

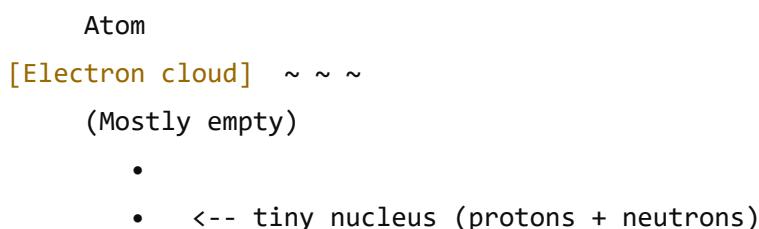
Class 12 Physics – Nuclei Study Guide

1. Theory in Simple Words with Visuals

1.1 What is a Nucleus?

- The nucleus is the **tiny, dense core of an atom**, containing **protons and neutrons**.
- It carries **positive charge** (from protons) and almost all **mass of the atom**.
- Imagine it as a **cherry inside a big watermelon** (the cherry = nucleus, watermelon = atom).

Visual:



1.2 Composition of Nucleus

Particle	Symbol	Charge	Mass (u)	Location
Proton	p^+	+1	1.007	Nucleus
Neutron	n^0	0	1.009	Nucleus
Electron	e^-	-1	0.0005	Outside

- **Mass number (A):** Total number of protons + neutrons
- **Atomic number (Z):** Number of protons
- **Number of neutrons (N):** $N = A - Z$

1.3 Nuclear Forces

- Strong force binds protons and neutrons together.
- Short-range but very strong.
- Analogy: **glue holding protons and neutrons tightly in the nucleus.**

1.4 Mass Defect & Binding Energy

- **Mass Defect (Δm):** Nucleus mass < sum of individual nucleons' masses.

- Why? Mass converts into **binding energy** ($E = mc^2$) that holds the nucleus together.

Formula:

$$\text{Binding Energy (BE)} = \Delta m \cdot c^2$$

Example Analogy:

- Like losing a tiny bit of weight when ingredients combine into a cake → energy released as heat (binding energy).
-

1.5 Nuclear Reactions

- **Radioactive decay:** Nucleus emits particles to become stable.
 - α -decay: emits helium nucleus
 - β -decay: neutron → proton + electron
 - γ -decay: emits gamma radiation
- **Fission:** Splitting of heavy nucleus → energy
- **Fusion:** Combining light nuclei → energy

Visual Table:

Reaction Type	Example	Energy Released?
α -decay	$\text{U-238} \rightarrow \text{Th-234} + \alpha$	Yes
β -decay	$\text{C-14} \rightarrow \text{N-14} + \beta^-$	Yes
γ -decay	$\text{Co-60} \rightarrow \text{Co-60} + \gamma$	Yes
Fission	$\text{U-235} + n \rightarrow \text{Ba} + \text{Kr} + 3n$	Huge
Fusion	$\text{H} + \text{H} \rightarrow \text{He} + \text{energy}$	Huge

1.6 Radioactivity

- Random, spontaneous process.
- Half-life ($T_{1/2}$): Time for half the nuclei to decay.

$$N = N_0 \left(\frac{1}{2}\right)^{t/T_{1/2}}$$

Mnemonic for decay types:

"Alpha Bears Grow Fast" → α , β , γ , fission.

2. Key Concepts & Formulas

Concept	Formula / Note
Mass number	$A = Z + N$
Binding energy	$BE = \Delta mc^2$
Mass defect	$\Delta m = Zm_p + Nm_n - m_{\text{nucleus}}$
Radioactive decay	$N = N_0 e^{-\lambda t}$
Half-life	$T_{1/2} = \frac{0.693}{\lambda}$
Activity	$A = \lambda N$
Energy-mass	$E = mc^2$
Fission energy	~200 MeV per U-235 nucleus

Mnemonic for BE calculation:

"Nuclear Cake Mass Lost Equals Sweet Energy" → Nucleus → Δm → $E=\Delta mc^2$.

3. Solved Numerical Problems

3.1 Example 1: Mass Defect

Problem: Mass of He-4 nucleus = 4.0026 u. Mass of proton = 1.0073 u, neutron = 1.0087 u. Find mass defect & BE.

Solution:

1. Total mass of nucleons:

$$2 \times 1.0073 + 2 \times 1.0087 = 4.0320 \text{ u}$$

2. Mass defect:

$$\Delta m = 4.0320 - 4.0026 = 0.0294 \text{ u}$$

3. Convert u → kg: $1u = 1.6605 \times 10^{-27} \text{ kg}$

4. $BE = \Delta m c^2$

$$= 0.0294 \times 1.6605 \times 10^{-27} \times (3 \times 10^8)^2 \approx 4.4 \times 10^{-12} \text{ J}$$

Tip: Always subtract nucleus mass from sum of nucleons (easy mistake: reversed).

3.2 Example 2: Half-Life

Problem: Half-life of a radioactive isotope = 10 days. Initial sample = 80 g. Find mass after 30 days.

Solution:

1. n half-lives = $30/10 = 3$

2. Remaining mass: $80 \times (1/2)^3 = 80/8 = 10$ g

Shortcut: Use powers of 2 → very fast in exams.

4. Previous Years' Board Questions (2013–2023)

Recurring Patterns:

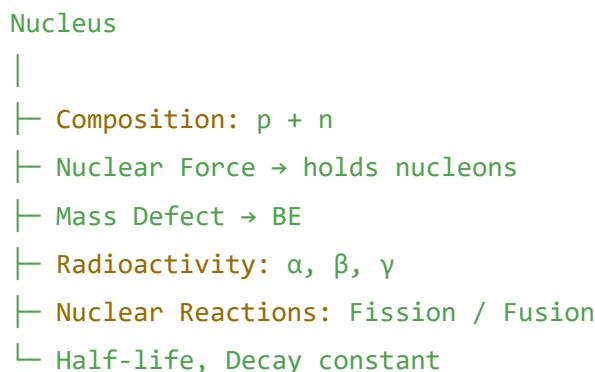
- Mass defect & binding energy calculations
- Half-life & decay constant numericals
- Fission and fusion questions
- Short definitions: nuclear force, mass number, atomic number

Sample Q:

1. Define binding energy. Find BE for He-4.
 2. Half-life of isotope = 5 h, sample = 80 g. Find remaining mass after 15 h.
 3. Draw and explain α , β , γ decay.
-

5. Quick Revision Notes / Important Points

Visual Memory Map:



Key Points:

- Most mass is in nucleus, most volume is empty space
 - Mass defect → BE
 - Fission = splitting, Fusion = joining
 - Half-life formula = $t_{1/2} = 0.693/\lambda$
-

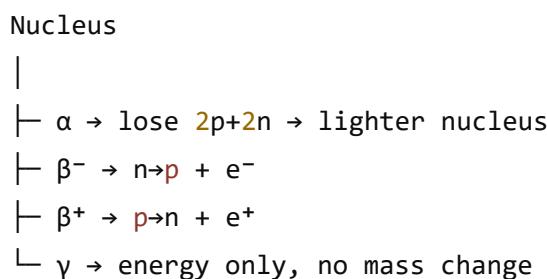
6. Predicted / Likely Questions

- BE & mass defect problems (very frequent)
- Half-life and decay numericals
- Short questions on nuclear reactions
- Diagram: α , β , γ decay paths
- Board loves 1-mark and 2-mark definitions: nuclear force, nucleons, mass number

7. Exam Tips & Tricks

- **Shortcuts:**
 - Powers of 2 for half-life
 - Keep Δm in u, convert at the last step
- **Common mistakes:**
 - Swapping A and Z
 - Forgetting to multiply by c^2
- **Time-saving:**
 - Use tables for decay constants & half-life
 - Draw mini diagrams for decay chains

Flowchart for decay types:



8. Visual & Kid-Friendly Learning Style

- Think of **nucleus** as a tiny jam-packed cherry in a watermelon
- Mass defect → tiny “weight lost in cake mixture”
- Fission → splitting firecracker, Fusion → sun fusion
- Use **colors**: red = protons, blue = neutrons, yellow = electrons

Mental Trick:

- “Protons make it positive, Neutrons neutral, Electrons orbit happily outside”