Atomic and electronic structure

Subatomic Particles

Through the work of Thomson, Rutherford, Chadwick and their colleagues, we now know that

- All atoms are composed of protons, neutrons and electrons.
- Have a small positive **nucleus** surrounded by a much larger region of space in which tiny negative electrons move continuously.
- Positive charge of nucleus is due to positively charged **protons.** Nucleus also contains neutrons – same mass as protons but no charge
- Protons and neutrons are around 1840 times heavier than electrons – so most of the mass of an atom is from its nucleus.
- Atoms have equal numbers of protons and electrons, so the positive charges on the protons cancel out the negative charges on electrons.
- The differences in the numbers of protons, neutrons and electrons determine the difference in different atoms.

Particle	Relative Mass	Relative charge	Position within atoms
Proton	1	+1	Nucleus
Neutron	1	0	Nucleus
Electron	$\frac{1}{1840}$	-1	In space outside nucleus

Isotopes

Isotopes are atoms of the same element with different number of **neutrons** (different masses).

- Have the same chemical properties, as they have the same number of electrons, and same electron configurations. (Chemical properties depend on arrangement and transfer of electrons)
- Isotopes have different number of neutrons (different masses) – therefore, have different physical properties.

Mass Spectrometer

Used to discover, identify and calculate the different masses and abundance of different **isotopes** of the same element.

Sample Inlet

- Contains gaseous sample of element, mostly combination of different isotopes.

Ionizer

- Gaseous sample of element is bombarded with e^- or laser so as to create positive ions of the element
- E.g. $K + e^- \rightarrow K^+ + e^- + e^-$

Mass Analyzer

- Ions of the same charge are separated according to their mass to charge ration (m/z) by using a magnetic or electric field.

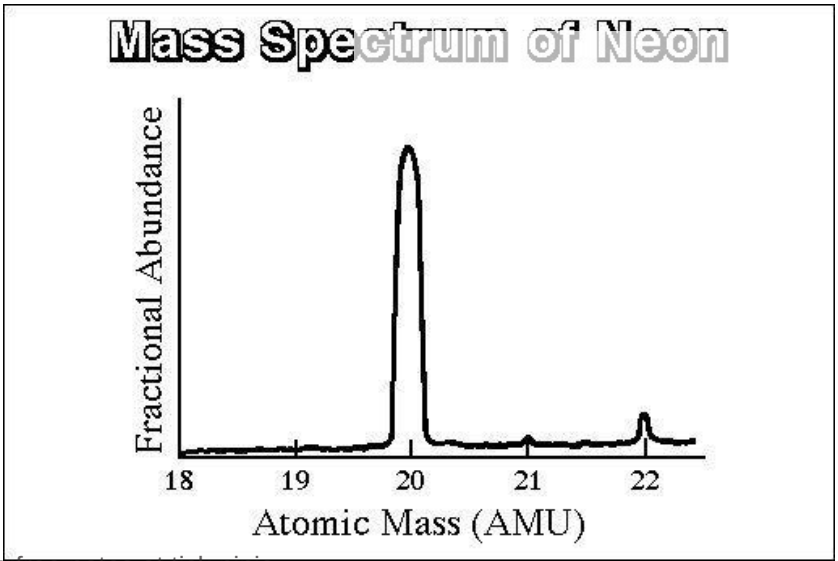
Detector

- Detects how many particles bombard a particular spot on the sheet, so as to determine abundance and the range of different masses.

Data Analysis

- Data is presented as a mass spectrum in which m/z is plotted against the intensity of the respective ion signals

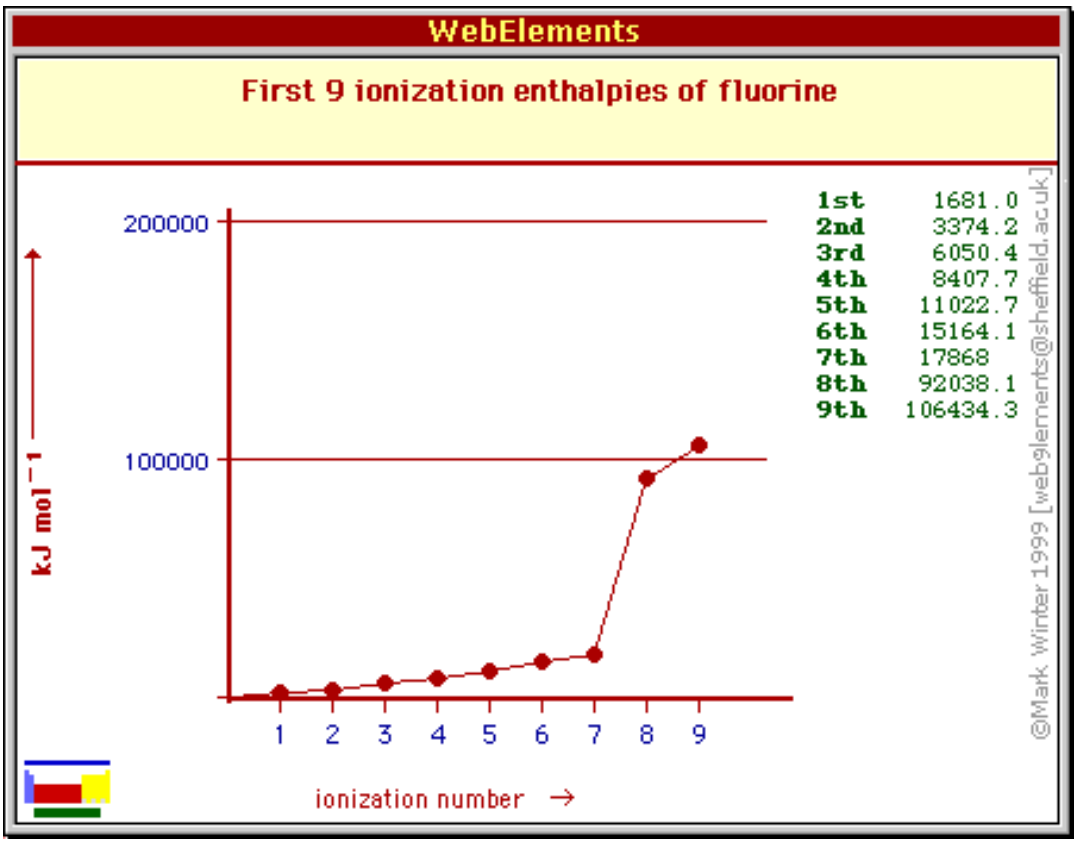
Mass Spectrum of Neon



Ionisation Energy

Is the amount of energy needed to remove one electron from a gaseous atom is known as its ionization energy.

- First IE is energy required to remove the 1st electron from one neutral atom.
- Second IE is the energy needed to remove the 2nd electron from the +ve ion.
- Additional supplies of energy will result in the removal of successive electrons
- Succession of ionizations is therefore possible, each of which has its associated ionization energy



Two Trends that can be observed in ionization energies

- Ionisation energy increases as +ve charge of the ion increases, due to the stronger electrostatic forces. (increases across a period)
- There are drastic increases in required IE as electrons are removed from inner shells as distance between electron shell and nucleus increases, and the protons have greater pull on the electrons.

Factors affection ionisation energies

- Distance of the outermost electron from the nucleus
    - As distance increases, attraction of positive nucleus for negative electron decreases
    - Ionisation energy decreases
- Size of positive nuclear charge
    - As the nuclear charge becomes more positive with increasing proton umber, its attraction for outermost electron increases
    - Ionisation energy increases

Subshells and Electronic Configuration

Wave Mechanical Model

- Postulates that electrons are arranged in "shells" or energy levels numbered 1, 2, 3 etc. Numbers are known as **principal quantum numbers**
- Each shell consists of subshells labeled s,p,d,f. Number of subshells in each shell equals to shell number.

s = 2 electrons
p = 6 electrons
d = 10 elements
f = 14 elements

Electrons must be filled into subshells with the lowest energy levels first.

E.g.
Helium 1s2
Nitrogen 1s2 2s2 2p3
Sodium 1s2 2s2 2p6 3s1

Boxes in each orbital must be all half-filled before continuing to fill them up.