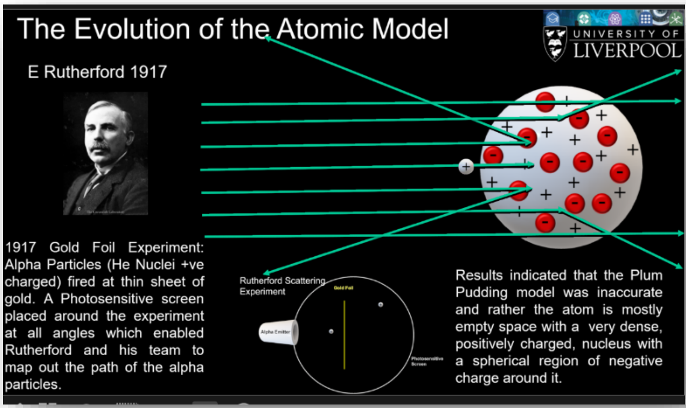
The Evolution of the Atomic Model: Plum Pudding to the modern Nuclear Model. (Click to progress animations)

In 1897 Joseph J Thomson, developed the Plum Pudding model of the atom which visualises the atom as a spere of positive charge with negative charges distributed throughout like fruit in a sponge pudding.

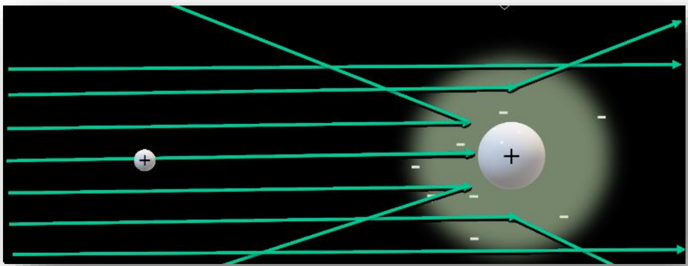
CLICK to Progress animation:



Ernest Rutherford was a graduate student of Thomson along with Neils Bohr (went on to propose that electrons orbit the nucleus) and investigated the structure of the atom with the 'Rutherford scattering experiment'.

The experiment conducted between 1908 and 1913 involved firing alpha particles (He Nuclei produced in radioactive alpha decay) ,which have a positive charge, at a thin sheet of gold foil. A fluorescent screen was placed all around the experiment which would give out a flash of light when it encountered an alpha particle. Rutherford's Graduate students, Hans Geiger and Ernest Marsden conducted this experiment and were able to calculate the angles that the alpha particles had been deflected as they passed through the gold atoms in the foil.

The results were not consistent with the Plum Pudding model. Many of the alpha particles passed straight through the gold atoms but some were deflected with a few of these at an angle greater than 90 which could only be explained by an electrostatic repulsion of 2 positive charges, the alpha particle and the nucleus.



The results led to the development of the Rutherford model of the atom which is mostly empty space in an indefinable sphere of negative charge with a dense, positively charged nucleus at the centre.

Rutherford won the Nobel Prize for his discovery in 1917.

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Rutherford's new atomic model developed further into the modern nuclear atomic model, particularly following James Chadick's discovery of the Neutron in 1932.

Thanks to the work of Physicists like Thompson, Rutherford, Bohr and Chadwick we now have an understanding of the structure of the Atom.

The atom is made from a dense nucleus containing Protons and Neutrons which is 'orbited' by Electrons.

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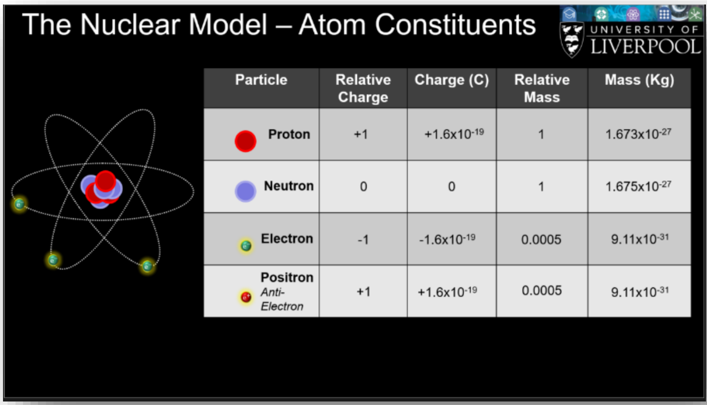
Atom Constituents: Protons, Neutrons, electrons and positrons; Charge and Mass.

Let's take a look at the particles that make up the atom in more detail.

It is important to note the difference between relative charge and actual charge on each particle.

CLICK to reveal numbers.



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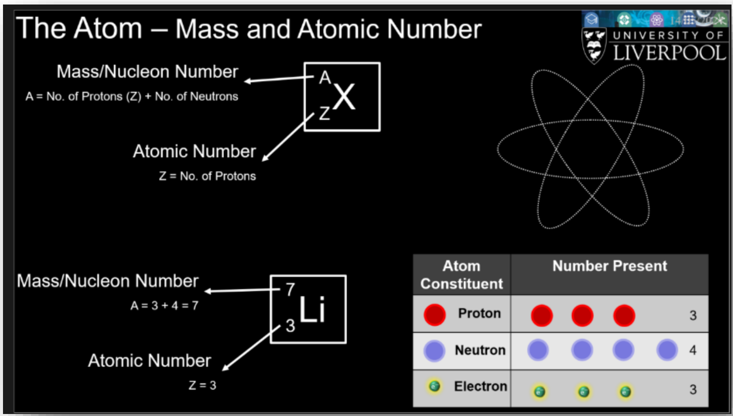
The Atom: Mass and Atomic Numbers; A and Z.



We can find all the information about the atom of each element from the periodic table.

The numbers in the top and bottom right of the element tell us how many particles are within the atom. The

Mass/Nucleon number, A, is the total number of nucleons: **A = No. of Protons + No. of Neutrons.**

The atomic number, Z, is the number of protons:

Z = No. of Protons This number is what makes the atom a specific element and is also equal to the number of electrons (in a neutral atom) making the net charge of the atom 0 as the negative charge of the electrons cancels the positive charge of the protons.

We can find the number of Neutrons by subtracting the Atomic number, Z, from the Mass number, A.

Let take a look at an example; here is an atom of Lithium with a Mass number of 7 and an Atomic number of 3. We know the number of protons is 3 and we can work out the number of neutrons:

No. Neutrons = A – Z = 7 – 3 = 4

Please note, particles do NOT drop out of the atom like this, this is just to help visualize the numbers!

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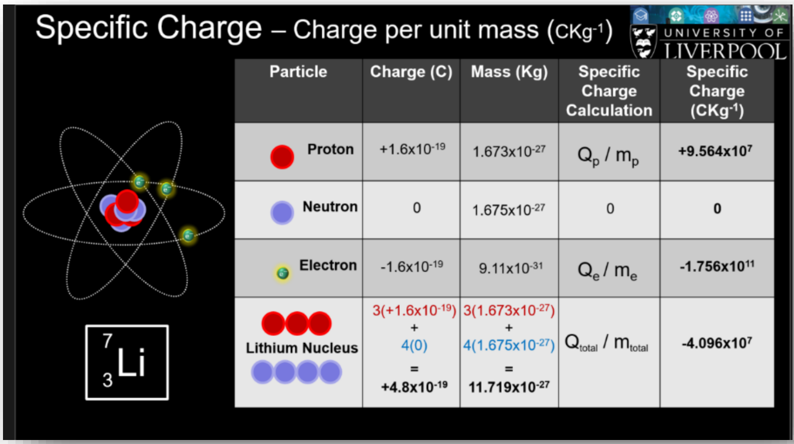
Specific Charge: Protons, neutrons, electrons and the nucleus of the Lithium atom.



Particle	Charge (C)	Mass (Kg)	Specific Charge Calculation	Specific Charge (CKg⁻¹)
Proton	$+1.6\times10^{-19}$	1.673×10^{-27}	Q_p / m_p	$+9.564\times10^{7}$
Neutron	0	1.675×10^{-27}	0	0
Electron	-1.6×10^{-19}	9.11×10^{-31}	Q_e / m_e	-1.756×10^{11}
Lithium Nucleus	$3(+1.6\times10^{-19})$ + $4(0)$ = $+4.8\times10^{-19}$	$3(1.673\times10^{-27})$ + $4(1.675\times10^{-27})$ = 11.719×10^{-27}	Q_{total} / m_{total}	-4.096×10^{7}

It is important to consider the specific charge on particles and nuclei.

Specific charge is defined as the charge per unit mass of a particle ,atomic nuclei or an ion (imbalanced no. of protons and electrons leaving a non zero net charge).This is measured in Coulombs per Kilogram **(CKg^{-1})**

Looking at the difference between the specific charge for the proton and electron we can see the latter has a lot more charge distributed in its mass because their charges are opposite but equal while the mass of the electron is significantly less than that of the proton.

Whilst the neutron has no charge and therefore no specific charge it does have mass so when we work out the specific charge of an atomic nucleus the mass does factor in, look at the lithium example where only the proton charge is factored in but for the mass, we include both the protons and neutrons.

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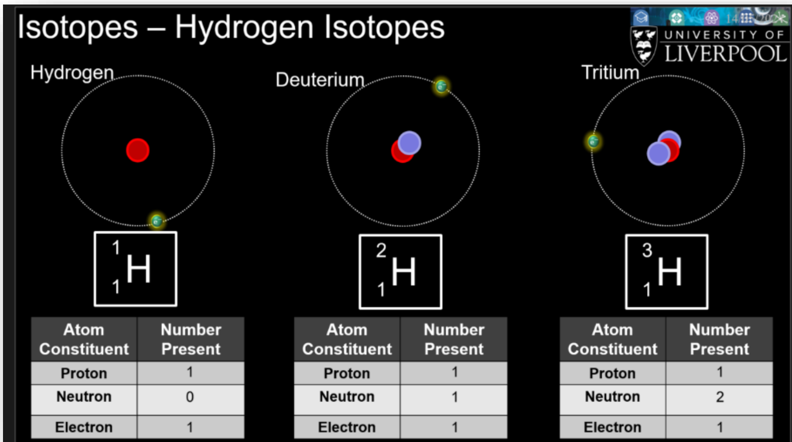
Isotopes: Hydrogen Isotopes.

Whilst the Atomic number makes the atom a specific element, the mass number can vary making a number of different versions of the atom called Isotopes.

Here we can see the simplest atom, Hydrogen, containing just one proton and one electron. An isotope of hydrogen known as Deuterium contains one neutron also. Tritium is another isotope of hydrogen and contains 2 neutrons. These isotopes are involved in the steps of stellar nuclear fusion and go on to form new elements in later steps.



Atom Constituent	Number Present (Hydrogen)	Number Present (Deuterium)	Number Present (Tritium)
Proton	1	1	1
Neutron	0	1	2
Electron	1	1	1

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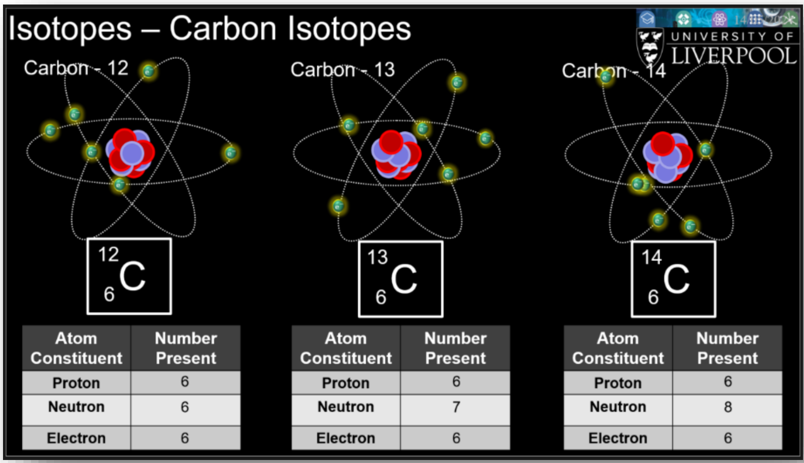
Isotopes: Carbon Isotopes.

Similar to Hydrogen, Carbon has isotopes Carbon-13 and Carbon-14, the latter being radioactive.

This means it will decay via a Beta – decay to Nitrogen-14 as Beta – decay involves a neutron transforming into a proton changing the atomic number and therefore changing the atom to a new element.

We can use this for an incredibly useful purpose.....



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Isotopic Data: Carbon Dating.

Living organisms continually absorb and contain carbon in their bodies, plants through photosynthesis where they absorb Carbon dioxide and convert this into sugar. Animals then consume the plants, and the carbon is passed through the food chain.

The Earth's atmosphere has a specific percentage of carbon and this itself is made from different percentages of the carbon isotopes. The carbon is oxidised into Carbon dioxide which is absorbed by living organisms ONLY when they are alive.

When the organism dies it stops taking on any more carbon, the percentages of the carbon isotopes in their bodies will be the same as the distribution in the atmosphere initially but the radioactive Carbon-14 decays over time and this distribution changes. Using what we know about the radioactive half-Life of Carbon-14 (~5000 years) and testing how much is left in the body we can calculate the amount of time the organism has been dead.