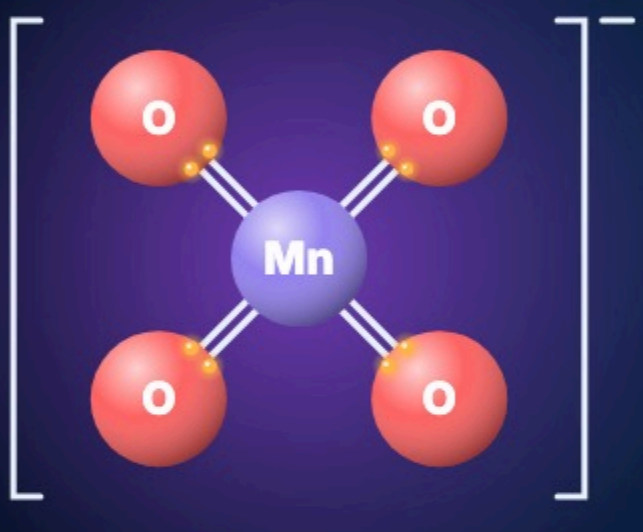
Highest oxidation states



+7

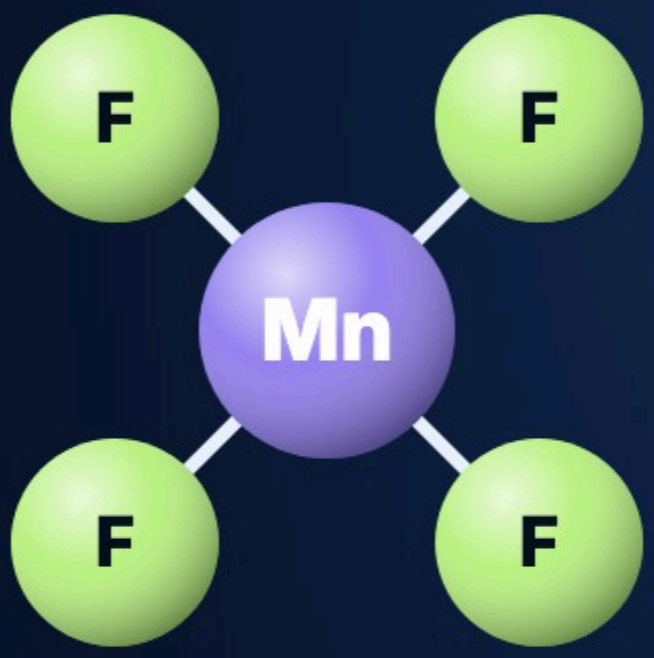
Mn in MnO_4^-

($KMnO_4$)

A metal shows its highest oxidation state only in its oxides and fluorides.

Oxygen and fluorine: small, highly electronegative partners.

Fluorine: 1 electron per atom



MnF_4

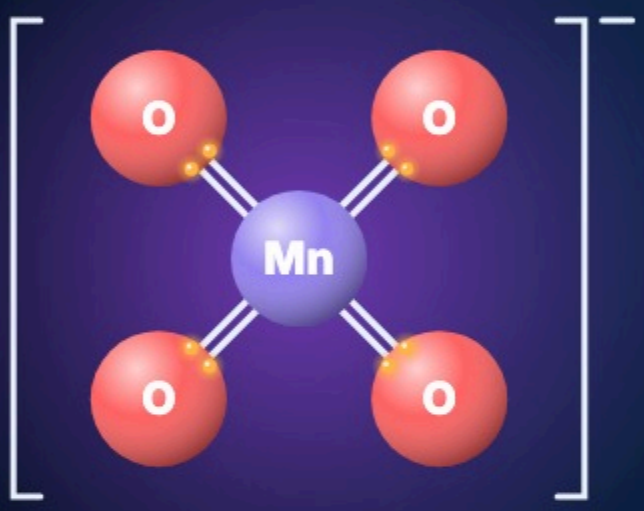
Mn = +4

MnF_7: never made

F forms only a **single bond**: one F counts **one** electron.

+7 would need seven F round one small Mn. The highest Mn fluoride is **MnF_4**.

Oxygen: 2 electrons per atom



4 × 2 = 8

7 from Mn

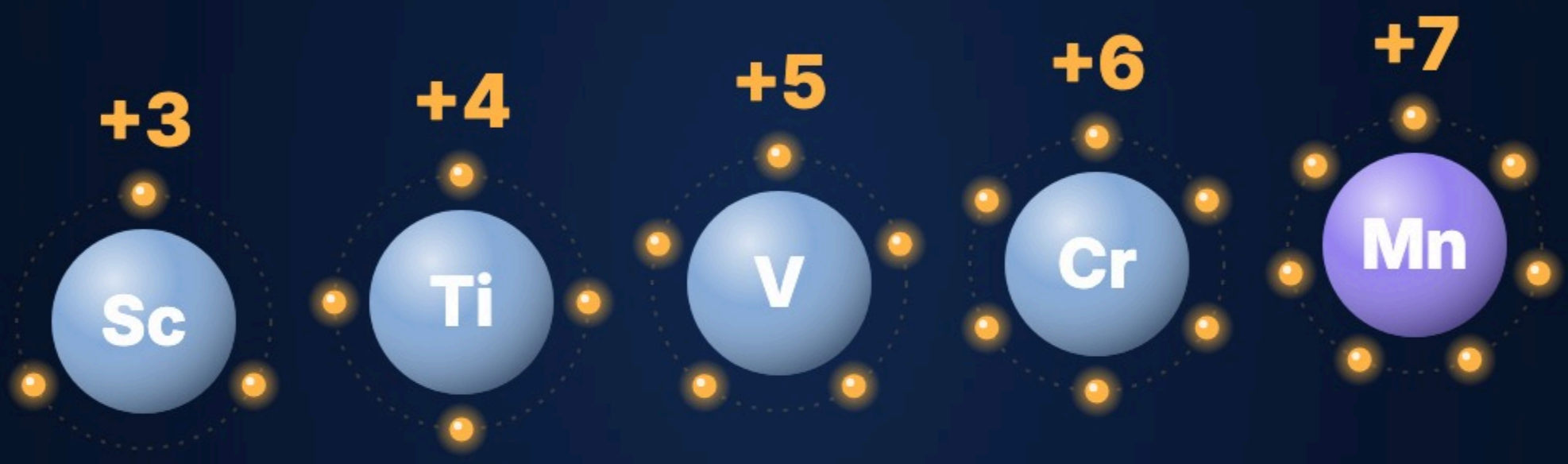
+ 1 from K

MnO_4^- · Mn +7

O forms a **multiple bond** with the metal: one O counts **two** electrons.

So just four oxygens take Mn to **+7**.

Highest oxide = group number

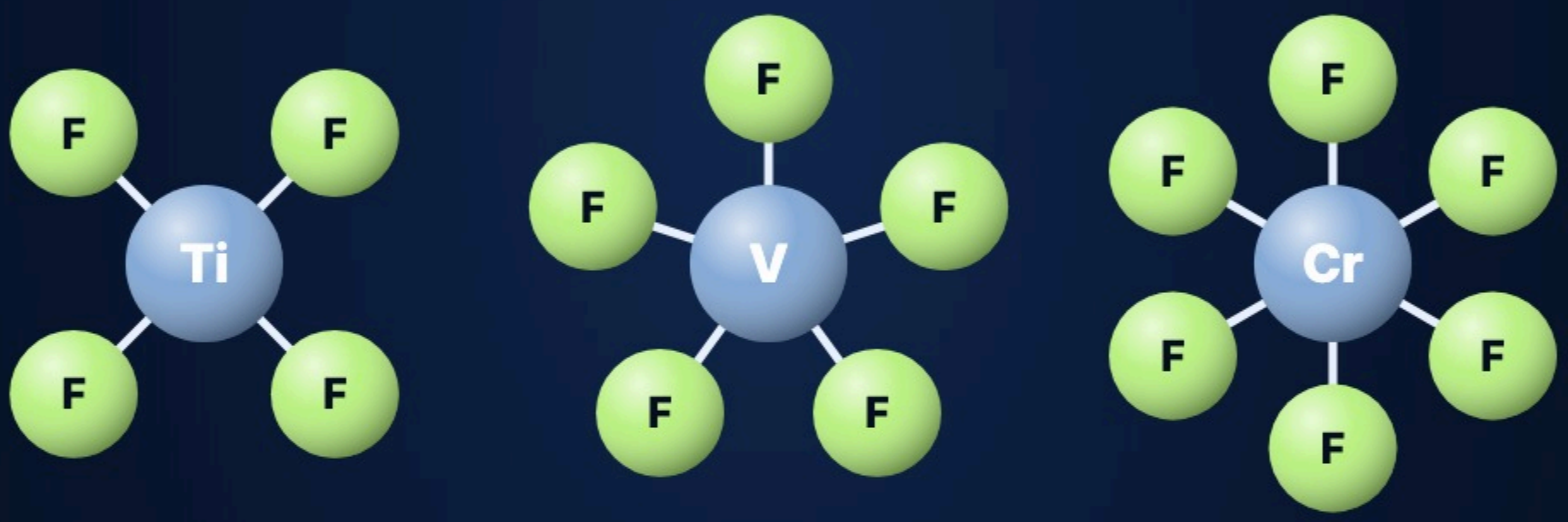


Sc_2O_3	TiO_2	V_2O_5	CrO_3	Mn_2O_7
group 3	group 4	group 5	group 6	group 7

From Sc_2O_3 to Mn_2O_7, the highest oxide has oxidation state = **group number**.

Beyond group 7, no higher oxide than Fe_2O_3 is known.

Highest fluorides



TiF_4 · +4 VF_5 · +5 CrF_6 · +6

Fluorine also stabilises high states: TiF_4, VF_5, CrF_6.

Beyond Mn, no trihalides except FeX_3 and CoF_3. Oxygen goes **further** than fluorine.

High state = strong oxidiser



$KMnO_4$

strong oxidising agent

Mn_2O_7

covalent, explosive

Mn(+7) is **hungry for electrons**: it takes them from other substances.

Mn_2O_7 is a covalent oxide: each Mn sits in a tetrahedron of O, with an Mn–O–Mn bridge.

Low state: Cu^{+} in water

$$2Cu^{+}(aq) \rightarrow Cu^{2+}(aq) + Cu(s)$$

disproportionation

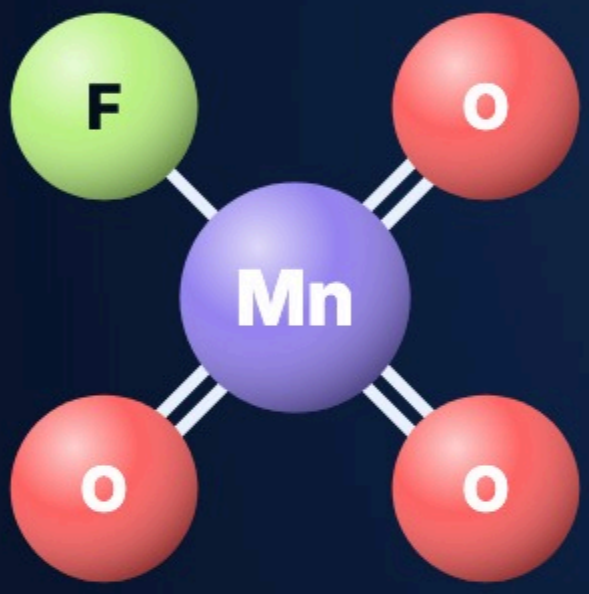
$$2Cu^{2+} + 4I^{-} \rightarrow Cu_2I_2(s) + I_2$$

so CuI_2 is not known

$Cu^{2+}(aq)$ is more stable than $Cu^{+}(aq)$: its **hydration enthalpy** is far more negative.

That more than pays for the second ionisation enthalpy of Cu.

Quick check



MnO_3F

Mn = + ?

What is the oxidation state of Mn in MnO_3F?

Hint: count 2 for each O and 1 for the F.