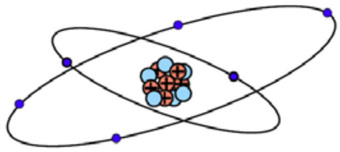
ATOMS

The Nuclear Structure of the atom:

- We cannot see an individual atom - it is too small at about 10^{-10}m across
- The overall charge on an atom is zero (neutral)
- Electrons can be removed to make a positive ion (chemistry)
- Electrons can be added to make a negative ion (chemistry)
- The positive charge resides in the nucleus (protons)
- There are also neutral particles in the nucleus (neutrons)
- The diameter of the nucleus is only about 10^{-15}m across



The basic model consists of a central positively charged nucleus surrounded by orbital negatively charged electrons. Electrons are relatively distant from the nucleus and have very small mass. The dense nucleus of the atom consists of heavier positive particles called protons and neutral particles called neutrons.

The number of protons in the nucleus of an atom of an element is called the **atomic number** (Z) of the element. The total number of protons **and** neutrons in the nucleus is called the **mass number** (A)**.**

e.g. An oxygen atom with a mass number of 16 and an atomic number of is represented: $^{16}_{8}O$

$^{A}_{Z}X$ e.g. $^{7}_{3}Li$ This means Lithium has an atomic number of 3 (3 protons) & a mass number of 7 (3 protons plus 4 neutrons).

The subatomic particles:

particle	relative mass	electric charge	location
proton (p)	1	+	nucleus
neutron (n)	1	zero	nucleus
electron (e)	1/2000	-	in electron shells

Subatomic particles involved in nuclear reactions:

proton	neutron	electron / beta β	helium nucleus/ alpha α
$^{1}_{1}p$	$^{1}_{0}n$	$^{0}_{-1}e$	$^{4}_{2}He$

Chemical and nuclear reactions:

Electrons can be removed from an atom, leaving a positive ion; or they can become attached to certain atoms to form negative ions. The outermost **electrons** are involved in **chemical reactions** and in bonding of atoms to form compounds, e.g. hydrogen reacts with oxygen forming water. Chemical reactions produce small amounts of energy. In Physics, we are interested in the production of ions because radioactive particles can collide with electrons, knocking them out of orbit.

Nuclear reactions are of a different order of magnitude in terms of energy absorbed or released.

When certain unstable atoms spontaneously decay, emitting radiations of different kinds, and often changing into atoms of different elements, the activity takes place in the **nucleus** of the atom. **Fission** (as in a nuclear reactor or an atomic bomb) and **fusion** (as in the formation of elements in the Sun and stars) are other kinds of nuclear reaction.

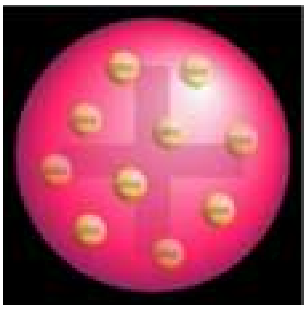
A brief history of Atomic Theory - Dalton:

Elements are made of tiny particles called atoms.

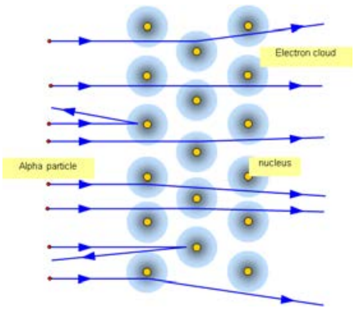
- All atoms of a given element are identical
- The atoms of a given element are different from those of any other element.
- Atoms of one element can combine with atoms of other elements to form compounds.
- A given compound always has the same relative numbers of types of atoms.
- Atoms cannot be created, divided into smaller particles, nor destroyed in the chemical process -
  they were indivisible.
- A chemical reaction simply changes the way atoms are grouped together.

A brief history of Atomic Theory - J. J. Thomson:

The plum pudding model of the atom was proposed by J. J. Thomson, the discoverer of the electron in 1897. In this model, the atom is composed of electrons, surrounded by a soup of positive charge to balance the electron's negative charge, like plums surrounded by pudding. The electrons were thought to be positioned throughout the atom. Instead of a soup, the atom was also sometimes said to have had a cloud of positive charge. Thomson believed there were spaces between these atoms.



A brief history of Atomic Theory - Rutherford:



The Rutherford model of the atom was devised by Ernest Rutherford. He performed his famous gold foil experiment, which showed that the Plum pudding model of the atom was incorrect. In the experiment, Rutherford allowed alpha particles to pass through a thin piece of gold foil. He expected that most of the particles would pass through the foil or only be deflected slightly. This happened most of the time, but a few particles, 1 in 8000, bounced back towards the source.

Rutherford concluded:

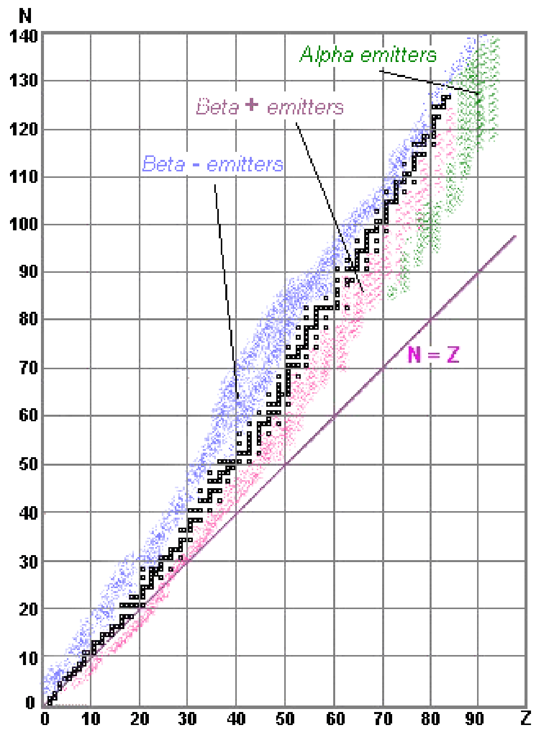
Evidence from the alpha particle scattering	**Conclusion about the gold atoms**
Because **most** α particles were deflected by less than 5°	There was a small nucleus in the atom
Because **some** of the positive α particles were deflected/repelled	The nucleus had a positive charge – the same charge as the positive α particles (and therefore the electrons must be outside the nucleus)
Because a **few** of the α particles bounced back	The nucleus was dense/massive

The experiment indicated that atoms have a dense, positive inner core instead of spread-out positive field. Rutherford proposed that the atom is made up of a positive nucleus consisting of protons surrounded by a cloud of orbiting electrons. However, the Rutherford model did not attribute any structure to the orbiting electrons and it did not include neutrons (that were added later by Chadwick). The Rutherford model of the atom was later superseded by the Bohr atom.

Stability:
Radioactivity can be considered in the following terms:

- a nucleus can be naturally unstable
- instability can be induced into a nucleus (e.g. by bombarding it with other particles)
- as a result the nucleus can decay
- in so doing it might change from one type of an element to another
- the decay is spontaneous (random in nature)

The nucleus is composed of protons and neutrons BUT only certain combinations of n/p seem to be stable. Radioactivity results from the random and spontaneous breakdown of the unstable nucleus of an atom. In the breakdown of the unstable nucleus, energy is released by the emission of alpha, beta and gamma radiation.



The neutron number (N) = mass number (A) - atomic number (Z).