Subatomic particles

Atoms are composed of three subatomic particles: **protons**, **neutrons** and **electrons**. The two important properties of these particles are mass and charge:

Particle	Relative mass	Relative charge
proton	1	+1
neutron	1	0
electron	1/1840	-1

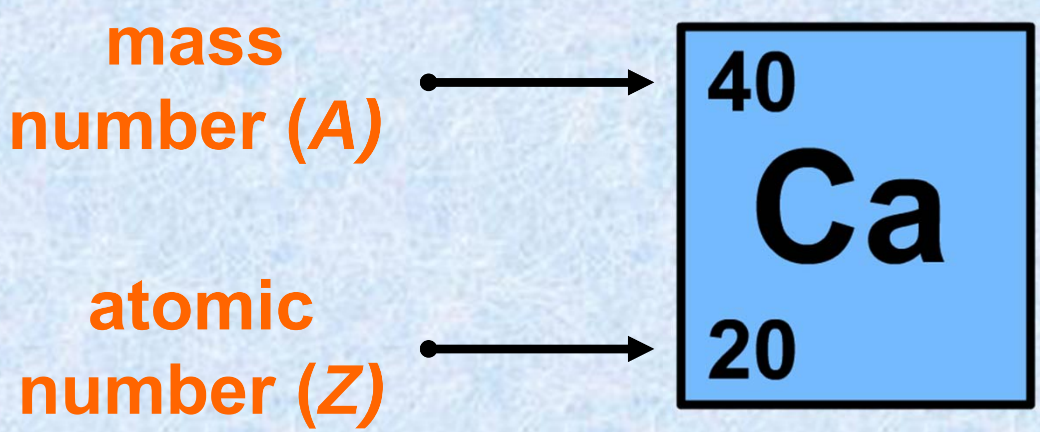
The mass of electrons is negligible when compared to the mass of protons and neutrons, so their mass is not included when calculating the mass of the atom.

Atomic number and mass number

The number of protons in an atom is known as the **atomic number** or **proton number** and is represented by the symbol ***Z***.

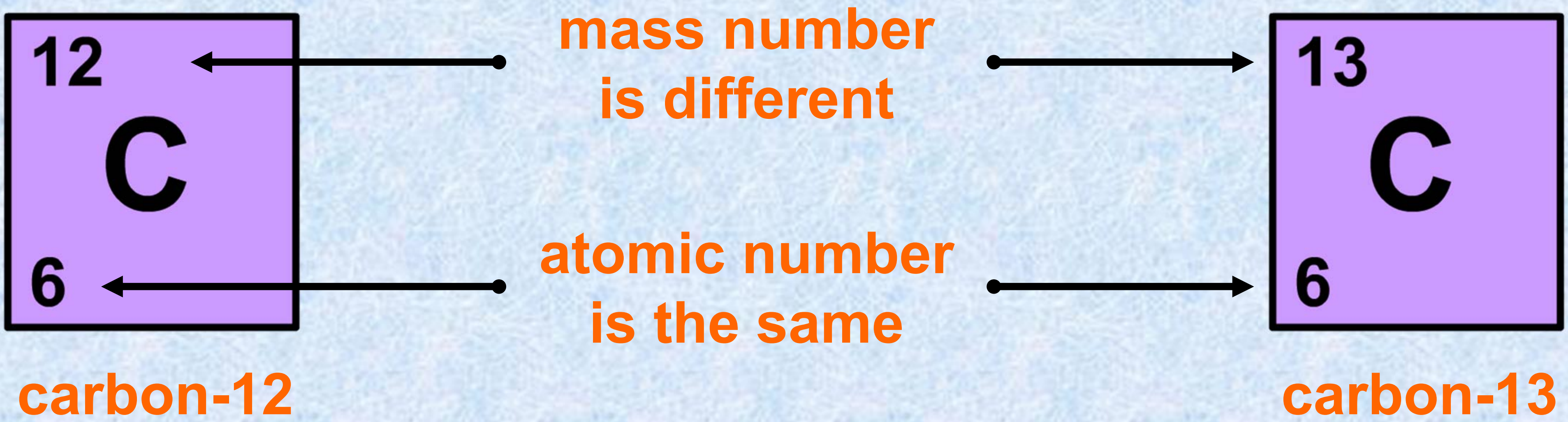
The **mass number** of an atom is the number of protons plus the number of neutrons, and is represented by the symbol ***A***.

When an atom is represented by its symbol, the mass number, and sometimes the atomic number, are shown.



What are isotopes?

Isotopes are atoms of the same element that contain different numbers of neutrons.



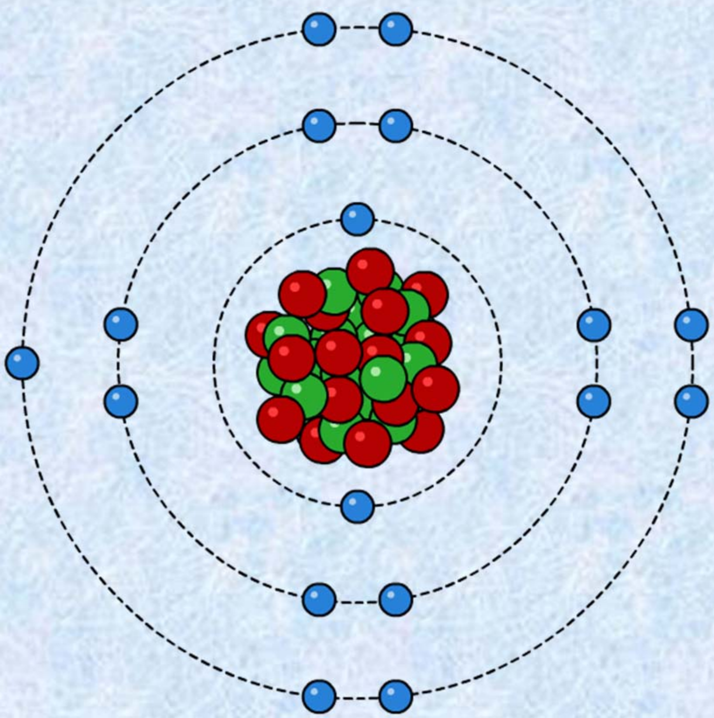
The reactivity of different isotopes of an element is identical because they have the same number of electrons.

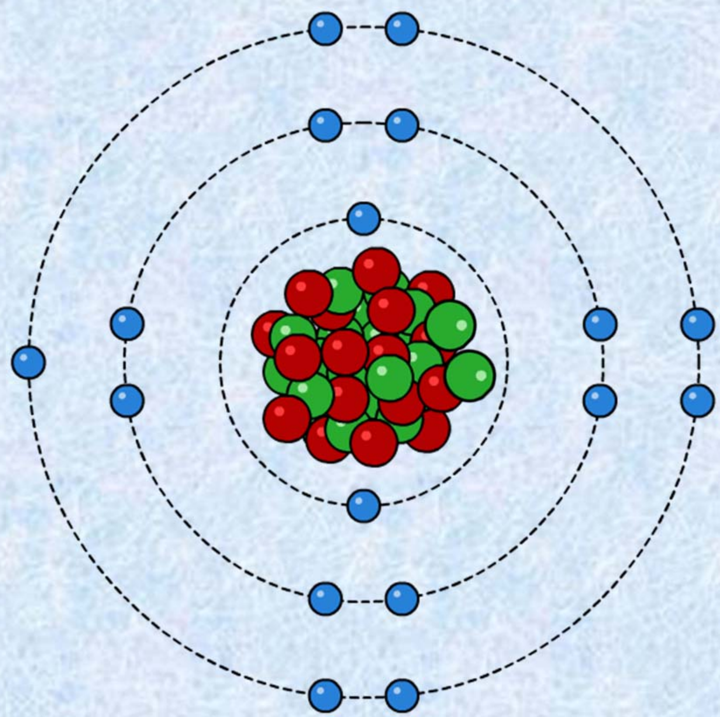
The different masses of the atoms means that physical properties of isotopes are slightly different.

Isotopes of chlorine

About 75% of naturally-occurring chlorine is chlorine-35 (^{35}Cl) and 25% is chlorine-37 (^{37}Cl).

35 **Cl** 17	17 protons 18 neutrons 17 electrons	37 **Cl** 17	17 protons 20 neutrons 17 electrons





Isotopes of carbon

There is also more than one isotope of carbon:

Isotope	Protons	Neutrons
^{12}C	6	6
^{13}C	6	7
^{14}C	6	8

All isotopes of carbon have 6 protons and so have 6 electrons.

Because chemical reactivity depends on the number of electrons the reactivity of the isotopes of carbon is identical.

‘Weighing’ atoms

Mass spectrometry is an accurate instrumental technique used to determine the **relative isotopic mass** (mass of each individual isotope relative to carbon-12) and the relative abundance for each isotope. From this, the **relative atomic mass** of the element can be calculated.

Some uses of mass spectrometry include:

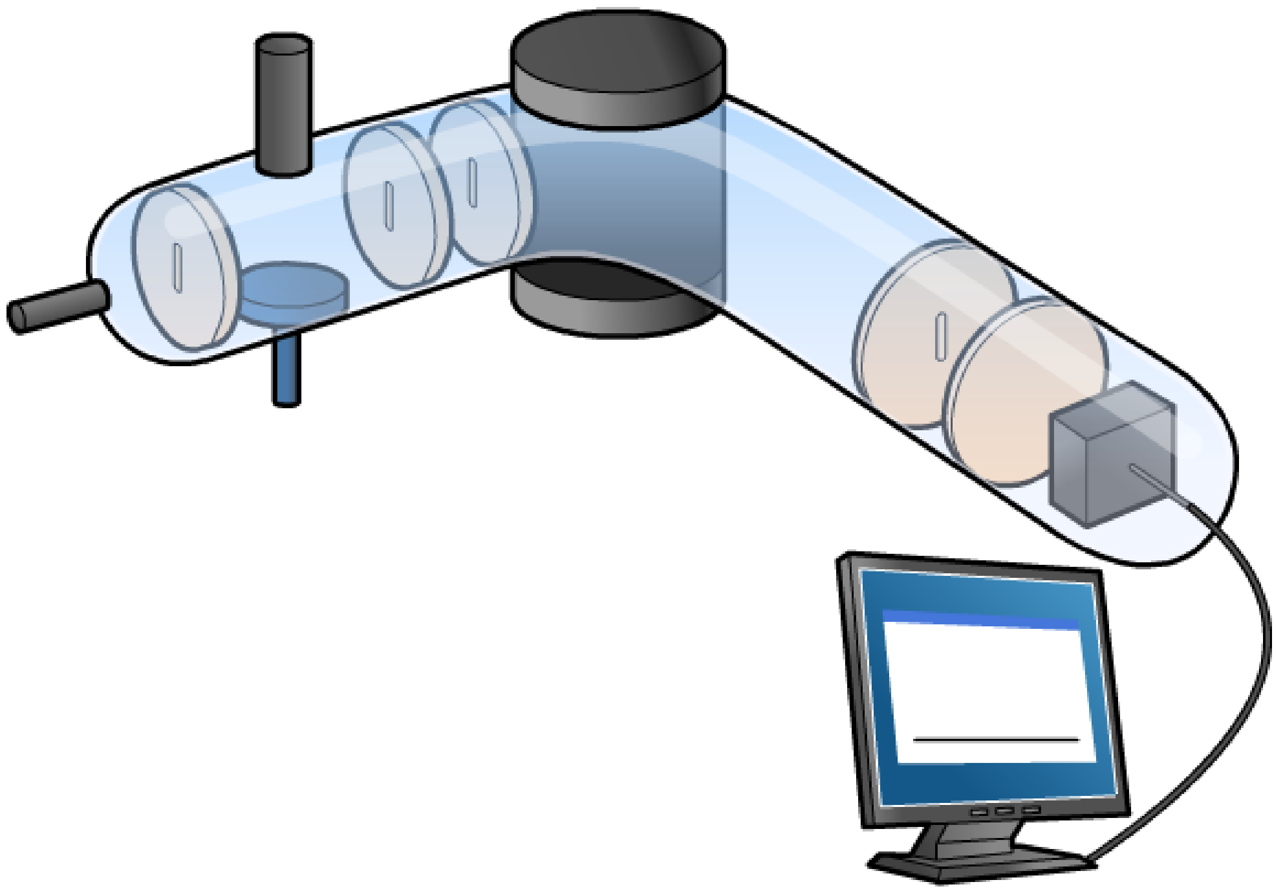
- carbon-14 dating
- detecting illegal drugs
- forensic science
- space exploration.

Mass spectrometry

How does a mass spectrometer work?

A mass spectrometer is used to determine the relative isotopic mass and the relative abundance for each isotope in a sample.

Click "**play**" to find out how it works.



Process of mass spectrometry

What is the order of the stages in mass spectrometry?

1. acceleration
2. deflection
3. detection
4. ionization
5. vaporization

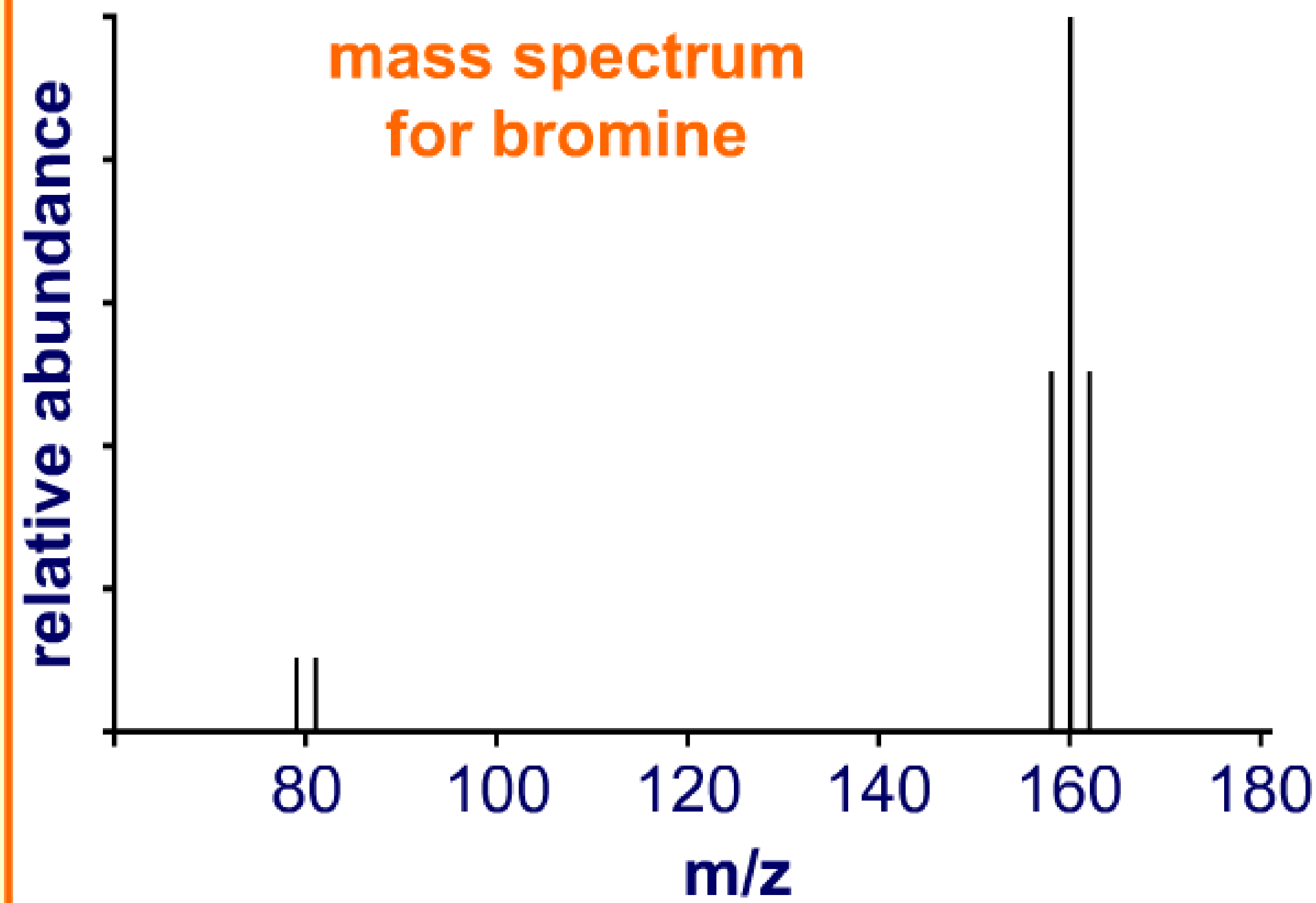
C S ?

Mass spectra of diatomic elements

Mass spectra of diatomic elements

Elements that exist as diatomic molecules have more complex mass spectra. For example, the spectrum for bromine contains five peaks.

Click "**play**" to find out why.



Process of mass spectrometry

Match these processes to a description of what happens

acceleration	ions strike a collector plate, causing a current to flow
detection	direction of ions is changed by electromagnetic field
ionization	an electron gun removes electrons from sample material
deflection	ions are attracted towards negatively-charged plates

What is relative atomic mass?

The **relative atomic mass** (A_r) of an element is the mass of one of its atoms relative to 1/12 the mass of one atom of carbon-12.

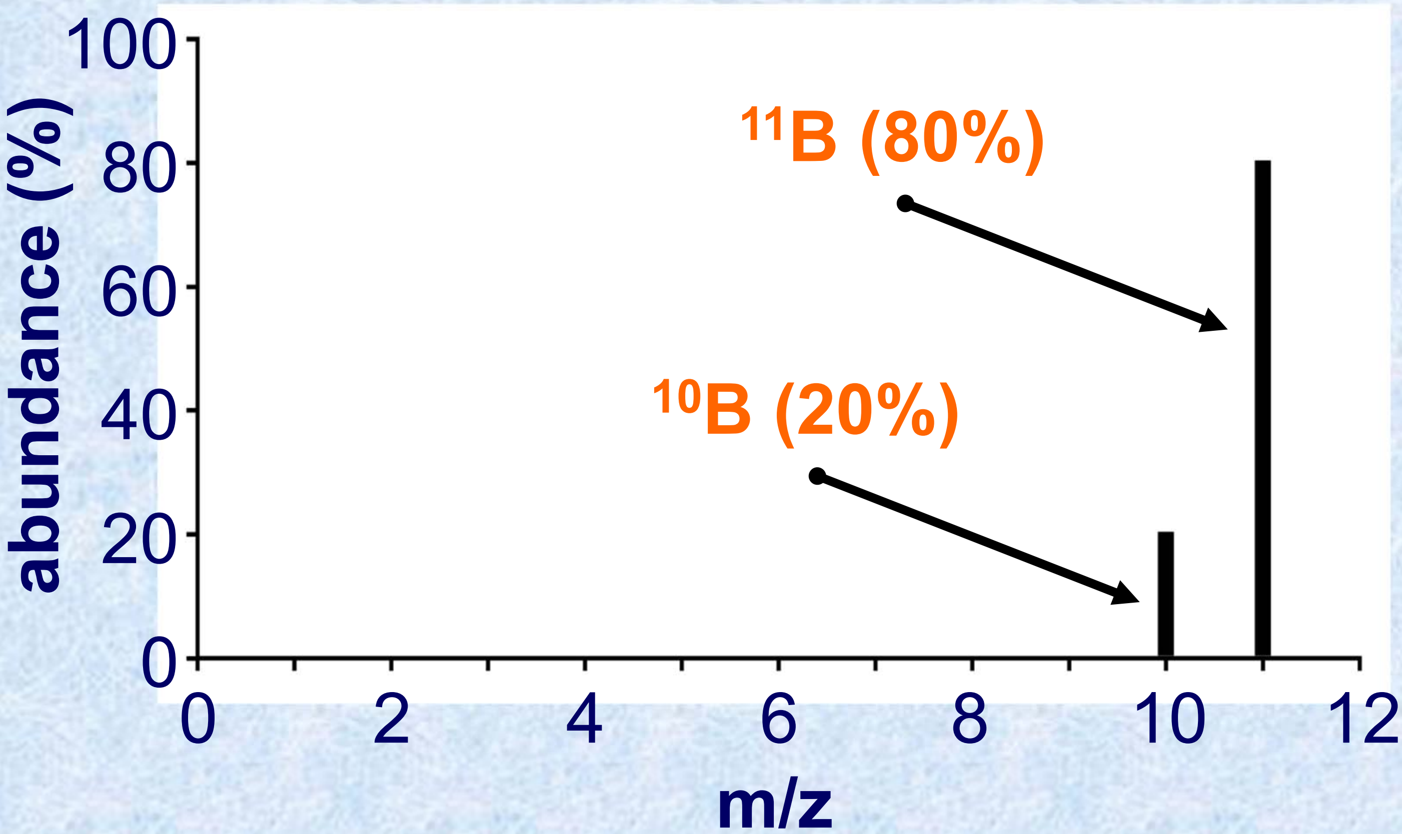
$$\text{relative atomic mass } (A_r) = \frac{\text{average mass of an atom} \times 12}{\text{mass of one atom of carbon-12}}$$

Most elements have more than one **isotope**. The A_r of the element is the average mass of the isotopes taking into account the abundance of each isotope. This is why the A_r of an element is frequently not a whole number.

16.0 O 8	19.0 F 9	20.2 Ne 10
32.1 P 16	35.5 Cl 17	39.9 Ar 18
79.0 Se 34	79.9 Br 35	83.8 Kr 36

Using mass spectra to calculate A_r

The mass spectrum of an element indicates the mass and abundance of each isotope present. For example, the mass spectrum of boron indicates two isotopes are present:



How can this be used to calculate the A_r of boron?

Calculating A_r

Most elements have more than one isotope. The relative atomic mass of the element is the average mass of the isotopes taking into account the abundance of each isotope.

Example: what is the A_r of boron?

In a sample of boron, 20% of the atoms are ^{10}Br and 80% are ^{11}Br.

If there are 100 atoms, then 20 atoms would be ^{10}Br and 80 atoms would be ^{11}Br.

The relative atomic mass is calculated as follows:

$$A_r \text{ of Br} = \frac{(20 \times 10) + (80 \times 11)}{100}$$

$$\mathbf{A_r \text{ of Br} = 10.8}$$