

Nuclear fission

4.4.4.1 · Atomic structure · revision notes

Nuclear fission is the splitting of a large, unstable nucleus such as uranium-235 or plutonium-239. You need to describe what happens in fission, explain how a chain reaction happens and how it is controlled in a nuclear reactor, and draw or interpret fission diagrams. GCSE Physics only, not in Combined Science.

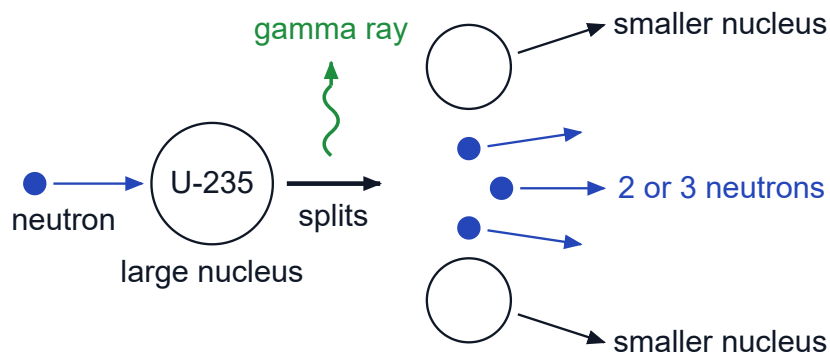
Key facts

- Fission: a large, unstable nucleus splits into two smaller nuclei
- Usually starts when the nucleus absorbs a neutron; spontaneous fission is rare
- Chain reaction: the released neutrons cause further fissions
- Nuclear weapon: uncontrolled chain reaction
- Fuels: uranium-235 and plutonium-239
- Products: 2 smaller nuclei + 2 or 3 neutrons + gamma rays, all with kinetic energy
- Nuclear reactor: controlled chain reaction (control rods absorb neutrons)

Notes

What happens in fission

- **Nuclear fission** is the splitting of a large and unstable nucleus, such as uranium or plutonium.
- Spontaneous fission (splitting without a trigger) is rare. Usually the nucleus must first **absorb a neutron**.
- The nucleus then splits into **two smaller nuclei**, roughly equal in size, and emits **two or three neutrons** and **gamma rays**.

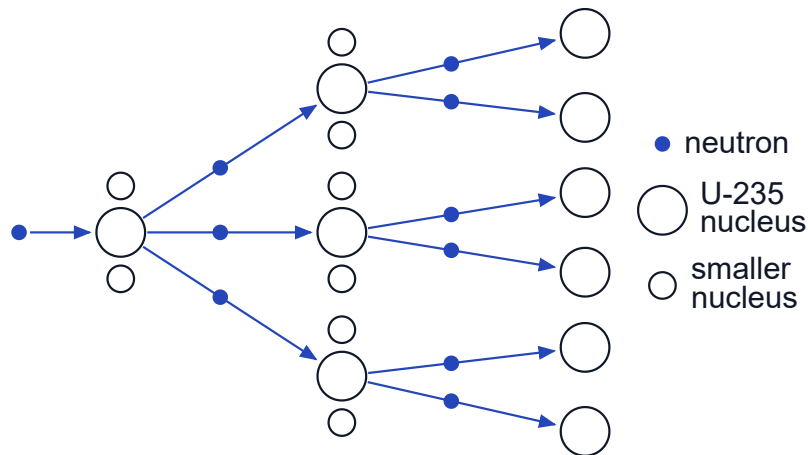


Fission of uranium-235. All the products move off fast: they have kinetic energy.

- Energy is released. All of the fission products have **kinetic energy**.

Chain reactions

- The neutrons released can be absorbed by other uranium or plutonium nuclei, which then split too. This is a **chain reaction**.
- Each fission releases 2 or 3 neutrons, so without control the number of fissions grows very quickly.
- In a diagram, show a neutron being absorbed by a large nucleus, the nucleus splitting into two smaller nuclei, and 2 or 3 neutrons coming out, each going on to a new large nucleus.



A chain reaction: each fission releases neutrons that cause more fissions.

Controlled and uncontrolled chain reactions

- In a **nuclear reactor** the chain reaction is **controlled**, to control the energy released.
- **Control rods** absorb some of the neutrons. Lowering them further into the reactor slows the reaction; raising them speeds it up.
- For a steady rate, on average one neutron from each fission goes on to cause another fission.
- The energy released is used to heat water to make steam, which turns turbines to generate electricity.
- The explosion of a **nuclear weapon** is caused by an **uncontrolled** chain reaction.

How to answer each type of question

Describe the process of fission

3 to 4 marks

Grade 5

1. Start with the nucleus absorbing a neutron.
2. Say what it splits into.
3. Say what else is emitted and that energy is released.

Example. Describe what happens when a uranium-235 nucleus undergoes fission.

Model answer. The nucleus absorbs a neutron (1). It splits into two smaller nuclei of roughly equal size (1). Two or three neutrons are released, along with gamma rays (1). Energy is released / the products have kinetic energy (1).

Don't lose marks

- ✗ Saying fission starts with the nucleus absorbing a proton or an alpha particle. It absorbs a neutron.
- ✗ Saying the nucleus splits into lots of pieces, or into protons and neutrons. It splits into two smaller nuclei, plus 2 or 3 neutrons.
- ✗ Saying control rods absorb 'energy' or 'radiation'. They absorb neutrons.
- ✗ Drawing a chain reaction where each fission releases only one neutron, or where the neutrons do not go on to other nuclei.

More tips

Memory tricks

- Fission = splitting (a fissure is a split or crack).
- Fission recipe: 1 neutron in $\rightarrow$ 2 smaller nuclei + 2 or 3 neutrons + gamma rays + energy out.
- Control rods catch neutrons: more rod in $\rightarrow$ fewer neutrons $\rightarrow$ slower reaction.

Exam technique

- In chain reaction diagrams, label the neutrons, the large nuclei and the smaller nuclei produced.
- Write 'the nucleus absorbs a neutron' rather than just 'is hit by a neutron'.
- When comparing a reactor and a weapon, the key words are 'controlled' and 'uncontrolled'.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 4

Define nuclear fission

The splitting of a large, unstable nucleus into two smaller nuclei.

Grade 4

Name nuclear fuels used for fission

Uranium (e.g. uranium-235) and plutonium (e.g. plutonium-239).

Grade 5

Describe the products of fission

Two smaller nuclei of similar size, two or three neutrons and gamma rays, all with kinetic energy.

Grade 5

Compare a reactor with a nuclear weapon

In a reactor the chain reaction is controlled; in a weapon it is uncontrolled, causing an explosion.

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