Atoms and Isotopes

All substances are made of atoms. They're really tiny — too small to see, even with a microscope.

Atoms Contain **Protons**, **Neutrons** and **Electrons**

The atom is made up of three subatomic particles — protons, neutrons and electrons.

- Protons are heavy and positively charged.
- Neutrons are heavy and neutral.
- Electrons have hardly any mass and are negatively charged.

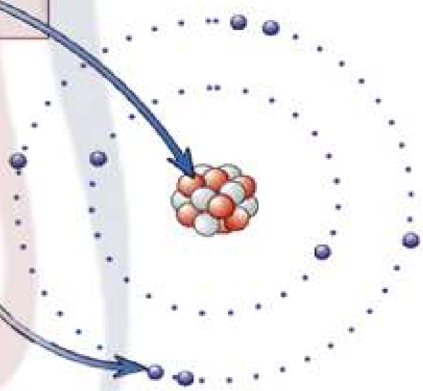
Relative mass (measured in atomic mass units) measures mass on a scale where the mass of a proton or neutron is 1.

Particle	Relative mass	Relative charge
Proton	1	+1
Neutron	1	0
Electron	0.0005	–1

The Nucleus

1) It's in the middle of the atom and is made up of protons and neutrons.
2) It has a positive charge because of the protons.
3) Almost the whole mass of the atom is found in the nucleus.
4) Compared to the overall size of the atom, the nucleus is tiny.

Protons and neutrons are still tiny — they're just heavy compared to electrons.



The Electrons

1) Electrons move around the nucleus in energy levels called shells.
2) Electrons are negatively charged.
3) They're tiny, but their orbitals cover a lot of space.
4) The size of their orbitals determines the size of the atom.
5) Electrons have virtually no mass.

The Atom

1) Neutral atoms have no charge overall.
2) The charge on the electrons is the same size as the charge on the protons — but opposite.
3) This means the number of electrons always equals the number of protons in a neutral atom.
4) If some electrons are added or removed, the atom becomes charged and is then an ion.

Proton Number and **Nucleon Number** Describe an Atom

These two numbers tell you how many of each kind of particle an atom has.

KEY TERM

The proton (atomic) number is the number of protons in the nucleus of an atom.

KEY TERM

The nucleon (mass) number is the total number of protons and neutrons in the nucleus of an atom.

nucleon number

$^{23}_{11}\mathrm{Na}$ element symbol

proton number

1) Atoms of the same element all have the same number of protons — so atoms of different elements will have different numbers of protons.
2) To find the number of neutrons in an atom, just subtract the proton number from the nucleon number.

Atoms and Isotopes

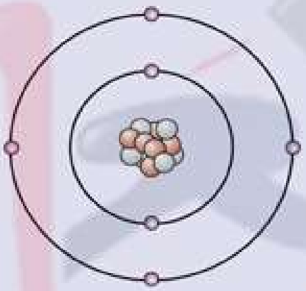
Isotopes are the Same Except for an Extra **Neutron** or Two

KEY TERM

Isotopes are atoms of the same element which have the same proton number but a different nucleon number.

1) Isotopes must have the same proton number but different nucleon numbers.
2) If they had different proton numbers, they'd be different elements altogether.
3) A very popular example of a pair of isotopes is carbon-12 and carbon-13.

Carbon-12

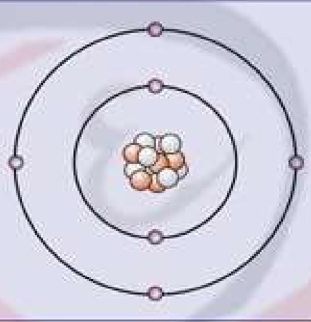


$^{12}_{6}C$

6 PROTONS
6 ELECTRONS
6 NEUTRONS

Remember — the number of neutrons is just the nucleon number minus the proton number.

Carbon-13



$^{13}_{6}C$

6 PROTONS
6 ELECTRONS
7 NEUTRONS

As all the isotopes of an element have the same number of electrons in their outer shell, they will have the same properties — they'll react in the same way.

See page 17 for more on how electrons affect reactivity.

Isotopes can be **Radioactive** or **Non-Radioactive**

1) Some isotopes are stable, but others are unstable and will undergo radioactive decay.
2) As these atoms decay, they release energy and small particles until they reach a point where they become stable.

This number represents its nucleon number.

3) Some radioactive isotopes are used in medicine. For example, cobalt-60 is used in radiotherapy to treat cancer and iodine-131 can be used to treat a range of thyroid diseases.
4) They are also used in industry — for things like scanning metal machinery for faults or damage.

REVISION TIP

Isotopes of an element have different numbers of neutrons

If you're struggling to recall how an isotope is defined, try using the letters in 'isotope' as a memory aid — iSotoPes of the same element have the Same Proton number but different nucleon numbers.

Electron Shells

The fact that electrons occupy 'shells' around the nucleus is what causes the whole of chemistry.

Electron Shell **Rules**:

1) Electrons always occupy shells (sometimes called energy levels).

2) The lowest energy levels are always filled first.

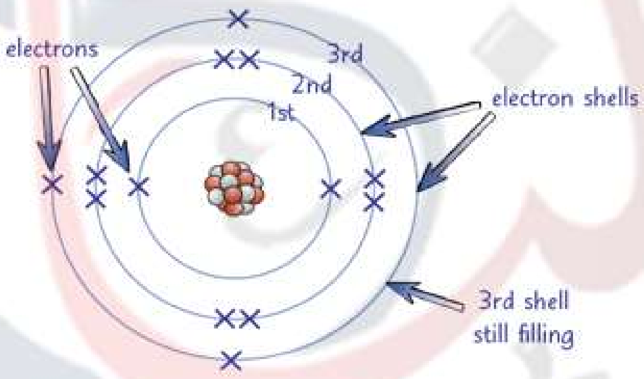
The lowest energy levels are the ones that are closest to the nucleus.

3) Only a certain number of electrons are allowed in each shell:

1st shell: 2   2nd shell: 8   3rd shell: 8

Electron Shells can be Shown as **Diagrams** or **Numbers**

1) Electronic structures can be shown as diagrams like this:



2) They can also be shown as numbers like this: 2,8,3.
3) Both electronic structures shown above are for aluminium.

The **Outer Shell Electrons** Control **Reactivity**

1) The electrons in the outer shell of an atom are involved in forming bonds with other atoms.
2) Atoms will form bonds which allow them to gain or lose enough electrons to be left with a full outer shell — like a noble gas element.
3) Noble gases (see page 93) are unreactive as they already have a full outer shell.

Example: Chlorine has 7 electrons in its outer shell. So when it reacts, it will gain 1 electron in order to have the structure of the closest noble gas, argon.

Electron shells — probably the most important thing in chemistry

It's important to learn the rules for filling electron shells, so here's a recap. The energy of the shells increases with increasing number (so shell 1 is the lowest energy level). You fill the shell with the lowest energy first. The 1st shell hold a maximum of 2 electrons and the 2nd and 3rd shells both hold a maximum of 8 electrons.