NUCLEAR SIZE

Nuclear Radius:

Experiments show that majority of atomic nuclei are spherical or nearly so, in shape.

$\therefore \frac{4}{3}\pi R^3 \propto A$ (its Atomic mass)

or, $\boxed{R \propto A^{1/3}}$ where R is the radius of the nucleus

$\boxed{R = r_0 A^{1/3}}$

and $r_0 \Rightarrow$ a constant, called nuclear radius parameter

Ranges of $r_0 \Rightarrow (1.1 - 1.5) \times 10^{-15}$ m.

- $\boxed{\text{charge radius (Z=0)} \simeq \text{mass radius}}$

- $\frac{1}{2}mv^2 = \frac{2e \times Ze}{4\pi\epsilon_0 R}$

$\Rightarrow R = 2e^2 / \pi\epsilon_0 m v^2$

substituting $m = 6.64 \times 10^{-27}$ kg, $v = 10^7$ m/s

The value of R for Z = 20 is

$\simeq 1.5 \times 10^{-14}$ m.

For uniformly charged sphere of radius R, ρ = const. and $\rho = 0$ for $r > R$

$$\therefore R^2 = \frac{5}{3}\langle r^2 \rangle$$

Estimation of nuclear radius by two methods →

(i) the mirror nuclei method

(ii) the muonic X-ray method.

Nuclear Density — (ρ_N)

$$\rho_N = \frac{\text{Nuclear mass}}{\text{Nuclear volume}}$$

But the nuclear mass $M_N \simeq A m_N$, A = mass no. and m_N = the mass of the nucleon $\simeq 1.67 \times 10^{-27}$ kg

Nuclear Volume — (V_N) $= \frac{4}{3}\pi R^3 = \frac{4}{3}\pi (r_0 A^{1/3})^3$

$$= \frac{4}{3}\pi r_0^3 A$$

$$\therefore \rho_N = \frac{A m_N}{\frac{4}{3}\pi r_0^3 A} \simeq 1.816 \times 10^{17} \text{ kg/m}^3$$

⇒ Unusually Large No.

Monday 26th day

(Day 360-005) • Week 53

Notes Appointment Contacts

So, the nuclear matter is in a highly compressed state and the nuclear density is extreemely high being comparable to that of some stars like the white dwarfs.

- The atomic radius $= 10^4 \times$ nuclear radius, the atomic density, $\rho_A \simeq 2 \times 10^{17} / (10^4)^3$,
$\simeq 2 \times 10^5$ kg/m^3 which is much smaller compared to ρ_N.
The density of water $\rho_W = 10^3$ kg/m^3 which is much smaller compared to ρ_A.
- As the density of Nucleus is independent of A, its value is almost the same for all nuclei.

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