The nuclear size is generally expressed in terms of its diameter.

The diameter of nucleus is about $10^{-15}\ m$ (for lighter nuclei) to $10^{-14}\ m$ (for heavier nuclei).

In terms of diameter,

The size of a nucleus is 10^{-14} m.

The size of an atom is 10^{-10} m.

2. Nuclear density:

Density of nucleus is the ratio of mass of nucleus to its volume.

If 'm' is average mass of a nucleon and R is the nuclear radius, then mass of nucleus = mA

Where, A is the mass number of the element.

$$\text{Volume of nucleus} = \frac{4}{3}\pi R^3 = \frac{4}{3}\pi(R_0 A^{\frac{1}{3}})^3 = \frac{4}{3}\pi {R_0}^3 A$$

$$\text{So, density of nucleus} = \frac{mA}{\frac{4}{3}\pi {R_0}^3 A}$$

$$= \frac{3m}{4\pi {R_0}^3}$$

$$= \frac{3 \times 1.67 \times 10^{-27}}{4 \times 3.14 \times (1.3 \times 10^{-15})^3}$$

$$= 1.81 \times 10^{17}\ \text{Kg/m}^3$$

Note:

Actually $m_n > m_p$; by about 2%

But we can approximate their masses to be equal.

i.e. $m_n \approx m_p = m$

Here, m = mass of a nucleon

$$m = 1.67 \times 10^{-27} Kg$$

Hence, density of nucleus is same for all the elements, which is very large as compared to density of ordinary matter.

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3. Nuclear mass: It is the sum of masses of protons & neutrons present in a nucleus.

$$Nuclear\ mass = Zm_p + Nm_n \qquad (expected\ mass)$$

Where, $mn = mass\ of\ neutron$

m_p=mass of proton

Types of nuclei:

1. Isotopes:

Isotopes of an element are that atoms which have the same atomic number but different mass number.

Example: ${}_1H^1$, ${}_1H^2$, ${}_1H^3$ are isotopes of hydrogen,

${}_6C^{12}$, ${}_6C^{13}$, ${}_6C^{14}$ are the isotopes of carbon.

As isotopes of an element have the same atomic number, hence these have identical chemical properties, but due to different mass number their physical properties are different.

2. Isobars:

Isobars are the atoms of different elements which have the same mass number but different atomic number.

Example: ${}_{11}Na^{22}$ and ${}_{10}Ne^{22}$ are isobars,

${}_{20}Ca^{40}$ and ${}_{18}Ar^{40}$ are isobars etc.

The chemical properties of isobars are different due to different atomic number but their physical properties may be identical due to same mass number.

3. Isotones:

Isotones are the atoms of different elements which contain the same number of neutrons.

$[(A - Z) = N$ is the same]

Example: ${}_{17}Cl^{37}$ and ${}_{19}K^{39}$ are isotones,

Similarly, ${}_1H^3$ and ${}_2He^4$ are isotones.

4. Mirror nuclei: The nuclei having same mass number but proton and neutron number interchanged are called mirror nuclei. For example, ${}_4Be^7$ (Z=4, N=3) and ${}_3Li^7$ (Z=3, N=4). } *are mirror nuclei*

5. Isomers:

The nuclei having same atomic number & mass number but differ in their radioactive characters are called Isomer. These nuclei are distinguished by their life time.