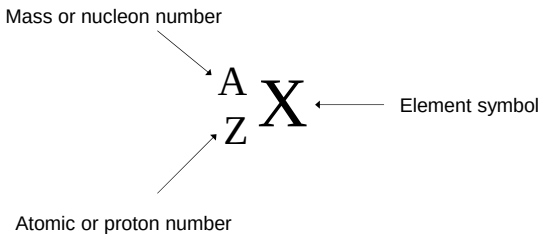
Nuclear Structure

Nucleons

- The particles in the nucleus of an atom
  - Protons and Neutrons

- The number of protons in a nucleus is denoted by Z
  - Atomic (or proton) number
- The total number of nucleons is denoted by A
  - Mass or nucleon number
- The number of neutrons is denoted by N
  - N=A-Z



A nucleus with a specific number of protons and neutrons is called a ***nuclide***

Examples

- ${}^{1}_{1}\mathrm{H}$ (hydrogen – 1 proton, 0 neutrons)
- ${}^{4}_{2}\mathrm{He}$ (helium – 2 protons, 2 neutrons)
- ${}^{210}_{82}\mathrm{Pb}$ (lead – 82 protons, 128 neutrons)
- ${}^{238}_{92}\mathrm{U}$ (uranium – 92 protons, 146 neutrons)

Isotopes

- Nuclei that have the same number of protons but a different number of neutrons
- Have identical chemical properties (all have same number of protons and thus electrons) but different physical properties
- The existence of isotopes is evidence for the existence of neutrons inside the nucleus

Examples

$^{1}_{1}H$ (hydrogen)

$^{2}_{1}H$ (deuterium)

$^{3}_{1}H$ (tritium)

$^{238}_{92}U$, $^{235}_{92}U$ (uranium)

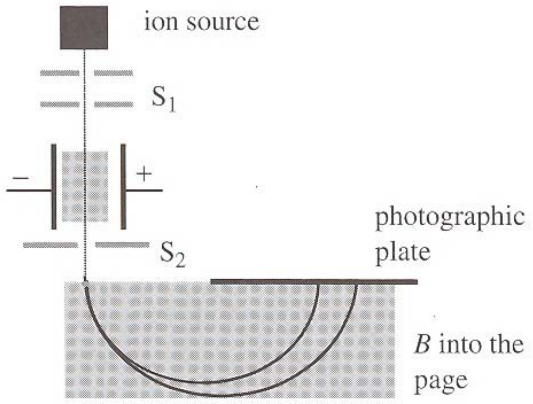
Note:

The nuclei of hydrogen, deuterium and tritium are called protons, deuterons, and tritons respectively

The Mass Spectrometer

- The existence of isotopes can be demonstrated with a mass spectrometer
- Singly ionized ions of an element move through a pair of slits (to collimate the beam) and enter a region of electric and magnetic fields at right angles to each other

- By choosing a suitable value for the magnetic field, ions of a specific velocity can pass through undeflected (the magnetic and electric forces are equal)
- Thus only ions of a specific velocity pass through a second slit
- This arrangement allows ions of a selected velocity to pass through
- The selected ions then enter a second region of magnetic field where they are thus deflected into a circular path, hitting a photographic plate where they are recorded



- The radius of the path is proportional to the mass of the ions

$$R = \frac{mv}{eB}$$

- If all of the ions have the same mass, they will all hit at the same point
- If isotopes are present, the heavier ions will hit the plate further to the right
- Measurements of the radius allow one to determine the mass