Electron Structure

Ionisation Energies

First ionisation energy is the energy needed to remove one electron form each atom, in a mole of atoms, in the gas phase.

$$X_{(g)} \longrightarrow X^{+}_{(g)} + e^{-}_{(g)}$$

Second ionisation energy is the energy needed to remove one electron from each ion, in one mole of +1 ions, in the gas phase.

$$X^{+}_{(g)} \longrightarrow X^{2+}_{(g)} + e^{-}_{(g)}$$

Successive ionisation energies for an element are the first, second, third, etc… ionisation energies.

A high ionisation energy means that the electron is difficult to remove because the attraction between it and the nucleus is strong

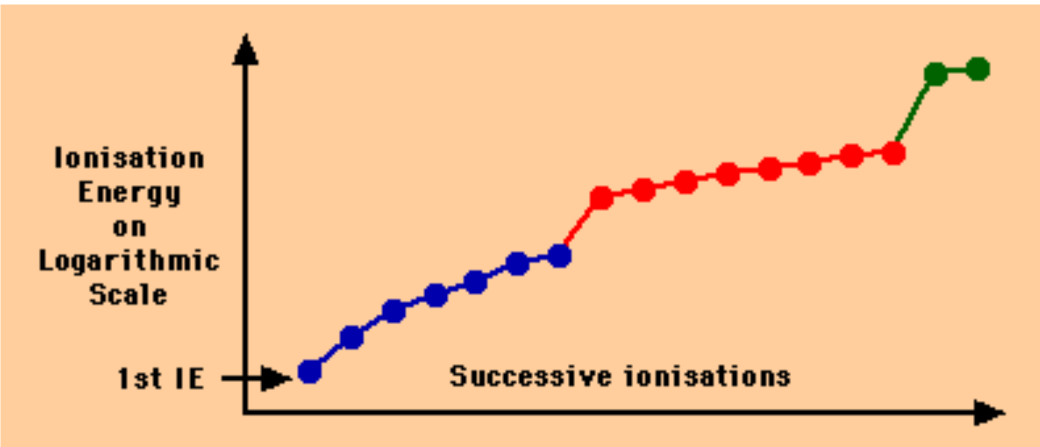
Ionisation energy depends on:-

a) The charge of the nucleus
b) The atomic radius (how far the outermost electron is from the nucleus)
c) The amount of **shielding** - this is related to the number of inner electrons which repel the outer electrons and make them easier to remove

As a simplification Effective nuclear charge = Nuclear charge - Shielding
= no of protons - number of inner electrons
= number of outer electrons

so as the number of outer electrons increases, the ionisation energy increases.

A plot showing the successive ionisation energies of chlorine



The plot shows:-

- the first 7 electrons are easily removed because they are far from the nucleus so the attraction is weak
- the next 8 electrons in the second shell - closer to nucleus - less shielding - stronger attraction
- the two 1s electrons being very difficult to remove as they are close to the nucleus with no shielding and strong attraction

From this plot, you can tell the number of electrons in each shell and that Chlorine is in group 7 of the Periodic Table as it has 7 electrons in the outermost shell.

Electrons and Orbitals

Electrons possess a property called spin. They can be thought of negative particles that spin either clockwise or anticlockwise.

An orbital is a region of space that can hold two electrons with opposite spins.

Quantum numbers (which are sometimes really letters) describe the position of an electron within the electron cloud.

The **principal quantum number** is the number of the shell: 1 is closest to the nucleus then 2 etc.

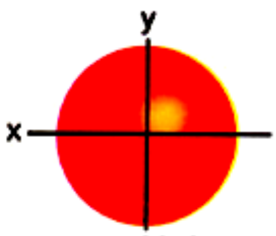
The secondary quantum numbers describe the type of subshell which the electron is in

s can have up to 2 electrons - 1 orbital
p can have up to 6 electrons - 3- orbitals
d can have up to 10 electrons - 5 orbitals
(f can have up to 14 electrons) - 7 orbitals)

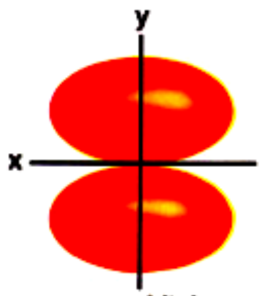
The different shells have different numbers of orbitals e.g.

principal quantum no	s subshell	p subshell	d subshell	f subshell	total
1	1 orbital	-	-	-	1 orbital **2** electrons
2	1 orbital	3 orbitals	-	-	4 orbitals **8** electrons
3	1 orbital	3 orbitals	5 orbitals	-	9 orbitals **18** electrons
4	1 orbital	3 orbitals	5 orbitals	7 orbitals	16 orbitals **32** electrons

Shapes of Orbitals



s orbital



p orbital

Order of filling of shells and subshells is in order of increasing energy:

1s,2s,2p,3s,3p,4s,3d,4p,5s…….

Electrons do not pair in the same orbital if it can be avoided because of repulsion between electrons, so if there are 3 electrons in a p subshell, they will be unpaired with one in each orbital:

	$2p_x$	$2p_y$	$2p_z$
p^3 (3 p electrons)	↑	↑	↑
p^4 (4 p electrons)	↑↓	↑	↑
p^5 (5 p electrons)	↑↓	↑↓	↑

Electronic configurations show how many electrons are in each subshell:

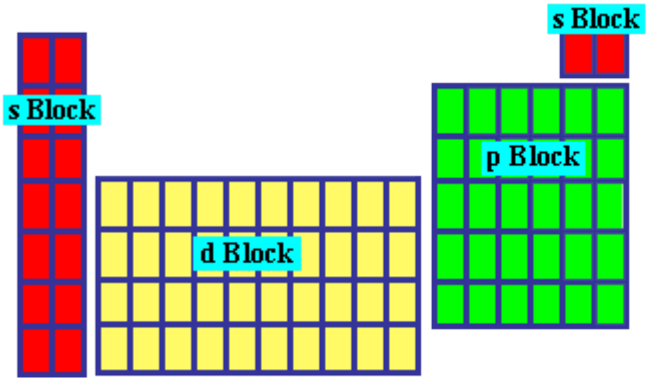
e.g. K which is 2,8,8,1 in simple form, would be written $1s^2,2s^2,2p^6,3s^2,3p^6,4s^1$

For ions add or remove electrons as necessary eg K^+ would be $1s^2,2s^2,2p^6,3s^2,3p^6$

NOTE: When atoms with the configuration $[Ar]4s^2 3d^x$ form ions the electrons are removed from the 4s subshell first and then the 3d. eg
Fe atom = $1s^2,2s^2,2p^6,3s^2,3p^6,4s^2,3d^6$
Fe^{2+} ion = $1s^2,2s^2,2p^6,3s^2,3p^6,3d^6$
Fe^{3+} ion = $1s^2,2s^2,2p^6,3s^2,3p^6,3d^5$

s-, p-, and d- blocks of elements

The elements are classified into s, p and d blocks depending on which subshell their outermost electron is in.



Groups 1 and 2 are in the s-block.
Groups 3 to 7 and 0 are in the p-block.
Transition elements are in the d-block.