

UNIT VIII

Atomic Nucleus

INTRODUCTION

In the 5th century B.C. the Greek philosophers Democritus and Leucippus proposed that matter was made up of tiny, indivisible particles in constant motion. Aristotle, however, did not accept the theory, and it was ignored for centuries. Modern atomic theory began with the publication in 1808 by John Dalton of his experimental conclusions that all atoms of an element have same size and weight, and that atoms of elements unite chemically in simple numerical ratios (as molecules) to form compounds. In 1911 Ernest Rutherford and his collaborators discovered that the atomic nucleus more than 99.9% of the atomic mass is concentrated in a tiny nucleus. Its size is only about 10^{-12} cm, i.e., 1000 times smaller than that of an atom. This discovery of the atomic nucleus marked the beginning of nuclear physics. It was soon realized that the atomic nucleus consists of two building blocks, protons and neutrons. The proton, the nucleus of the hydrogen atom, is the lightest atomic nucleus.

IMPORTANT FORMULAE

- ◇ Impact parameter,

$$b = \frac{1}{4\pi\epsilon_0} \frac{2Ze^2 \cot\left(\frac{\theta}{2}\right)}{mu^2}$$

- ◇ Distance of closest approach,

$$r_0 = \frac{1}{4\pi\epsilon_0} \frac{4Ze^2}{mu^2}$$

- ◇ Nuclear radius, $R = R_0 A^{1/3}$.

- ◇ Mass defect of nucleus,

$$\Delta m = (A - Z) m_e + Zm_p - M_{\text{nucleus}}$$

- ◇ Binding energy, $E_b = \Delta mc^2$

- ◇ Half life, $T_{1/2} = \frac{0.693}{\lambda}$

- ◇ Mean life, $T_{av} = \frac{1}{\lambda}$

- ◇ Activity, $A = \frac{dN}{dt} = -\lambda N$

- ◇ Decay law, $N = N_0 e^{-\lambda t}$

- ◇ Time for disintegration, $t = \frac{1}{\lambda} \log_e \left(\frac{N_0}{N} \right)$

- ◇ Amount of substance decayed is given by

$$N_0 - N = N_0 (1 - e^{-\lambda t})$$

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