

Nucleus and Nuclear Physics

Nuclear Physics:

The branch of physics dealing with the study of atomic nucleus is called nuclear physics. It studies about properties of nucleus, nuclear phenomena, interaction of nuclei, nuclear transmutation and their application.

Discovery of nucleus and its components:

- Henry Becquerel Discovered radioactivity from a uranium salt which provoked an idea of an atom having nucleus.
- Rutherford with his coworker discovered nucleus in his famous experiment of alpha particle scattering from a gold foil.
- Rutherford also discovered proton (when beam of alpha particle bombarded with air, hydrogen was detected).
- James Chadwick discovered neutron (when beryllium bombarded with alpha particle).

Constituent of nucleus:

All atomic nuclei are made up of elementary particles called protons and neutrons (except the nucleus of hydrogen which contain only one proton). **Proton and neutron are collectively called Nucleons.**

1. Proton:

It is a stable positively charged particle having rest mass $1.6726231 \times 10^{-27}$ kg and charge 1.6×10^{-19} C.

It is a fermion having spin $\frac{1}{2}$ and has small magnetic moment.

The charge of the nucleus is provided by the charge of proton.

2. Neutron:

Neutron in free state is unstable. It is a charge less particle having rest mass $1.6749286 \times 10^{-27}$ kg.

It is also a fermion having spin $\frac{1}{2}$ and has very small magnetic moment.

Atomic Number(Z):

It is the number of protons present in the nucleus of an atom of the element. It is represented by Z.

$$Z = \text{atomic number} = \text{number of Protons} = \text{Number of electrons}$$

Mass number(A):

It is the total number of protons and neutrons present in the atomic nucleus of the element. It is represented by A.

$$A = \text{Number of nucleons (neutron + protons)}$$

$$\text{Then, } A - Z = \text{Number of neutrons} = N$$

A nuclide is represented as ${}_Z X^A$, where X is the chemical symbol of the element.

Examples: ${}_6 C^{12}$, ${}_{79} Au^{197}$, ${}_{92} U^{238}$ etc.

GENERAL PROPERTIES OF NUCLEUS:

1. Nuclear size:

The shape of a nucleus is assumed to be spherical in shape.

If R is the radius of the nucleus, then its volume is:

$$V = \frac{4}{3} \pi R^3 \quad \dots \dots \dots (1)$$

Experimentally, it has been found that, $R \propto A^{1/3}$

$$\text{or } R = R_0 A^{1/3} \quad \dots \dots \dots (2)$$

Where, R_0 is a constant whose value is 1.3×10^{-15} m.

Using equation (2) in equation (1), we get

$$V = \frac{4}{3} \pi (R_0 A^{1/3})^3$$

$$V = \frac{4}{3} \pi R_0^3 A$$

$$\therefore V \propto A$$

As 'A' (mass number) is different for different elements (nucleus), therefore atomic nuclei of different elements have different sizes.