

## ELECTRONIC CONFIGURATIONS

### THEORY

*Old*

- electrons existed in definite energy levels or shells; the levels were concentric rings
- the further the energy level is from the nucleus, the higher its energy
- each level held a maximum number of electrons
- when a level was full up you moved to fill the next level

*New*

Instead of circulating in orbits around the nucleus, electrons were to be found in **orbitals**.

**ORBITAL** *"A region in space where one is likely to find an electron"*.

- like 3-dimensional statistical maps showing the likeliest places to find electrons.
- come in different shapes and sizes but can only hold a maximum of two electrons each.

Electrons do not in fact orbit the nucleus in an orderly way. In fact they occupy areas of space known as **orbitals**. The exact position of an electron within an orbital is impossible to imagine; an orbital is simply an area of space in which there is a high probability of finding an electron. Orbitals can have a number of different shapes, the most common of which are as follows:

**s-orbitals: these are spherical.**

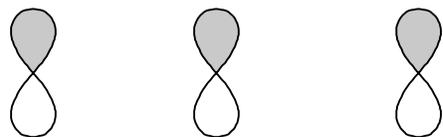


Every energy level contains one s-orbital.

An s-orbital in the first energy level is a 1s orbital.

An s-orbital in the second energy level is a 2s orbital, etc

**p-orbitals: these are shaped like a 3D figure of eight, a dumbbell shape.** They exist in groups of three:



Every energy level except the first level contains three p-orbitals. Each p-orbital in the same energy level has the same energy but different orientations: x, y and z.

A p-orbital in the second energy level is a 2p orbital ( $2p_x$ ,  $2p_y$ ,  $2p_z$ )

A p-orbital in the third energy level is a 3p orbital ( $3p_x$ ,  $3p_y$ ,  $3p_z$ ), etc

In addition, the third and subsequent energy levels each contain five d-orbitals, the fourth and subsequent energy levels contain seven f-orbitals and so on. Each type of orbital has its own characteristic shape.

S, p and d orbitals do not all have the same energy. In any given energy level, s-orbitals have the lowest energy and the energy of the other orbitals increases in the order  $p < d < f$  etc. Thus each energy level must be divided into a number of different sub-levels, each of which has a slightly different energy.

## ENERGY

**LEVELS** In the newer theory, the main energy levels are split into sub-levels. Each level has orbitals and the electrons fill the orbitals. The orbitals in the first four main levels are ...

Main level	Sub-levels	Orbitals	Electrons
n = 1	1	1s	2 = 2
n = 2	2	2s 2p	2 6 = 8
n = 3	3	3s 3p 3d	2 6 10 = 18
n = 4	4	4s 4p 4d 4f	2 6 10 14 = 32

## RULES FOR FILLING ENERGY LEVELS

**Aufbau Principle** "Electrons enter the lowest energy orbital available."  
Energy levels are not entered until those below them are filled.

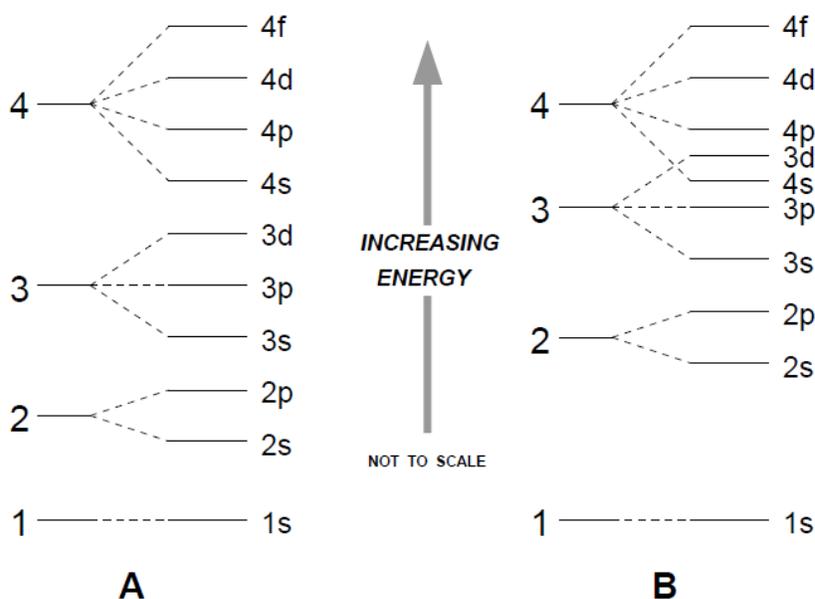
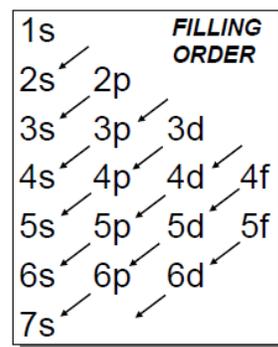
**Pauli's Exclusion Principle** "No two electrons can have the same four quantum numbers."  
Orbitals can hold a max. of 2 electrons provided they have opposite spin.

**Hund's Rule** Orbitals of the same energy remain singly occupied before pairing up.  
This is due to the repulsion between electron pairs.

## FILLING

### ORDER

- Orbitals are filled in order of increasing energy
- Orbitals are **not** filled in numerical order ...  
**1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, etc.**  
*The 4s is filled before the 3d because it is lower in energy*
- The effect can be explained by assuming the ...  
**principal energy levels get closer together as they get further from the nucleus.**
- As a result, the highest energy orbitals in one principal level may be above the lowest in the next level



The diagram helps explain why the 4s orbitals are filled before the 3d orbitals. *There is plenty of evidence to explain the filling order*