

Chemistry - Topic 15 - Transition Metals

TRANSITION METAL $\Rightarrow$ elements that form one or more stable ions with **incompletely filled d-orbitals**

LIGAND $\Rightarrow$ a species with one or more **lone pairs of electrons** that surrounds a transition metal ion using coordinate bonding to form a **complex ion**

THE 3d SERIES OF THE PERIODIC TABLE

$\hookrightarrow$ you need to know how to work out the electronic configuration for any atom or ion.

SCANDIUM and **ZINC** only form **one ion each** and their ions have **no incomplete d-orbitals**:

Scandium Sc $4s^2 3d^1$	Titanium Ti $4s^2 3d^2$	Vanadium V $4s^2 3d^3$	Chromium Cr $4s^1 3d^5$	Manganese Mn $4s^2 3d^5$	Iron Fe $4s^2 3d^6$	Cobalt Co $4s^2 3d^7$	Nickel Ni $4s^2 3d^8$	Copper Cu $4s^1 3d^9$	Zinc Zn $4s^2 3d^{10}$
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$\left. \begin{array}{l} \text{Zn}^{2+} = 4s^0 3d^{10} \\ \text{Sc}^{3+} = 4s^0 3d^0 \\ \text{no } d \text{ transition metals} \end{array} \right\}$

GENERAL IDEAS ABOUT TRANSITION METALS

- They are hard solids with **high melting and boiling temperatures**
- Can have **variable oxidation numbers** so they make good catalysts
- They form **coloured ions** when in solution as they absorb some lights.

REMEMBER: Copper and Chromium disobey the aufbau principle
(it is simply more **stable** for the electrons to fill like this).

REMEMBER: Electrons from the **4s orbital** are lost before those in **3d**!

OTHER IONS



WHY DO TRANSITION METALS HAVE VARIABLE OXIDATION STATES?

The compound formed is the one where **the most energy is released** as the more energy that is released, **the more stable the compound becomes**. You need lots of energy to **ionise the metal** but then more energy is released in **hydration or lattice formation**. As most of the electrons being removed in transition metals are in the **d-orbital**, it is not too 'costly' to **increase the oxidation state** if it is going to 'pay-off' during lattice formation.

COMPLEX IONS	COMMON LIGAND	MORE INFORMATION
	Water H_2O	There are two lone pairs of electrons on the oxygen atom . Water often forms octahedrons .
	Ammonia NH_3	One lone pair of electrons on the nitrogen atom . Ammonia is small so forms octahedral structures .
	Hydroxide ion OH^-	Forms 'hydroxo' complexes, charge on the ion will reduce the charge of the complex ion .
	Chloride ion Cl^-	Cl^- ions are large so often cannot form octahedral complexes so form tetrahedral complexes .

MORE ON VARIABLE OXIDATION STATES

Transition metals can **donate and receive electrons** and are able to act as **oxidising agents** and as **trans- reducing agents**. The sub-shells of the **d-orbital** can easily gain or lose electrons meaning the **energy differences** between the **oxidation states** is small.

- $+2$ state stability with respect to the $3+$ state **increases** across a period.
- Compounds with **high oxidation states** tend to be **oxidising agents** e.g. MnO_4^- (Mn is $7+$)
- Compounds with **low oxidation states** tend to be **reducing agents** e.g. V^{2+} , Fe^{2+} ($2+$ and $2+$)

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