Atoms: nature's building blocks

You are made up of atoms. So is everything around you - natural or man-made, visible or invisible (like air). Atoms make up everything except *nothing*.

- Your body consists of many parts.
- Each part contains materials such as flesh and blood.
- The cells of each material contain millions of molecules of chemical compounds.
- Each molecule is made up of a group of atoms.

Your body is built from about fifty thousand million, million, million (5×10^{27}) atoms - a number far bigger than anybody can imagine!

Question 1

Can you think of an example of **nothing**?

Answer

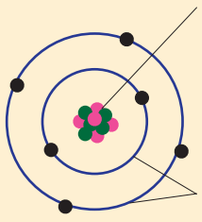
Chemists explain the physical and chemical properties of materials using the idea of electrons moving between atoms. You will learn more about this on pages 46-49.

What's in an atom?

Atoms are made up of even smaller particles. These are **protons**, **neutrons** and **electrons**. We call them **sub-atomic** particles. You need to remember:

- the charge and mass of each sub-atomic particle
- where they are in the atom
- how to work out how many of each there are in an atom.

In diagrams, the electrons are shown in layers, called **shells**. These are like layers in an onion. The diagram shows a cross-section, like an onion cut in half.



Nucleus. Contains protons ● and neutrons ●

Electron shells. Contain electrons ●

protons
charge: +1
mass: 1

neutrons
charge: 0
mass: 1

electrons
charge: -1
mass: $^1/_{1840}$

For any atom:

- **number of protons = number of electrons**
  So charges balance out, making the atom electrically neutral.
- Most of its mass is in its nucleus, since electrons have very little mass compared with protons and neutrons.

Question 2

Which sub-atomic particles have a negative charge and which have a positive charge?

Answer

Atomic number: an atom's ID

Every element has an **atomic number**.

The atomic number is the number of protons in the nucleus (also the total number of electrons). It's different for each element and is always a whole number. The atomic number identifies the element.

- All atoms of an element have the same number of protons.
- Atoms of different elements have different numbers of protons.

note:

Relative atomic mass is the average mass of all the atoms of an element (*see q&a on page 33*).

Question 3

Look at the diagram (right).

(a) How many protons in a carbon atom?

(b) How many electrons in a chlorine atom?

(c) Which element has atoms with 7 protons?

Answer

Part of The Periodic Table:

6	7	8	9	10
C	**N**	**O**	**F**	**Ne**
12.0	14.0	16.0	19.0	20.2
14	15	16	17	18
Si	**P**	**S**	**Cl**	**Ar**
28.1	31.0	32.0	35.5	39.9

atomic number

relative atomic mass

Electron shells

Electrons move in **shells** arranged around the nucleus of an atom. Each shell can hold more electrons than the one before. There may be:

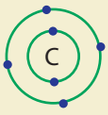
- up to two in the first shell
- up to eight in the second shell
- up to 18 in the third shell.

The **electron arrangement** can be shown by **diagrams** or **numbers**. For example:

Hydrogen (atomic number = 1)

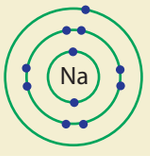
H 1

Carbon (atomic number = 6)



C 2.4

Sodium (atomic number = 11)



Na 2.8.1

Question 4

What is the electron arrangement in:
(a) fluorine (Atomic number = 9)
(b) aluminium (Atomic number = 13)
(c) sulfur (Atomic number = 16)?

Answer

Mass number: counting p's and n's

A neutron (n) has the same mass as a proton (p). We ignore electrons, since even a hundred of them weigh much less than one proton. So we can compare the masses of atoms by counting the numbers of protons and neutrons. For example:

- A hydrogen atom has only 1p.
- An oxygen atom has 8p and 8n.
- So, an oxygen atom is 16 times heavier than a hydrogen atom: its **mass number** = 16.

For any atom: **mass number = total number of protons and neutrons in its nucleus**

This is how we write this information:

mass number — $^{12}_{6}C$ — symbol of the element

atomic number

Complete this table ...

Number of p	Number of n	Number of e	Atomic no.	Mass number
9	10	9	_____	_____
11	12	_____	_____	23
_____	34	_____	29	_____
_____	_____	_____	82	207

q&a

Q. *What is* atomic mass?

A. Atomic mass is a name we sometimes use instead of mass number.

Q. *What's the difference between* atomic mass *and* relative atomic mass?

A. Some elements have atoms with different numbers of neutrons, so different atomic masses. E.g:

$^{35}_{17}Cl$ and $^{37}_{17}Cl$ have 18 and 20 neutrons respectively.

- Atoms of the same element with different atomic masses are called **isotopes**.
- The atomic number cannot change.

Relative atomic mass is the **average** mass of all the atoms of the element. E.g:

- about 75% of chlorine atoms are $^{35}_{17}Cl$ and 25% are $^{37}_{17}Cl$
- the average mass is therefore about $(^{75}/_{100} \times 35) + (^{25}/_{100} \times 37) = 35.5$
- so, the relative atomic mass of chlorine is about 35.5

Complete these six facts:

(a) atomic number = number of _____

(b) number of _____ = number of protons

(c) _____ = number of protons + number of neutrons

(d) number of _____ = mass number - number of protons

(e) _____ mass = mass of one particular atom

(f) _____ mass number = average mass of all atoms of the element, including different isotopes.