

CLASS 12

PHYSICS

REVISION NOTES

## Class 12 Physics Chapter 13 Nuclei – Revision Notes

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Quick revision notes for Class 12 Physics Chapter 13 – Nuclei, covering nuclear size and composition, mass defect and binding energy, the binding-energy-per-nucleon curve, and nuclear fission and fusion — ideal for last-minute board exam revision.

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Quick revision notes for **Class 12 Physics Chapter 13 – Nuclei**, covering nuclear size and composition, mass defect and binding energy, the binding-energy-per-nucleon curve, and nuclear fission and fusion — ideal for last-minute board exam revision.

## Composition and Size of the Nucleus

A nucleus contains **protons** (charge  $+e$ ) and **neutrons** (uncharged) — together called **nucleons**. The number of protons is the **atomic number  $Z$** ; the total number of nucleons is the **mass number  $A$** . Nuclei with the same  $Z$  but different  $A$  (i.e. a different number of neutrons) are called **isotopes**. The nuclear radius follows  **$R=R_0A^{1/3}$**  ( $R_0\approx 1.2\text{fm}$ ), so nuclear volume is proportional to  $A$  — which means **nuclear density is essentially the same for every nucleus**, regardless of size (NCERT Exercise 13.10).

## Mass Defect and Binding Energy

A nucleus's actual mass is always slightly *less* than the sum of the masses of its separate protons and neutrons; this shortfall is the **mass defect**,  $\Delta m = Zm_H + (A-Z)m_n - M$ . By Einstein's mass-energy relation, this missing mass corresponds to the nucleus's **binding energy**,  $BE = \Delta m \times c^2$ , conventionally computed as  $BE(\text{MeV}) = \Delta m(\text{u}) \times 931.5$ . Binding energy is the energy that would need to be supplied to completely separate a nucleus into free protons and neutrons.

## The Binding-Energy-per-Nucleon Curve

Plotting  $BE/A$  against mass number  $A$  gives a curve that rises steeply for light nuclei, peaks at about **8.7–8.8 MeV around  $A\approx 56$**  (the iron region — the most stable nuclei), and then declines slowly for heavier nuclei. This single curve explains why both **fusion of very light nuclei** and **fission of very heavy nuclei** release energy: both processes move the resulting nuclei toward the peak, increasing total binding energy, with the difference released as energy.

## Nuclear Fission

Fission is the splitting of a heavy nucleus (e.g. uranium-235, plutonium-239) into two lighter nuclei, usually triggered by neutron absorption, releasing a large amount of energy (typically  $\approx 180\text{--}200\text{MeV}$  per event) along with more free neutrons that can sustain a chain reaction. This is the basis of nuclear power plants. Not every split releases energy, though — splitting a nucleus already near the peak of the  $BE/A$  curve (like iron) requires energy rather than releasing it (NCERT Exercise 13.6).

## Nuclear Fusion and the Coulomb Barrier

Fusion is the combining of two light nuclei (e.g. isotopes of hydrogen) into a heavier one, releasing energy because the product moves closer to the  $BE/A$  peak. Because both nuclei are positively charged, they must overcome a repulsive **Coulomb barrier** (of order a few hundred keV for light nuclei) before the short-range attractive nuclear force can bind them — which is why fusion requires extremely high temperatures (as in the Sun's core) and remains difficult to sustain in a controlled way on Earth.

## One-Line Summary

Chapter 13 explains nuclear structure and the mass-energy relationship behind binding energy, and uses the binding-energy-per-nucleon curve to show why splitting heavy nuclei (fission) and combining light nuclei (fusion) are the two processes that release nuclear energy.

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