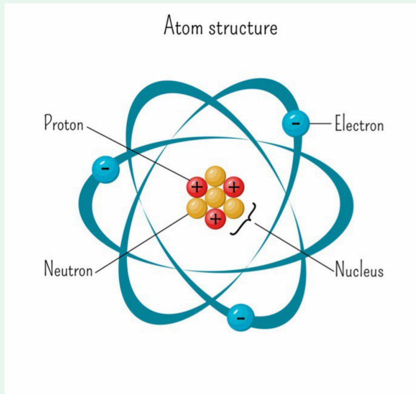
Protons, neutrons, and electrons

Atoms consist of a nucleus and a cloud of electrons that move around the nucleus. The nucleus is itself a cluster of two kinds of particles, protons and neutrons. All the particles in an atom are very light. So their mass is measured in atomic mass units, rather than grams. Protons and electrons also have an electric charge:

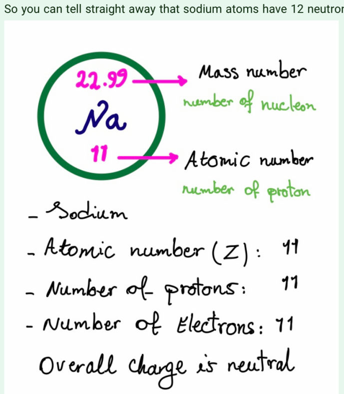


Proton number

A sodium atom has 11 protons. This can be used to identify it, since only a sodium atom has 11 protons. Every other atom has a different number. The number of protons in an atom is called its proton number.
How many electrons? The sodium atom also has 11 electrons. So it has an equal number of protons and electrons. The same is true for every sort of atom: Every atom has an equal number of protons and electrons. So atoms have no overall charge.

Nucleon number

Protons and neutrons form the nucleus, so are called **nucleons** .
The total number of protons and neutrons in an atom is called its nucleon number.
The nucleon number for the sodium atom is 23.
The lower number is always the proton number.
The other number is the nucleon number.
So you can tell straight away that sodium atoms have 12 neutrons.



Electrons

As we discussed, electrons move through the space surrounding the nucleus and are associated with varying levels of energy.The mass of an electron is approximately 1/2000 that of a proton. The electrons closer to the nucleus are at lower energy levels, while those that are further out (in higher electron shells) have higher energy. The electrons that are farthest from the nucleus have the strongest interactions with the surrounding environment and the **weakest interactions** with the nucleus. **These electrons are called valence electrons;** they are much more likely to become involved in bonds with other atoms because they experience the least electrostatic pull from their own nucleus.

Generally speaking, the valence electrons **determine the reactivity of an atom** .
The losing electrons results in the atom gaining a **positive charge** , while gaining electrons results in the atom gaining a **negative charge** . A positively charged atom is called a cation, and a negatively charged atom is called an anion.

Atomic Mass

The atomic mass of an atom (in amu) is nearly equal to its mass number, the sum of protons and neutrons.

Avogadro's number

The utility of the atomic weight is that it represents both the mass of the "average" atom of that element, in amu (atomic mass unit) and the mass of one mole of the element, in grams.
A mole is a number of "things" (atoms, ions, molecules) equal to Avogadro's number, NA = 6.02×10^{23} . For example, the atomic weight of carbon is 12.0 amu, which means that the average carbon atom has a mass of 12.0 amu(carbon-12 is far more abundant than carbon-13 or carbon-14), and 6.02×10^{23} carbon atoms have a combined mass of 12.0 grams.

Bohr Model

Bohr assumed that the hydrogen atom consisted of a central proton around which an electron traveled in a circular orbit. He postulated that the centripetal force acting on the electron as it revolved around the nucleus was created by the electrostatic force between the positively charged proton and the negatively charged electron.
Before Bohr Model, the classical mechanics postulates that an object revolving in a circle, such as an electron, may assume an infinite number of values for its radius and velocity. The angular momentum (L = mvr) and kinetic energy $K=1/2\ mv^2$ of the object could therefore take on any value.

However, Bohr placed restrictions on the possible values of the angular momentum. Bohr predicted that the possible values for the angular momentum of an electron orbiting a hydrogen nucleus. The energy of the electron changes in discrete amounts with respect to the quantum number. A value of zero energy was assigned to the state in which the proton and electron are separated completely, meaning that there is no attractive force between them. Therefore, the electron in any of its quantized states in the atom will have an attractive force toward the proton. The only thing the energy equation is saying is that the energy of an electron increases—becomes less negative—the farther out from the nucleus that it is located (increasing n). This is an important point: while the magnitude of the fraction is getting smaller, the actual value it represents is getting larger (becoming less negative).
Bohr came to describe the structure of the hydrogen atom as a nucleus with one proton forming a dense core, around which a single electron revolved in a defined pathway (orbit) at a discrete energy value. If one could transfer an amount of energy exactly equal to the difference between one orbit and another, this could result in the electron "jumping" from one orbit to a higher-energy one. These orbits had increasing radii, and the orbit with the smallest, lowest-energy radius was defined as the ground state (n = 1). More generally, the ground state of an atom is the state of lowest energy, in which all electrons are in the lowest possible orbitals. In Bohr's model, the electron was promoted to an orbit with a larger radius (higher energy), the atom was said to be in the excited state. In general, an atom is in an excited state when at least one electron has moved to a sub-shell of higher than normal energy. **Bohr likened** his model of the hydrogen atom to the planets orbiting the sun, in which each planet traveled along a roughly circular pathway at set distances—and energy values—from the sun.
The electrons in an atom can be excited to different energy levels. When these electrons return to their ground states, each will emit a photon with a wavelength characteristic of the specific energy transition it undergoes. As described above, these energy transitions do not form a continuum, but rather are quantized to certain values. **Thus** , the spectrum is composed of light at specified frequencies. It is sometimes called a line spectrum, where each line on the emission spectrum corresponds to a specific electron transition. Because each element can have its electrons excited to a different set of distinct energy levels, each possesses a unique atomic emission spectrum, which can be used as a fingerprint for the element.

Periodic Table

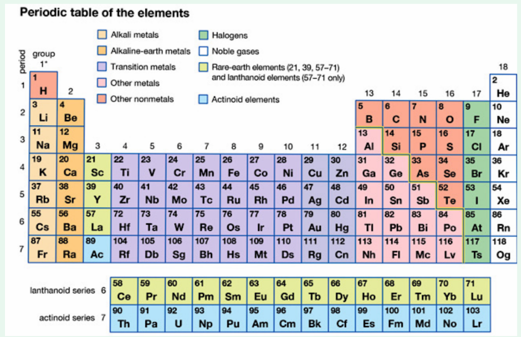
It gives the names and symbols for the elements.

The column and row an element is in gives us lots of clues about it. For example, look at the columns numbered I, II, III ...

The elements in these form families or groups, with similar properties.Each group has similar behaves,

The rows are called periods.

Look at the **zig-zag line** . It separates metals from non-metals, with the non-metals on the right of the line, except for hydrogen. So there is a change from metal to non-metal, as you go across a period.

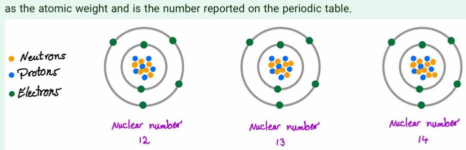


Isotopes and radioactivity

Note: You can identify an atom by the number of protons in it.

Isotopes

All carbon atoms have 6 protons. But not all carbon atoms are identical. Some have more neutrons than others.The three atoms above are called isotopes of carbon. Isotopes are atoms of the same element, **with different numbers of neutrons**. Most elements have isotopes. For example calcium has six, magnesium has three, iron has four, and chlorine has two. These isotopes are usually present in the same proportions in any sample of a naturally occurring element. The weighted average of these different isotopes is referred to as the atomic weight and is the number reported on the periodic table.



Some isotopes are radioactive

atoms of the same element, that have a different numbers of neutrons

...ange way. It is radioactive. That means its nucleus is unstable. Sooner or ...lly or decays, giving out radiation in the form of rays and particles, plus a ...arbon, a number of other elements have radioactive isotopes – or ...ly, and eventually decay. But the other two isotopes of carbon (like most natural isotopes) are non-radioactive.

Decay is a random process

We can't tell whether a given atom of carbon-14 will decay in the next few seconds, or in a thousand years. But we do know how long it takes for half the radioisotopes in a sample to decay. This is called the **half-life** . The half-life for carbon-14 is 5730 years. So if you have a hundred atoms of carbon-14, fifty of them will have decayed 5730 years from now.

How electrons are arranged

Electron shells

Electrons are arranged in shells around the nucleus. The first shell, closest to the nucleus, is **the lowest energy level**. The further a shell is from the nucleus, the higher the energy level. Each shell can hold only a certain number of electrons. These are the rules:

Shell	Sub-shell						No
n	*s*	*p*	*d*	*f*	*g*	*h*	
1	1s=2						*2*
2	2s=2	2p=6					*8*
3	3s=2	3p=6	3d=10				*18*
4	4s=2	4p=6	4d=10	4f=14			*32*
5	5s=2	5p=6	5d=10	5f=14	5g=18		*50*
6	6s=2	6p=6	6d=10	6f=14	6g=18	6h=22	*72*