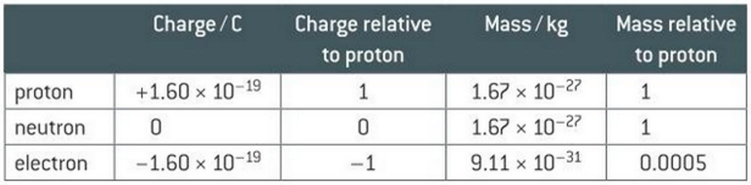
Particles All that Intro Stuff

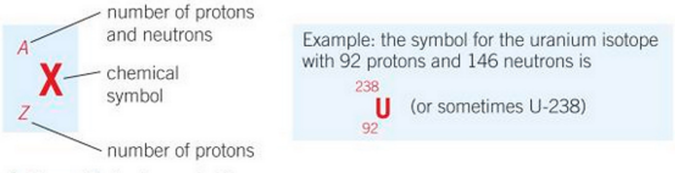
17 January 2020 09:54

Atoms cannot be seen as we understanding seeing - they are too small. However, lots of evidence suggests they exist and we know a lot about them



	Charge / C	Charge relative to proton	Mass / kg	Mass relative to proton
proton	$+1.60 \times 10^{-19}$	1	1.67×10^{-27}	1
neutron	0	0	1.67×10^{-27}	1
electron	-1.60×10^{-19}	−1	9.11×10^{-31}	0.0005

The Nucleus is small, extremely dense and contains the protons and neutrons (known as nucleons). The electrons 'orbit' this nucleus at some distance.

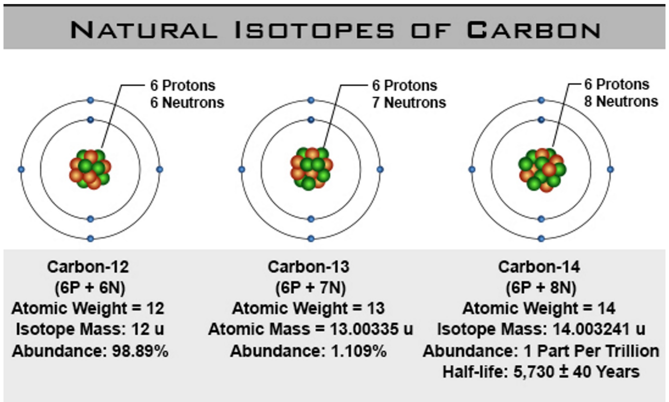


Example: the symbol for the uranium isotope with 92 protons and 146 neutrons is $^{238}_{92}\mathrm{U}$ (or sometimes U-238)

▲ **Figure 3** *Isotope notation*

It amazes me just how much information comes from these two, simple numbers. Arranging the elements in order of Z was a stroke of genius. But I digress...

Each element is defined by its Z number. However, you can have the same element with different A numbers (think mass). This would mean they have the same number of protons (and hence e- for atoms) but different numbers of protons. Chemically they are very similar, but clearly they have different masses, and probably densities. Additionally many isotopes are unstable.



So nearly all of the carbon in humans is C-12 - normal, boring carbon. However a tiny fraction is C-13(one more p^+) and even less is C-14 (2 more p^+). C-14 is radi0active. So there are 3 nuclides of carbon.

Specific Charge

This is defined as the charge of a particle divided by its mass (the minus sign is often, but not always ignored).

p^+ mass $= 1.67 \times 10^{-27}$ Kg and its charge $= 1.6 \times 10^{-19}$ C ∴

Specific charge $= \frac{q}{c} = \frac{1.6 \times 10^{-19}}{1.67 \times 10^{-27}}$

$= 9.58 \times 10^{7}$ C/K

This means that if you had 1kg of protons in a pile (which would be hard to do) it would have 9.56×10^{7} C of charge - that is enormous.

The Strong Force

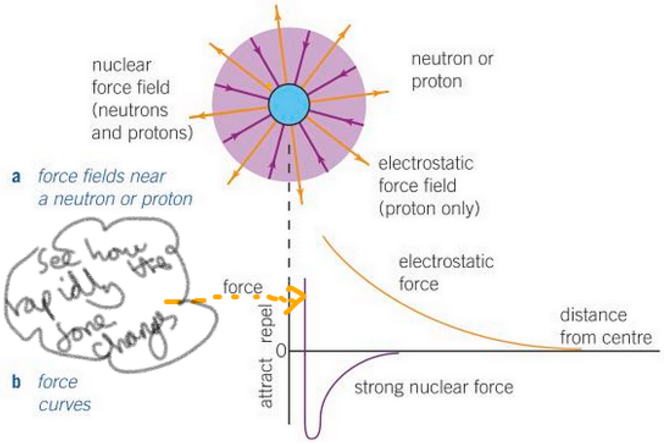
Ever wondered how a nucleus stays together if positive charges repel each other? It was thought that perhaps the gravitational attraction between them could overcome the electrical repulsion. However, the repulsive force is simple enormous compared to the gravitational attraction.

This is where a new force was suggested - given the name the strong force (since the repulsive force is just so big). The strong force:

- Acts only over a small distance
- Is very strong
- Is the same between any nucleon (ie same between two p^+ or two n or a p^+n combination)

The first point is interesting since gravitational (and electrical) forces continue to act even if the masses are very far apart or very close though obviously the size of the force varies. The strong force is not like this. As you bring two nucleons together then is NO strong force until you get to a separation of around 3×10^{-15}m at which point a strong attractive force kicks in. If you go closer than 0.5×10^{-15}m - the strong force becomes strongly repulsive. This goes some way to explaining the size of the nucleus.

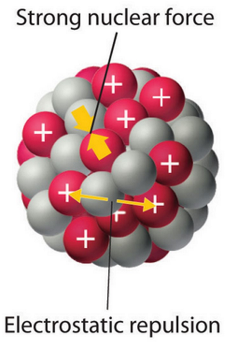
This is often shown in a diagram:



The strong force is really weird - can you think of another force that changes it's nature (ie repulsive/attractive) without changing anything relating to the objects involved except their separation? Weird indeed.

An Aside

It is interesting to think about the forces across a nucleus given the short ranges involved.

	This shows that two positive nucleons that are separated from each other experience a repulsive, electrical force whereas two close to each other experience a strong attractive force. Gravitational forces aren't even included (but are tiny anyway) So, clearly the nucleus is a complex beast, and given that everything moves (including the protons and neutrons) then things are always changing deep in the heart of the atom.