## 1(a). Basic Nuclear Properties-Introduction

An ordinary hydrogen atom has as its nucleus a single proton, whose charge is $+e$ and whose mass is 1836 times that of the electron. All other elements have nuclei that contain neutrons as well as protons. As its name suggests, the neutron is uncharged; its mass is slightly greater than that of the proton. Neutrons and protons are jointly called **nucleons**.

The **atomic number** of an element is the number of protons in each of its nuclei, which is the same as the number of electrons in a neutral atom of the element. Thus atomic number of hydrogen is 1, of helium 2, of lithium 3, and of uranium 92. All nuclei of a given element do not necessarily have equal numbers of neutrons. For instance, although over 99.9 percent of hydrogen nuclei are just single protons, a few also contain a neutron, and a very few two neutrons, along with the protons. The varieties of an element that differ in the numbers of neutrons their nuclei contain are called **isotopes**.

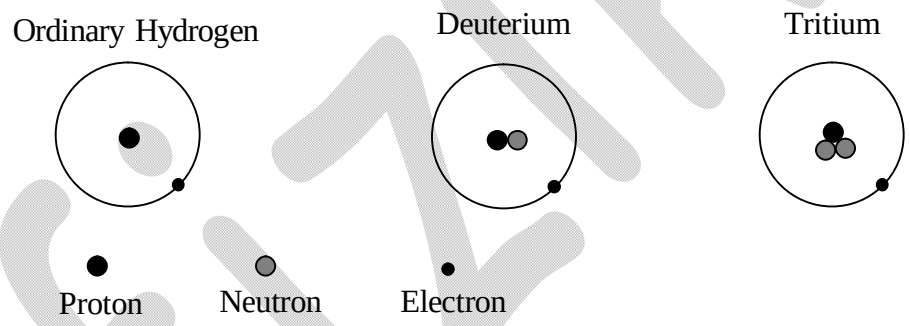


**Figure:** The isotope of hydrogen

The conventional symbols for nuclear species, or nuclides, follow the pattern ${}^{A}_{Z}X$, where

$X$ = Chemical symbol of the element

$Z$ = Atomic number of the element = Number of protons in the nucleus

$A$ = Mass number of the nuclide = Number of nucleons in the nucleus

**Nuclear Terminology**

- **Isotopes**

If two nuclei have same atomic number $Z$ (proton), then they are called as isotopes.

Example: ${}^{13}_{6}C$ & ${}^{14}_{6}C$, ${}^{16}_{8}O$ & ${}^{17}_{8}O$ and ${}^{1}_{1}H$, ${}^{2}_{1}H$, ${}^{3}_{1}H$

- **Isotones**

If two nuclei have same neutron number $N$ (proton), then they are called as isotones.

Example: ${}^{13}_{6}C$ and ${}^{14}_{7}N$

- **Isobars**

If two nuclei have same mass number $A$, then they are called as isobars.

Example: ${}^{14}_{6}C$ and ${}^{14}_{7}N$

- **Mirror nuclei**

Nuclei with same mass number $A$ but with proton and neutron number interchanged and their difference is $\pm 1$.

Example: ${}^{11}_{6}C$ & ${}^{11}_{5}B$ and ${}^{13}_{7}N$ & ${}^{13}_{6}C$

**Atomic masses:** Atomic masses refer to the masses of neutral atoms, not of bare nuclei. Thus an atomic mass always includes the masses of $Z$ electrons. Atomic masses are expressed in **mass units** ($u$), which are so defined that the mass of a ${}^{12}_{6}C$ atom is exactly $12u$. The value of mass unit is $1u = 1.66054 \times 10^{-27} kg \approx 931.4\, MeV$.

Some rest masses in various units are:

| **Particle** | **Mass(kg)** | **Mass($u$)** | **Mass($MeV/c^2$)** |
|---|---|---|---|
| Proton | $1.6726 \times 10^{-27}$ | 1.007276 | 938.28 |
| Neutron | $1.6750 \times 10^{-27}$ | 1.008665 | 939.57 |
| Electron | $9.1095 \times 10^{-31}$ | $5.486 \times 10^{-4}$ | 0.511 |
| ${}_{1}H^{1}$ | $1.6736 \times 10^{-27}$ | 1.007825 | 938.79 |