HL Sub-levels and orbitals

TYPES OF ORBITAL

Electrons are found in orbitals. Each orbital can contain a maximum of two electrons each with opposite spins. The first level contains just one orbital, called an s orbital. The second level contains one s orbital and three p orbitals. The 2p orbitals are all of equal energy but the sub-level made up of these three 2p orbitals is slightly higher in energy than the 2s orbital. This explains why the first ionization energy of B is lower than Be as a higher energy 2p electron is being removed from the B compared with a lower energy 2s electron from Be.

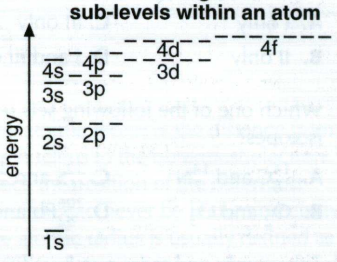
Principal level (shell)	Number of each type of orbital				Maximum number of electrons in level
	s	p	d	f	
1	1	–	–	–	2
2	1	3	–	–	8
3	1	3	5	–	18
4	1	3	5	7	32

The relative position of all the sub-levels for the first four main energy levels is shown.

Note that the 4s sub-level is below the 3d sub-level. This explains why the third level is sometimes stated to hold 8 or 18 electrons.

Electrons with opposite spins tend to repel each other. When orbitals of the same energy (degenerate) are filled the electrons will go singly into each orbital first before they pair up to minimize repulsion. This explains why there is a regular increase in the first ionization energies going from B to N as the three 2p orbitals each gain one electron. Then there is a slight decrease between N and O as one of the 2p orbitals gains a second electron before a regular increase again.

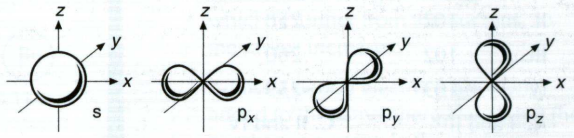
Relative energies of sub-levels within an atom



SHAPES OF ORBITALS

An electron has the properties of both a particle and a wave. Heisenberg's uncertainty principle states that it is impossible to know the exact position of an electron at a precise moment in time. An orbital describes the three-dimensional shape where there is a high probability that the electron will be located.

s orbitals are spherical and the three p orbitals are orthogonal (at right angles) to each other.



AUFBAU PRINCIPLE

The electronic configuration can be determined by following the aufbau (building up) principle. The orbitals with the lowest energy are filled first. Each orbital can contain a maximum of two electrons. Orbitals within the same sub-shell are filled singly first – this is known as Hund's rule,

e.g. F $1s^2 2s^2 2p^5$
V $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$.

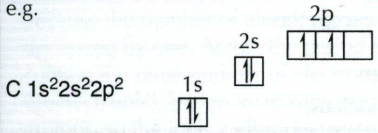
To save writing out all the lower levels the configuration may be shortened by building on the last noble gas configuration, e.g. V is more usually written:

[Ar] $4s^2 3d^3$.

(When writing electronic configurations check that for a neutral atom the sum of the superscripts adds up to the atomic number of the element.)

Sometimes boxes are used to represent orbitals so the number of unpaired electrons can easily be seen,

e.g.



ELECTRONIC CONFIGURATION AND THE PERIODIC TABLE

An element's position in the Periodic Table is related to its valence electrons so the electronic configuration of any element can be deduced from the Table, e.g. iodine ($Z = 53$) is a p block element. It is in group 7 so its configuration will contain ns^2np^5. If one takes H and He as being the first period then iodine is in the fifth period so n = 5. The full configuration for iodine will therefore be:

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^5$ or [Kr] $5s^2 4d^{10} 5p^5$