
CBSE Class-12 Physics Quick Revision Notes

Chapter-13: Nuclei

- **Atomic Number:**

The number of protons in the nucleus is called the atomic number. It is denoted by Z .

- **Mass number:**

The total number of protons and neutrons present in a nucleus is called the mass number of the element. It is denoted by A .

- **No. of Protons, Electrons, nucleons and Neutrons in an Atom:**

- a) Number of protons in an atom = Z
- b) Number of electrons in an atom = Z
- c) Number of nucleons in an atom = A
- d) Number of neutrons in an atom = $N = A - Z$.

- **Nuclear Mass:**

The total mass of the protons and neutrons present in a nucleus is called the nuclear mass.

- **Nuclide:**

A nuclide is a specific nucleus of an atom characterized by its atomic number Z and mass number A . It is represented as, ${}_Z\text{X}^A$

Where X = chemical symbol of the element, Z = atomic number and A = mass number

- **Isotopes:**

- a) The atoms of an element which have the same atomic number but different mass number are called isotopes.
- b) Isotopes have similar chemical properties but different physical properties.

- **Isobars:**

The atoms having the same mass number but different atomic number are called isobars.

- **Isotones:**

The nuclides having the same number of neutrons are called isotones.

- **Isomers:**

These are nuclei with same atomic number and same mass number but in different energy states.

- **Electron Volt:**

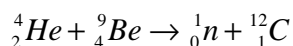
It is defined as the energy acquired by an electron when it is accelerated through a potential difference of 1 volt and is denoted by eV.

- **Atomic Mass Unit:**

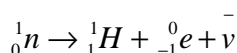
- a) It is $\frac{1}{12}$ th of the actual mass of a carbon atom of isotope ${}_6\text{C}^{12}$. It is denoted by amu or just by u.
- b) $1 \text{ amu} = 1.660565 \times 10^{-27} \text{ kg}$
- c) The energy equivalence of 1 amu is $1 \text{ amu} = 931 \text{ MeV}$

- **Discovery of Neutrons:**

- a) Neutrons were discovered by Chadwick in 1932.
- b) When beryllium nuclei are bombarded by alpha-particles, highly penetrating radiations are emitted, which consists of neutral particles, each having mass nearly that of a proton. These particles were called neutrons.



- c) A free neutron decays spontaneously, with a half-life of about 900 s, into a proton, electron and an antineutrino.



- **Size of the Nucleus:**

- a) It is found that a nucleus of mass number A has a radius

$$R = R_0 A^{1/3}$$

Where, $R_0 = 1.2 \times 10^{-15} \text{ m}$

- b) This implies that the volume of the nucleus, which is proportional to R^3 is proportional A.

- **Density of the Nucleus:**

Density of nucleus is constant; independent of A, for all nuclei and density of nuclear matter is approximately $2.3 \times 10^{17} \text{ kg m}^{-3}$ which is very large as compared to ordinary matter, say water which is 10^3 kg m^{-3} .

- **Mass-Energy equivalence:**

Einstein proved that it is necessary to treat mass as another form of energy. He gave the mass-energy equivalence relation as,

$$E = mc^2$$

Where m is the mass and c is the velocity of light in vacuum.

- **Mass Defect:**

The difference between the rest mass of a nucleus and the sum of the rest masses of its constituent nucleons is called its mass defect. It is given by,

$$\Delta m = [Zm_p + (A - Z)m_n] - m$$

- **Binding Energy:**

- a) It may be defined as the energy required to break a nucleus into its constituent protons and neutrons and to separate them to such a large distance that they may not interact with each other.
- b) It may also be defined as the surplus energy which the nucleus gives up by virtue of their attractions which they become bound together to form a nucleus.
- c) The binding energy of a nucleus ${}_Z X^A$ is,

$$B.E. = [Zm_p + (A - Z)m_n - m]c^2$$

- **Binding Energy per Nucleon:**

It is average energy required to extract one nucleon from the nucleus.

It is obtained by dividing the binding energy of a nucleus by its mass number.

$$\frac{B}{A} = \frac{B.E}{A} = \frac{[Zm_p + (A-Z)m_n - m]c^2}{A}$$

- **Nuclear Forces:**

- These are the strong attractive forces which hold protons and neutrons together in a tiny nucleus.
- These are short range forces which operate over very short distance of about 2 – 3 fm of separation between any two nucleons.
- The nuclear force does not depend on the charge of the nucleon.

- **Nuclear Density:**

The density of a nucleus is independent of the size of the nucleus and is given by,

$$\begin{aligned}\rho_v &= \frac{\text{Nuclear mass}}{\text{Nuclear volume}} \\ &= \frac{m_v}{\frac{4}{3}\pi R^2} = 2.9 \times 10^{17} \text{ kg m}^{-3}\end{aligned}$$

- **Radioactivity:**

- It is the phenomenon of spontaneous disintegration of the nucleus of an atom with the emission of one or more radiations like α -particles, β -particles or γ -rays.
- The substances which spontaneously emit penetrating radiation are called radioactive substances.

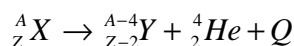
- **Radioactivity Displacement Law:**

It states that,

- When a radioactive nucleus emits an α -particle, atomic number decreases by 2 and mass number decreases by 4.
- When a radioactive nucleus emits β -particle, its atomic number increases by 1 but mass number remains same.
- The emission of a γ -particle does not change the mass number or the atomic number of the radioactive nucleus. The γ -particle emission by a radioactive nucleus lowers its energy state.

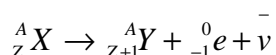
- **Alpha Decay:**

It is the process of emission of an α -particle from a radioactive nucleus. It may be represented as,



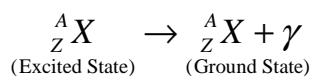
- **Beta Decay:**

It is the process of emission of an electron from a radioactive nucleus. It may be represented as,



- **Gamma Decay:**

It is the process of emission of a γ -ray photon during the radioactive disintegration of a nucleus. It can be represented as,



- **Radioactive Decay Law:**

It states that the number of nuclei disintegrated of undecayed radioactive nuclei present at that instant. It may be written as,

$$N(t) = N(0)e^{-\lambda t}$$

Where $N(0)$ is the number of nuclei at $t = 0$ and λ is disintegration constant.

- **Decay or disintegration Constant:**

It may be defined as the reciprocal or the time interval in which the number of active nuclei in a given radioactive sample reduces to 36.8% of its initial value.

- **Half-life:**

The half-life of a radioactive substance is the time in which one-half of its nuclei will disintegrate. It is inversely proportional to the decay constant of the radioactive substance.

$$T_{1/2} = \frac{0.693}{\lambda}$$

- **Mean Life:**

The mean-life of a radioactive sample is defined as the ratio of the combined age of all the atoms and the total number of atoms in the given sample. It is given by,

$$\tau = \frac{T_{1/2}}{0.693} = 1.44T_{1/2}$$

- **Rate of Decay or Activity of a Radioactive Sample:**

It is defined as the number of radioactive disintegrations taking place per second in a given sample. It is expressed as,

$$R(t) = \left[\frac{dN}{dt} \right] = \lambda N(t) = \lambda N(0)e^{-\lambda t}$$

- **Curie:**

- It is the SI unit of decay.
- One curie is the decay rate of 3.7×10^{10} disintegrations per second.

- **Rutherford:**

One Rutherford is the decay rate of 10^6 disintegrations per second.

- **Natural Radioactivity:**

It is the phenomenon of the spontaneous emission of α , β and γ radiations from the nuclei of naturally occurring isotopes.

- **Artificial or Induced Radioactivity:**

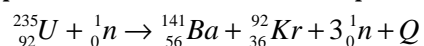
It is the phenomenon of inducing radioactivity in certain stable nuclei by bombarding them by suitable high energy sub atomic particles.

- **Nuclear Reaction:**

It is a reaction which involves the change of stable nuclei of one element into the nucleus of another element.

- **Nuclear Fission:**

It is the process in which a heavy nucleus when excited gets split into two smaller nuclei of nearly comparable masses. For example,



- **Nuclear Reactor:**

It is a device in which a nuclear chain reaction is initiated, maintained and controlled.

- **Nuclear Fusion:**

It is the process of fusion of two smaller nuclei into a heavier nucleus with the liberation of large amount of energy.

- **Critical size and Critical Mass:**

- a) The size of the fissionable material for which reproduction factor is unity is called critical size and its mass is called critical mass of the material.
- b) The chain reaction in this case remains steady or sustained.

- **Moderator:**

- a) Any substance which is used to slow down fast moving neutrons to thermal energies is called a moderator.
- b) The commonly used moderators are water, heavy water (D_2O) and graphite.