

CLASS 12

PHYSICS

EXTRA QUESTIONS

Class 12 Physics Chapter 13 Nuclei – Extra Questions with Answers

These extra practice questions for Class 12 Physics Chapter 13 – Nuclei go beyond the NCERT textbook exercises to reinforce nuclear size and density, mass defect and binding energy, the binding-energy-per-nucleon curve, and nuclear fission and fusion. Useful for board exam revision and quick concept checks.

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Very Short Answer Type Questions (1 Mark)

Q1. Define mass defect.

Ans: Mass defect is the difference between the sum of the masses of the free (separated) protons and neutrons that make up a nucleus and the actual measured mass of that nucleus. It arises because some of the mass is converted into the nucleus's binding energy.

Q2. In what unit is nuclear binding energy usually expressed, and why?

Ans: In **MeV (mega electron-volt)**, because the energies involved at the nuclear scale (of order 1–10 MeV per nucleon) are far too small to conveniently express in joules; 1 u of mass defect corresponds to 931.5 MeV of energy.

Q3. What does the binding-energy-per-nucleon curve show about nuclear stability?

Ans: BE/nucleon rises sharply for light nuclei, peaks at about 8.7–8.8 MeV for nuclei near mass number $A \approx 56$ (iron region), and then falls off slowly for heavier nuclei. Nuclei near the peak are the most stable; this is why fusing very light nuclei or fissioning very heavy nuclei both move a nucleus toward the peak and release energy.

Q4. Name the two types of nuclear reactions that release energy, and state which kind of nuclei undergo each.

Ans: **Nuclear fission** (heavy nuclei splitting into lighter ones) and **nuclear fusion** (light nuclei combining into a heavier one). Both release energy because they move the resulting nucleus or nuclei closer to the peak of the binding-energy-per-nucleon curve.

Short Answer Type Questions (2–3 Marks)

Q5. Explain why the fission of very heavy nuclei releases energy, while the fission of a mid-mass nucleus like iron does not.

Ans: Heavy nuclei (like uranium, $A \approx 235$ – 238) sit on the falling right-hand side of the binding-energy-per-nucleon curve, well below the peak near $A \approx 56$; splitting them into two mid-mass fragments moves both fragments toward the peak, increasing total binding energy and releasing the difference as energy. Iron already sits near the peak, so splitting it moves its fragments to a *lower* binding energy per nucleon, which would require energy to be supplied rather than releasing any — exactly what NCERT Exercise 13.6 demonstrates with a negative Q-value.

Q6. State two key differences between nuclear fission and nuclear fusion.

Ans: (1) Fission splits one heavy nucleus into two (or more) lighter nuclei, while fusion combines two light nuclei into one heavier nucleus. (2) Fission can proceed at room temperature once initiated (e.g. by a neutron), and is the basis of nuclear power plants and fission weapons; fusion requires extremely high temperatures (tens of millions of kelvin) to give nuclei enough kinetic energy to overcome their mutual Coulomb repulsion, and currently powers the Sun and stars but is not yet a viable large-scale power source on Earth.

Q7. Why does nuclear fusion require such high temperatures, even though the reaction ultimately releases energy?

Ans: Even though fusion is energetically favourable overall, the two positively charged nuclei must first get

close enough (a few femtometres) for the short-range attractive nuclear force to take over, and doing so means pushing through their mutual Coulomb (electrostatic) repulsion — a potential barrier of order a few hundred keV to about 1 MeV for light nuclei (as found for two deuterons in NCERT Exercise 13.9). Only at extremely high temperatures do a large enough fraction of nuclei have sufficient kinetic energy to overcome or quantum-mechanically tunnel through this barrier.

Higher Order Thinking Skills (HOTS)

Q8. Calculate the binding energy per nucleon of a helium-4 (α -particle) nucleus, given its atomic mass is 4.002603u. Compare it qualitatively with iron-56's binding energy per nucleon (≈ 8.79 MeV, from NCERT Exercise 13.2) and comment on what this implies for fusion reactions that produce helium.

Ans: For He-4 ($Z=2$, $A=4$): mass defect $= (2 \times 1.007825 + 2 \times 1.008665) - 4.002603 = 0.030377$ u.
 $BE = 0.030377 \times 931.5 \approx 28.30$ MeV, so **BE/nucleon ≈ 7.07 MeV**. This is noticeably lower than iron-56's ≈ 8.79 MeV/nucleon, confirming that helium-4 sits well below the peak of the binding-energy curve. Consequently, fusing lighter nuclei (like hydrogen isotopes) into helium releases a large amount of energy per reaction, since the fusion products move substantially closer to the peak — which is exactly why hydrogen-to-helium fusion is such an efficient energy source in stars.

Q9. Two students argue about whether it would be easier to release nuclear energy by fissioning a light nucleus like carbon-12 or by fissioning a heavy nucleus like uranium-238. Using the shape of the binding-energy-per-nucleon curve, explain which student is correct and why.

Ans: The student who says **uranium-238 is the easier and more useful choice is correct**. Carbon-12 already lies on the steeply rising, low- A side of the binding-energy-per-nucleon curve, far below the peak; splitting it would move its fragments to *even lower* binding energy per nucleon (just as splitting iron-56 does in NCERT Exercise 13.6), so fission of light nuclei is energetically unfavourable and does not occur spontaneously or usefully. Uranium-238, on the falling high- A side of the curve, is well below the peak in the opposite direction; splitting it into two mid-mass fragments moves them toward the peak, releasing a large amount of energy — which is precisely why only heavy nuclei are used in fission reactors and weapons, never light ones.

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