Introduction to Transition metals

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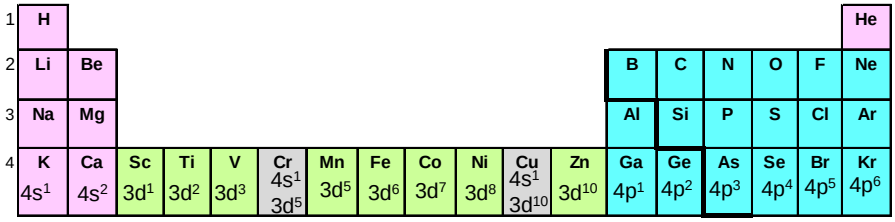
Transition Metals

ATransition metals are metals that contain an incomplete d sub shell in atoms or ions.

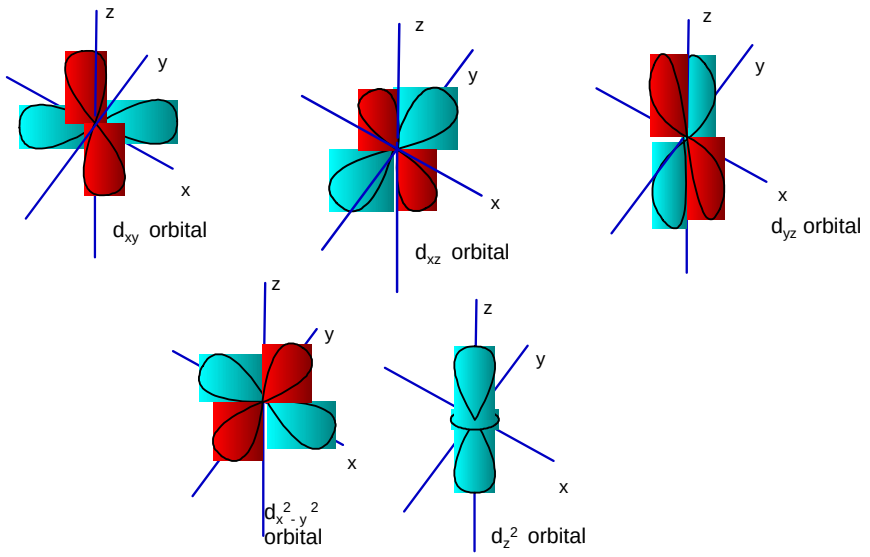
Top row transition metals: Sc – Cu

Zn is not a transition metal (Zn & Zn^{2+})

A d block element is one where the outer electron fills the d sub-shell
In period 4 Sc to Zn



The 3d orbitals



Summary of electronic structure

Sc $1s^2 2s^2 2p^6 3s^2 3p^6\ 4s^2 3d^1$

Ti $1s^2 2s^2 2p^6 3s^2 3p^6\ 4s^2 3d^2$

V $1s^2 2s^2 2p^6 3s^2 3p^6\ 4s^2 3d^3$

Cr $1s^2 2s^2 2p^6 3s^2 3p^6\ 4s^1 3d^5$

Mn $1s^2 2s^2 2p^6 3s^2 3p^6\ 4s^2 3d^5$

Fe $1s^2 2s^2 2p^6 3s^2 3p^6\ 4s^2 3d^6$

Co $1s^2 2s^2 2p^6 3s^2 3p^6\ 4s^2 3d^7$

Ni $1s^2 2s^2 2p^6 3s^2 3p^6\ 4s^2 3d^8$

Cu $1s^2 2s^2 2p^6 3s^2 3p^6\ 4s^1 3d^{10}$

Zn $1s^2 2s^2 2p^6 3s^2 3p^6\ 4s^2 3d^{10}$

Notice that one of the 4s electrons has been transferred to 3d so that 3d is now a ***half filled*** shell with extra stability. 4s and 3d contain only unpaired electrons.

Notice that again one of the 4s electrons has been promoted to 3d so that 3d is now a ***completely filled*** shell with extra stability.

Why is Zn not a transition metal?

Zn can only form a +2 ion

When a d block element forms ions it loses the 4s before the 3d . So the electronic structure of the Zn^{2+} ion is

$$1s^2 2s^2 2p^6 3s^2 3p^6\ 3d^{10}$$

In this ion the Zn^{2+} has a **complete** d orbital and so does not meet the criteria of having a incomplete d orbital in one of its compounds.

Forming ions

When transition metals form ions they lose the 4s electrons before the 3d

Cu $1s^2 2s^2 2p^6 3s^2 3p^6\ 4s^1 3d^{10}$

Cu^+ $1s^2 2s^2 2p^6 3s^2 3p^6\ 3d^{10}$

Cu^{2+} $1s^2 2s^2 2p^6 3s^2 3p^6\ 3d^9$

The 3d sub-shell is lower in energy than the 4s when electrons start filling the 3d sub-shell. When electrons are removed they are therefore first taken from the 4s.

Common Properties of transition metals

Zn is excluded from the transition metals because it does not share the common properties associated with them.

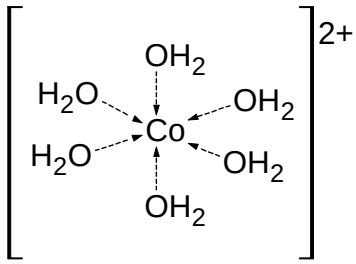
Common Properties:
- Form variable oxidation states
- Form coloured compounds
- Form complex ions
- Similarity of physical properties (have similar mp, bp, Conductivity)
- Show catalytic behaviour

Zn does not show the first two properties: it only have one oxidation state and form white compounds.

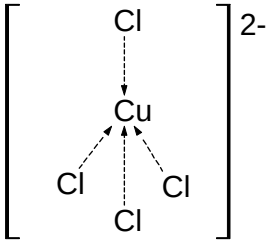
1) They form coloured ions.

2) They form complexes (ligands form co-ordinate bonds to the metal ion).

$[Co(H_2O)_6]^{2+}$



$[CuCl_4]^{2-}$



3) They exhibit variable oxidation states.

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
+3	+4	+5	+6	+7	+6	+5	+4	+3	+2
	+3	+4	+5	+6	+5	+4	+3	+2	
	+2	+3	+4	+5	+4	+3	+2	+1	
	+1	+2	+3	+4	+3	+2	+1		
		+1	+2	+3	+2	+1			
			+1	+2	+1				
				+1					

4) They show catalytic activity.

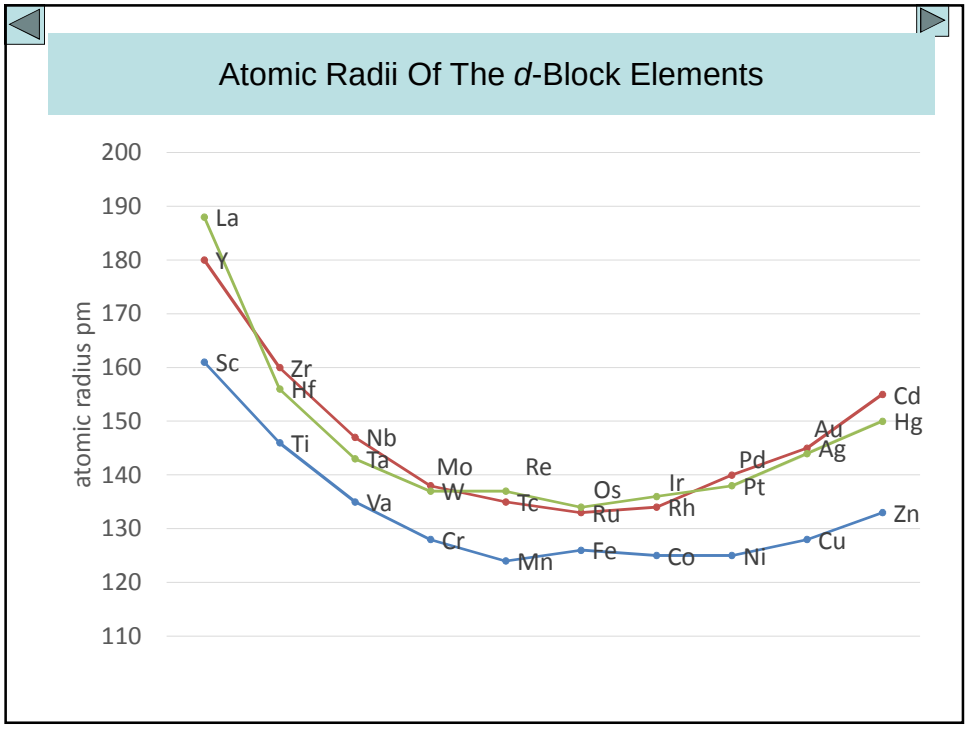
e.g.	Ni	margarine production
	V_2O_5	making SO_3 for H_2SO_4
	Fe	Haber process to make NH_3
	Pt, Pd	catalytic converters

Physical properties of Transition metals

- Dense metals
- Have high Tm and Tb
- Tend to be hard and durable
- Have high tensile strength
- High electrical conductivity
- Malleable

Properties derive from strong metallic bonding

- Transition metals can release e^- into the pool of mobile electrons from both outer and inner shells.
- Strong metallic bonds are formed between the mobile pool and the +ve metal ions


Atomic Radii Of The d-Block Elements
atomic radius pm
200
190
180
170
160
150
140
130
120
110
La
Y
Sc
Zr
Hf
Ti
Nb
Ta
Va
Mo
W
Cr
Re
Tc
Mn
Os
Ru
Fe
Ir
Rh
Co
Pd
Pt
Ni
Au
Ag
Cu
Cd
Hg
Zn