Electron configurations of transition metal elements

Hydrogen

Z = 1. Its electron configuration is $1s^1$. Its electron diagram is on the right.

[↑]

Helium

Z = 2. Its electron configuration is $1s^2$. Its electron diagram is on the right.

[↑↓]

The 1s sub-level is full, so completing the first principal energy level.
The n = 2 level is used next.

Lithium

Z = 3. Its electron configuration is $1s^2\ 2s^1$. Its electron diagram is on the right.

[↑]
[↑↓]

Nitrogen

Z = 7. Its electron configuration is $1s^2\ 2s^2\ 2p^3$. Its electron diagram is on the right.

Nitrogen obeys **Hund's multiplicity rule**, i.e. the favoured configuration is the one in which the electrons occupy different orbitals and have the same spins.

[↑][↑][↑]
[↑↓]
[↑↓]

Oxygen

Z = 8. Its electron configuration is $1s^2\ 2s^2\ 2p^4$. Its electron diagram is on the right.

The fourth 2p electron pairs with one of the other three 2p electrons.

[↑↓][↑][↑]
[↑↓]
[↑↓]

Neon

Z = 10. Its electron configuration is $1s^2\ 2s^2\ 2p^6$ (see electron diagram on the right).

The 2p sub-level is full, completing the n = 2 level. The n = 3 level is used next.

[↑↓][↑↓][↑↓]
[↑↓]
[↑↓]

Argon

Z = 18. Its electron configuration is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$ (see diagram on the right).

This electron configuration can also be written as [Ne] $3s^2\ 3p^6$, which saves space.

The 3p sub-level is full, completing the n = 3 level. The n = 4 level is used next.

[↑↓][↑↓][↑↓]
[↑↓]
[↑↓][↑↓][↑↓]
[↑↓]
[↑↓]

Potassium (Z = 19) is [Ar] $4s^1$, and Ca (Z = 20) is [Ar] $4s^2$. Once the 4s sub-level is full, the next ten elements (the **d block** elements, Sc to Zn) use the 3d orbitals.

Transition metals

The d block elements contain the **transition metals**. These are elements which form some compounds in which there is an incomplete sub-level of d electrons. This means that strictly speaking scandium and zinc ([Ar] $3d^0$ and [Ar] $3d^{10}$ in compounds), and copper to some extent, are **not** transition metals. However, they are often included as their compounds resemble those of transition metals.

Electron configurations of transition metal elements

Remember: $[Ar] = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

Note: The orbitals of n = 4 overlap with those of n = 3, i.e. in energy 4s below 3d, so after argon the 4s sub-level is filled first.

1. Complete the electron diagrams for potassium and calcium:

4s

K (Z = 19), $[Ar]\,4s^1$ [Ar]

Ca (Z = 20), $[Ar]\,4s^2$ [Ar]

2. Now complete the electron diagrams for scandium, titanium and vanadium:

3d 4s

Sc (Z = 21), $[Ar]\,3d^1\ 4s^2$ [Ar]

Ti (Z = 22), $[Ar]\,3d^2\ 4s^2$ [Ar]

V (Z = 23), $[Ar]\,3d^3\ 4s^2$ [Ar]

3. As far as vanadium, everything is straightforward. However, the electron configuration of the next element (chromium) is not $[Ar]\,3d^4\ 4s^2$ as you might expect. A half-filled d sub-level is more energetically favourable than a half-filled s sub-level, so one of the 4s electrons is promoted to a 3d orbital. Now complete the electron diagram for chromium:

3d 4s

Cr (Z = 24), $[Ar]\,3d^5\ 4s^1$ [Ar]

4. For the next four elements, the 3d sub-level continues to fill.
Complete the electron configurations and diagrams for manganese, iron, cobalt and nickel:

3d 4s

Mn (Z = 25), [Ar] 3d 4s [Ar]

Fe (Z = 26), [Ar] 3d 4s [Ar]

Co (Z = 27), [Ar] 3d 4s [Ar]

Ni (Z = 28), [Ar] 3d 4s [Ar]

5. When we get to copper, the situation is similar to that found with chromium. In this case, a full 3d sub-level is more energetically favourable than a full 4s sub-level.
Complete the electron configurations and diagrams for copper and zinc:

3d 4s

Cu (Z = 29), [Ar] 3d 4s [Ar]

Zn (Z = 30), [Ar] 3d 4s [Ar]

