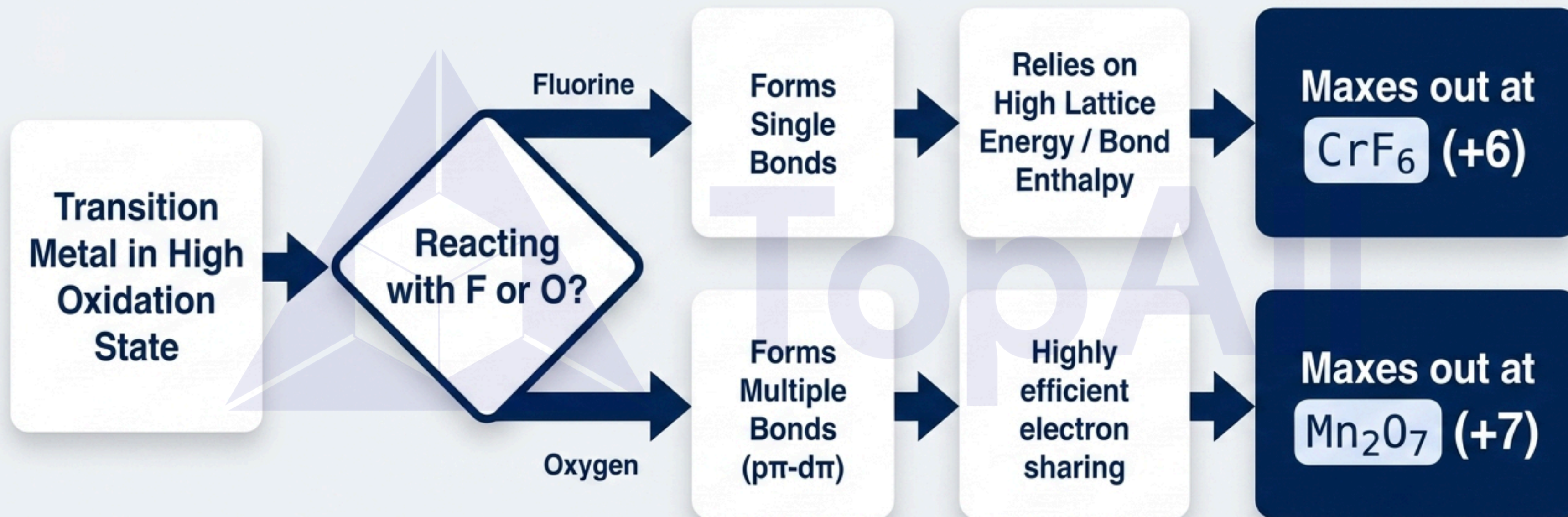
Cr^{+VI}

Mn^{+V}

Mn^{+VI}

Mn^{+VII}

The High-State Stability Logic Flow



Key Trends in 3d Series Oxidation States



Sc & Zn

Extremely Limited

Sc is only **+3** (achieves noble gas core).

Zn is only **+2** (d-electrons are full and not involved). No variable extremes.



Mn

The Maximum

Middle elements have the maximum number of unpaired electrons to share. Peak stability of **+3** and **+7** is achieved here.



Fe to Cu

Abrupt Drop

Abrupt decrease in stability of higher states after **Mn**. Typical states drop back down to **+2** and **+3**.



High-Yield Exam Traps

Claim: Fluorine stabilizes the highest oxidation state overall.

FALSE. Oxygen does (Mn_2O_7 vs MnF_4), due to its ability to form multiple bonds.

Claim: V+5 is only found in oxides.

FALSE. It is represented by the halide VF_5 , though it easily hydrolyzes to oxohalides like VOX_3 .

Claim: Higher oxides of Iron are highly stable.

FALSE. Ferrates(VI) (FeO_4^{2-}) form in alkaline media but readily decompose to Fe_2O_3 and O_2 .

Quick Revision

Q: Why does $O > F$ in stabilizing high states?

A: Oxygen forms multiple bonds to metals.

Q: Why are low oxidation fluorides unstable?

A: Lower lattice/bond enthalpies cannot compensate for $F - F$ bond breaking energy.

Q: What is the geometry of Mn in Mn_2O_7 ?

A: Tetrahedral (with a central $Mn - O - Mn$ bridge).

Q: Highest oxidation state of Sc and Zn ?

A: Sc is $+3$. Zn is $+2$.



You've Learned the Theory.

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