Fission

International Baccalaureate · IB Diploma · Physics · HL

Scope and prerequisites

This handout covers selected HL topics for the course first assessed in 2025; it is not the whole syllabus.

Prerequisites: read the stated quantities and units, and use arithmetic and the model conditions below.

The examples are original and fictional: they are not real measurements or real student investigations.

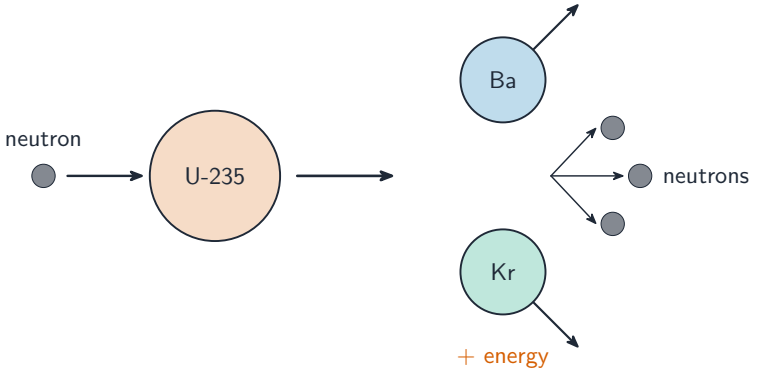
Fission : conserve charge and nucleons, account for energy

What would explain this observation?

- A neutron can trigger a heavy nucleus to split, releasing energy and further neutrons. Whether the process becomes a **chain reaction** depends on what happens to those neutrons.

Build the model

- In nuclear **fission** a heavy nucleus splits into lighter nuclei.
- Proton number and nucleon number balance in a nuclear equation.
- The total rest mass can decrease; the difference corresponds to released energy through $E = \Delta mc^2$.
- fission: Splitting of a heavy nucleus into lighter nuclei.
- chain reaction: A sequence in which products initiate further events.



Neutron in, two fragments and two or three neutrons out, with energy released

Choose evidence that can test it

- Separate conservation of nucleon number from conservation of total energy.
- Released neutrons may initiate further fissions, escape or be absorbed.
- A controlled reactor and an uncontrolled chain reaction have different neutron-management conditions.

In the lab: Balance a supplied nuclear equation, use the specified mass data and identify the system. Analyse models or published reactor data; this is not a school attempt to produce fission or handle reactor materials.

Work from known quantities

- Known: U-235 absorbs one neutron, forming Ba-141, Kr-92 and three neutrons.
- Nucleon balance: 235+1 = 141+92+3 = 236.
- Proton balance: 92 = 56+36.
- A mass decrease of 2.0×10^{-28} kg corresponds to 1.8×10^{-11} J using c=3.0×10^{8} m/s.

Your turn: A U-235 nucleus plus one neutron produces fragments with mass numbers 141 and 92. How many neutrons balance the equation?

Check the conclusion and its limits

- Mass number is not a precise mass in kilograms.
- Balanced integer labels alone do not calculate the released energy.
- Radioactive decay and neutron-induced fission are not interchangeable descriptions.

Not true: A balanced nucleon-number equation alone gives the energy release in joules. Integer mass and charge labels only check conservation; they say nothing about energy. The released energy comes from the small decrease in actual MASS via E = mc^2, which needs measured masses, not mass numbers.

Key:

- In nuclear fission a heavy nucleus splits into lighter nuclei.
- Separate conservation of nucleon number from conservation of total energy.
- Watch for: mass number is not a precise mass in kilograms.

Write from 4 balancing neutrons

- A U-235 nucleus plus one neutron produces fragments with mass numbers 137 and 95.
- Find how many neutrons balance the nucleon number. That count is not the energy release in joules.

Write from a conserved check

- U-235 absorbs a neutron: Xe-140 + Sr-94 + two neutrons.
- Nucleons: 236 = 140 + 94 + 2. Protons: 92 = 54 + 38. BOTH balances must hold – if either fails, the equation is wrong.

Write from a mass-defect direction

- Fission products are weighed against the reactants.
- The products weigh LESS: the missing mass appears as energy through $E = \Delta mc^2$, because binding energy per nucleon rises toward iron.