Nuclear Physics

1. Rutherford α-particle scattering experiment

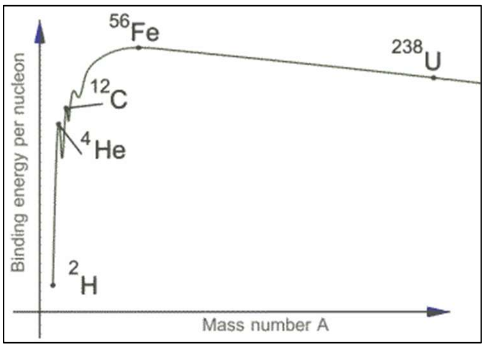
Results	Interpretation
Most scintillations are observed along the original path of the α-particles.	Much of the atom is made up of empty spaces.
Fewer scintillations are observed at an acute angle to the original path of the α-particles.	Some of the α-particles are repelled by positively charged objects.
Very rarely are scintillations observed at an angle larger than 90˚. Some are even reflected at 180˚.	Those positively charged objects are very massive compared with the α-particles.

2. Elements

- Nucleon = Proton + Neutron. In the notation ${}^{A}_{Z}X$, A is the mass (nucleon) number, Z is the proton (atomic) number, and X is the nuclide symbol.
- Isotopes are two forms of the same element having the same number of protons but different number of neutrons.

3. Mass defect and nuclear binding energy

- $\Delta E = \Delta mc^2$. Any change in the energy of a body implies a corresponding change in its inertial mass.
- A mass at rest has a corresponding energy called rest-mass energy.
- Mass defect is the difference between the sum of the rest-mass energy of the constituent nucleons of a particular nucleus and the mass of the nucleus itself.
- Binding energy is the amount of work needed to take all its constituent nucleons apart so that they are separated an infinite distance from one another.
- Mass of nucleus + Binding energy = Mass of all constituents of the nucleus. $\Delta m = \frac{E_b}{c^2}$.
- A nucleus with a higher binding energy per neucleon is more stable. Iron atom is the most stable.
- The rising part of the curve shows that elements with low mass number can combine to produce more stable nuclide, releasing energy in the process known as fusion; the other part shows that elements with high mass number can disintegrate to be more stable, known as fission.



- Fusion releases more energy than fission.
- Nuclides with big number are unstable and may decay spontaneously. They are radioactive.

4. Nuclear processes

- When there is a nuclear reaction, proton number, nucleon number, mass-energy and linear momentum are all conserved.
- Energy released, $E = (m_{reactant} - m_{product})c^2$.
- For nuclear reaction to occur, total rest-mass energy of reactants plus initial kinetic energy of reactants must be larger than total rest-mass energy of products.

5. Radioactive decay

- Radioactive decay is a process whereby an unstable 'parent' nucleus undergoes spontaneous disintegration to form a stable 'daughter' nucleus.
- 3 types of radiation are emitted: α-particles are helium neucleus with a charge of +2e, β-particles are electrons with a charge of -e; γ-ray is an electromagnetic radiation.
- The activity of a radioactive material is the rate of disintegrations of its atoms per unit time (i.e. $A = -\frac{dN}{dt}$). It is proportional to the number of atoms (i.e. $A = \lambda N$).
- The final number of atoms, $N = N_0 e^{-\lambda t}$.
- Half-life is the time taken for half the number of radioactive nuclei to decay.