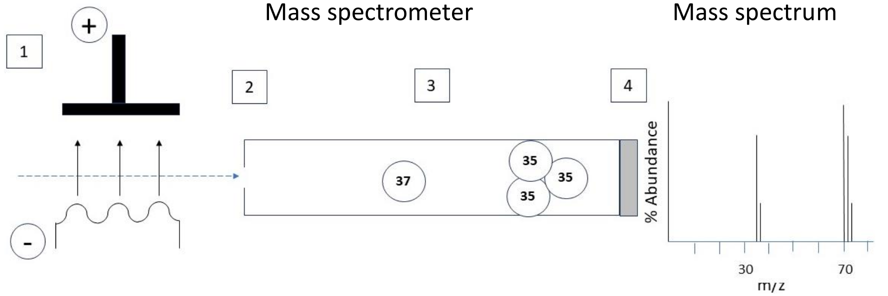
Atomic structure
3.1.1.1 Fundamental particles
3.1.1.2 Mass number and isotopes

3.1.1.1 Fundamental particles

The atom is made up of a very dense, small and positively charged nucleus surrounded by negatively charged electrons. The electrons occur at specific energy levels, the principal energy levels are known as shells. The nucleus has neutrons and positively charged protons having a relative mass of 1 whereas the mass of an electron is so small about 1/1836.

Mass spectrometer　　　Mass spectrum

1.Ionisation
2.Acceleration
3.Flight tube
4.Detection



1. Electrons are released by the electron gun knock electrons off particles to produce + ions.
2. A negative plate attracts and accelerates the positive ions so they all have the same energy.
3. + ions pass through flight tube, as they all have the same energy lighter isotopes move faster.
4. At the detector, which is negatively charged, the ions are discharged producing a current.

3.1.1.2 Mass number and isotopes

Atomic mass (mass number) is number of protons + neutrons
Atomic number (proton number) is the number of protons in nucleus

Isotopes are atoms of the same element having the same atomic number but different mass numbers due to the difference in the number of neutrons. Isotopes have the same chemical properties but different physical properties.

3.1.1.2 Mass number and isotopes

Isotopes can be written down using the following notation:
$^{A}_{Z}X$ where A is the atomic mass and Z represents the atomic number. **Examples:** isotopes of hydrogen

Name	Isotope	Number of neutrons
Protium	$^{1}_{1}H$	0
Deuterium	$^{2}_{1}H$	1
Tritium	$^{3}_{1}H$	2

There are two methods of ionisation:

- **Electrospray ionisation** used for large molecules, less likely to fragment molecule. Sample is dissolved in water or alcohol, passed through hyperdermic with needle at high voltage so particle gains a proton: $X_{(g)} + H^{+} \rightarrow XH^{+}{}_{(g)}$

- **Electron impact** is used for smaller molecules and will usually knock one electron per particle to produce positive ions: $X_{(g)} \rightarrow X^{+}{}_{(g)} + e^{-}$

Calculating relative atomic mass:

Abundance is the percentage of one isotope in a given sample of a mixture of isotopes.

$$\text{relative atomic mass } A_r = \frac{\text{combined mass of all isotopes}}{\text{combined abundance of all isotopes}}$$

Example: Calculate the RAM of silver which has the isotopes ^{107}Ag 51.88% and ^{109}Ag 48.12%.

$$A_r = \frac{107 \times 51.88 + 109 \times 48.12}{100} = 108$$

Exercise 1

1. State the meaning of the word isotope.
2. There are two methods of ionisation used in the mass spectrometer, these are electrospray ionisation and electron impact. For these methods state:
   a. one similarity
   b. one difference

Exercise 2

1. When particles are accelerated in the mass spectrometer why do different isotopes have different speeds in the flight tube?
2. Explain how a small current is produced when particles reach the detector in a mass spectrometer.
3. For the mass spectrum of chlorine shown above, what produces the peaks at:
   a) m/z 72
   b) m/z 74
4. Write down the formula for calculating relative atomic mass.
5. Calculate the relative atomic mass of the Boron isotopes $^{10.0}B$ and $^{11.0}B$ if their abundances are 19.8% and 80.2% respectively.
6. Calculate the relative atomic mass of Silicon having isotopes $^{28.0}Si$, $^{29.0}Si$ and $^{30.0}Si$ with relative abundances of 92.21%, 4.70% and 3.09% respectively.