Electron arrangement

EVIDENCE FROM IONIZATION ENERGIES

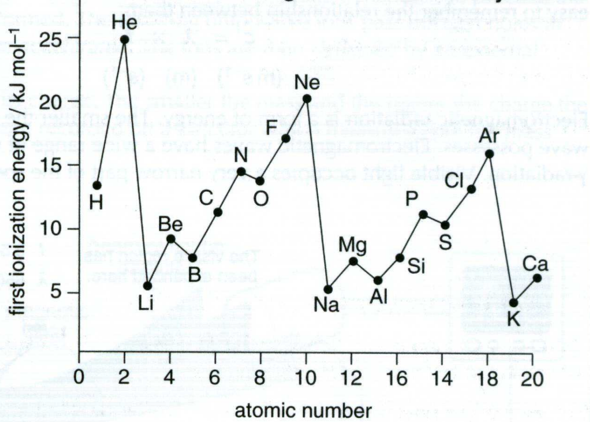
The first ionization energy of an element is defined as the energy required to remove one electron from an atom in its gaseous state. It is measured in kJ mol^{-1}.

$$X(g) \rightarrow X^{+}(g) + e$$

A graph of first ionization energies plotted against atomic number shows a repeating pattern.

It can be seen that the highest value is for helium, an atom that contains two protons and two electrons. The two electrons are in the lowest level and are held tightly by the two protons. For lithium it is relatively easy to remove an electron, which suggests that the third electron in lithium is in a higher energy level than the first two. The value then generally increases until element 10, neon, is reached before it drops sharply for sodium. This graph provides evidence that the levels can contain different numbers of electrons before they become full.

First ionization energies for the first twenty elements



Level	Maximum number of electrons
1 (K shell)	2
2 (L shell)	8
3 (M shell)	8 (or 18)

ELECTRON ARRANGEMENT

The arrangement of electrons in an atom is known as its electronic configuration. Each energy level or shell is separated by a dot (or a comma). The electrons in the highest main energy level (outermost level) are known as the **valence electrons**.

Element	Electron configuration	Element	Electron configuration
H	1	Na	2.8.1
He	2 (first level full)	Mg	2.8.2
Li	2.1	Al	2.8.3
Be	2.2	Si	2.8.4
B	2.3	P	2.8.5
C	2.4	S	2.8.6
N	2.5	Cl	2.8.7
O	2.6	Ar	2.8.8 (third level full)
F	2.7	K	2.8.8.1
Ne	2.8 (second level full)	Ca	2.8.8.2

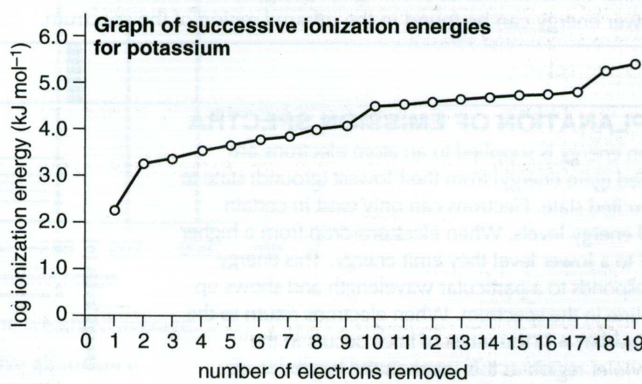
EVIDENCE FOR SUB-LEVELS

The graph already shown above was for the first ionization energy for the first twenty elements. Successive ionization energies for the same element can also be measured, e.g. the second ionization energy is given by:

$$X^{+}(g) \rightarrow X^{2+}(g) + e$$

As more electrons are removed the pull of the protons holds the remaining electrons more tightly so increasingly more energy is required to remove them, hence a logarithmic scale is usually used. A graph of the successive ionization energies for potassium also provides evidence of the number of electrons in each main level.

Graph of successive ionization energies for potassium



By looking to see where the first 'large jump' occurs in successive ionization energies one can determine the number of valence electrons (and hence the group in the Periodic Table to which the element belongs).
If the graph for first ionization energies is examined more closely then it can be seen that the graph does not increase regularly. This provides evidence that the main levels are split into sub-levels.