

15 The nucleus - fission, fusion, and decay – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary

*Write each word three times.***English****Write it 3 times** (English)

nucleus

Fission

Fusion

radioactive decay

alpha

beta

gamma

half-life

Recall

You already know some nuclear physics:

- Atoms have a tiny, dense **nucleus** of protons and neutrons.
- Some atoms are **radioactive** and give off radiation.
- Nuclear power and the Sun both release huge amounts of energy.

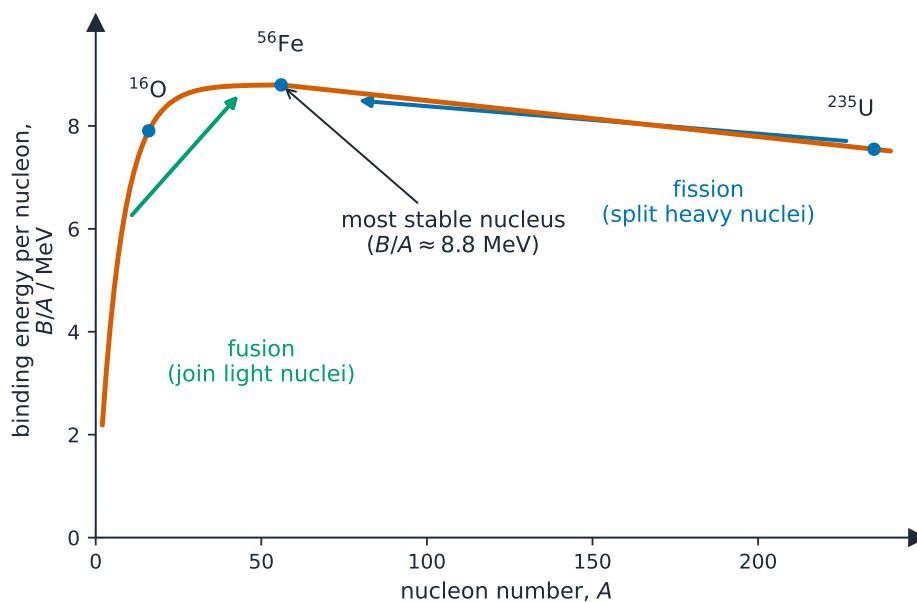
This sheet explains where that energy comes from. Each idea has a worked example.

New ideas

■ 1 Energy from the nucleus

The **nucleus** stores enormous energy. Two processes release it:

- **Fission** splits a heavy nucleus into lighter pieces (nuclear reactors).
- **Fusion** joins light nuclei into a heavier one (the Sun).



■ 2 Mass becomes energy

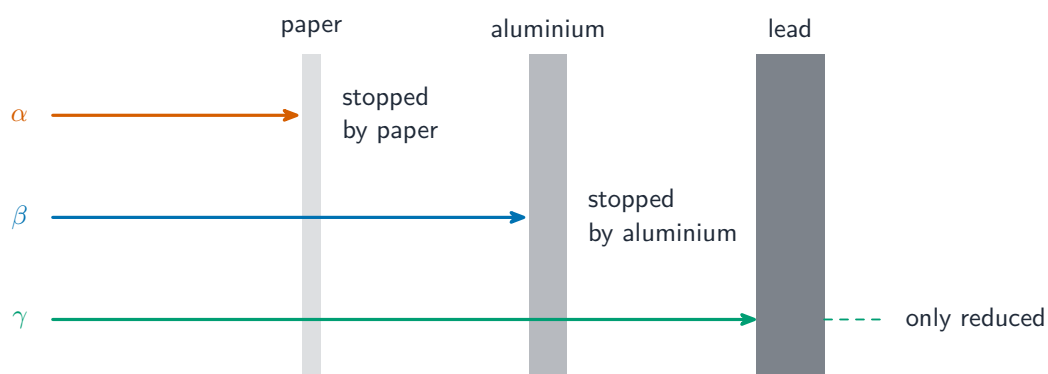
Both release energy because the products have slightly **less mass** than the starting materials, converted by Einstein's equation

$$E = mc^2.$$

Worked example. If a reaction loses 1.0×10^{-3} kg of mass, it releases $E = mc^2 = 1.0 \times 10^{-3} \times (3.0 \times 10^8)^2 = 9.0 \times 10^{13}$ J – a tiny mass, an enormous energy.

■ 3 Radioactive decay

Unstable nuclei undergo **radioactive decay**, emitting three kinds of radiation:



- **alpha** – a helium nucleus (stopped by paper),
- **beta** – a fast electron (stopped by aluminium),
- **gamma** – a high-energy photon (needs thick lead).

■ 4 Half-life

Decay is random, but a sample halves every **half-life** : after each half-life, half of the remaining nuclei have decayed.

Worked example. A sample has a half-life of 8.0 days. After 24 days that is $24/8.0 = 3$ half-lives, so the fraction left is $(\frac{1}{2})^3 = \frac{1}{8}$ (about 12.5%).

Watch out: in every decay, the total **mass number** and total **charge** are conserved – use this to balance a decay equation and find the new nucleus.

Practice

Try these in order. The methods are all above.

2.1 State the difference between nuclear fission and nuclear fusion. [2]

2.2 A nuclear reaction loses 2.0×10^{-4} kg of mass. Find the energy released ($c = 3.0 \times 10^8$ m/s). [3]

2.3 Name the three types of radioactive decay, in order of increasing penetrating power. [2]

2.4 A sample has a half-life of 5.0 years. What fraction remains after 15 years? [3]

2.5 State the two quantities that are always conserved in a radioactive decay. [1]
