The Atom

Models of the Atom

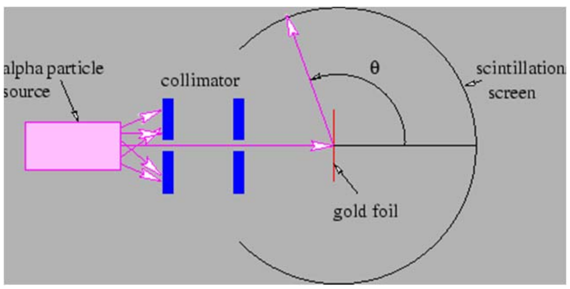
- Simple Model (Bohr)
  - A nucleus surrounded by orbiting electrons
  - The electrons are kept in orbit as a result of the electrostatic attraction between the electrons and the nucleus
- Quantum Model
  - A nucleus with electrons moving randomly in orbitals
  - The orbitals are described by wave functions

Difficulty with the Simple Model

- According to the theory of electromagnetism, an accelerated charge should radiate electromagnetic waves and thus lose energy
- Since the electrons are orbiting the nucleus, they have centripetal acceleration
- The electrons should then radiate and lose energy, thus spiraling into the nucleus in the order of nanoseconds
- The model cannot explain why matter is stable

The Geiger-Marsden Experiment

- Hans Geiger and Ernest Marsden working with Ernest Rutherford, measure the angular distribution of alpha particles (He nucleus) scattered from a thin gold foil
- The typical scattering should have been very small (around 0.01º)
- Most particles suffered only small deflections, but a small fraction scattered through large angles, some greater than 90º



Schematic of Geiger-Marsden experiment

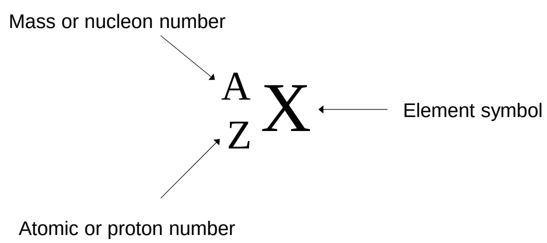
- Rutherford calculated theoretically the number of alpha particles expected at a particular scattering angle based on Coulomb's force law
- His results agreed with the experimental data if the positive atomic charge was confined to a region of linear size of approximately 10^{-15} m
- This and subsequent experiments confirmed the existence of a small massive positive nucleus inside the atom

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

Forces within the Nucleus

- Protons are positively charged and therefore the nucleus should blow apart due to the electromagnetic force between them
- However, atoms are stable (another force must be present)
  - The strong nuclear force

The Strong Nuclear Force

- An attractive force much stronger than the electromagnetic force if the separation between the particles is very small (10^{-15}m or less)