

Different half-lives of radioactive isotopes

4.4.3.2 · Atomic structure · revision notes

Radioactive isotopes have half-lives from fractions of a second to billions of years. You need to explain why the hazard from a radioactive material depends on its half-life, and use half-life to choose a suitable isotope for a job. GCSE Physics only, not in Combined Science.

Key facts

- Half-lives range from fractions of a second to billions of years
- Long half-life → activity falls slowly → hazardous for a long time
- Smoke alarm or thickness gauge: half-life of years
- Short half-life → activity falls quickly → hazardous for a short time
- Medical tracer: half-life of a few hours
- Long half-life waste must be stored safely for thousands of years

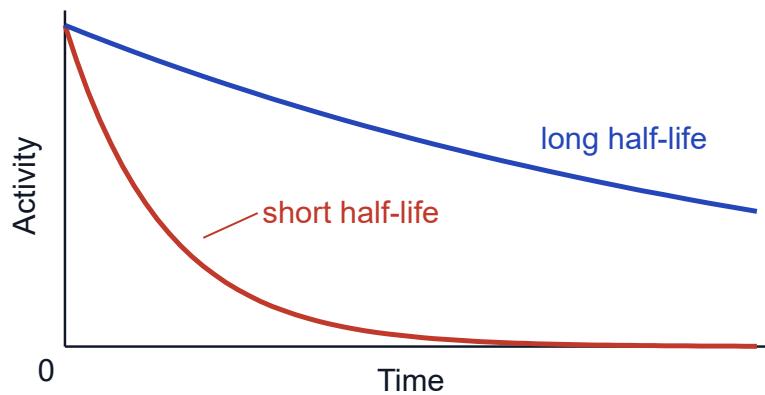
Notes

A very wide range of half-lives

- Different radioactive isotopes have very different half-lives, from fractions of a second to billions of years.
- Examples: technetium-99m about 6 hours; iodine-131 about 8 days; cobalt-60 about 5 years; carbon-14 about 5700 years; uranium-238 about 4.5 billion years.

How half-life affects the hazard

- **Short half-life:** the activity falls quickly, so the material is only hazardous for a short time (hours or days).
- **Long half-life:** the activity falls very slowly, so the material stays hazardous for a very long time. Nuclear waste containing such isotopes must be stored safely for thousands of years.



Same starting activity: the short half-life source is soon safe; the long half-life source stays hazardous.

- The hazard also depends on the type of radiation emitted, and whether the material is inside or outside the body.

Choosing an isotope for a job

- **Medical tracers** need a short half-life (a few hours): long enough to take the images, short enough that the activity in the patient soon falls.
- **Smoke alarms** and **thickness gauges** need a long half-life (years), so the count rate stays nearly constant and the source does not need replacing often.
- When choosing from a table, check the half-life AND the type of radiation.

Don't lose marks

- ✗ Saying a long half-life isotope is more dangerous in every way. For the same number of nuclei its activity is lower; the problem is that it lasts.
- ✗ Choosing a medical tracer with a long half-life (the patient would stay radioactive) or an alpha emitter (it would not leave the body).
- ✗ Using only the half-life, or only the type of radiation, when choosing an isotope from a table.

More tips

Memory tricks

- Short half-life: 'bright but brief'. Long half-life: 'weak but lasting'.
- Tracer half-life: think of a hospital visit, so hours, not years.
- Gauge or alarm half-life: think of the life of the machine, so years.

Exam technique

- In 'choose an isotope' questions, give reasons for your choice and say why the others are unsuitable.
- Quote the half-life from the table in your answer, e.g. '6 hours is long enough to...'.
→ how fast the activity falls → how long it stays dangerous.

What each grade needs

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

Grade 4

State that half-lives vary widely

Half-lives range from fractions of a second to billions of years.

Grade 5

Link half-life to how fast activity falls

A short half-life means the activity falls quickly; a long half-life means it falls slowly.

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