Radioactive decay

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.

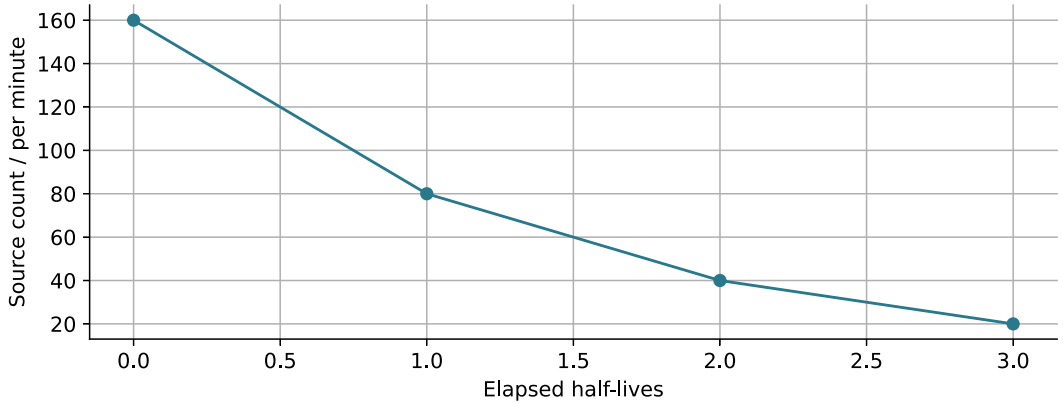
Nuclear changes and radiation evidence

What would explain this observation?

- A detector records counts even when the classroom source is removed. Background must be considered before attributing every count to the source.

Build the model

- Radioactive decay is spontaneous and random for an individual nucleus.
- **Half-life** describes the time for half the undecayed nuclei in a large population to decay, or for background-corrected activity to halve.
- half-life: Time for activity or undecayed population to halve.
- **background radiation** : Radiation measured apart from the investigated source.



Each half-life halves the count rate: 160 → 80 → 40 → 20

Choose evidence that can test it

- Subtract background counts measured over the same time interval.
- Distinguish irradiation from contamination.
- Shielding, distance and reduced exposure time can reduce risk under a school-controlled procedure.

In the lab: Use teacher-managed sources and the school radiation rules. Record count duration and repeat background measurements. Do not extrapolate a half-life from one nucleus or from uncorrected readings.

Work from known quantities

- Known: measured count rate falls from 100 to 55 counts per minute; background is 10.
- Source rates are 90 and 45, so one half-life has elapsed.
- Without subtraction, 55/100 would obscure the exact half in this example.

Your turn: An initial source count is 160 per minute. Find it after three half-lives.

Check the conclusion and its limits

- An irradiated object is not automatically radioactive.
- A half-life does not predict the exact decay time of one nucleus.

Not true: Half-life predicts the exact decay time of an individual nucleus. Radioactive decay is random at the level of single nuclei. Half-life is a statistical quantity: it predicts the fraction of a LARGE number of nuclei decaying in a given time, never the moment one nucleus will decay.

Key:

- Radioactive decay is spontaneous and random for an individual nucleus.
- Subtract background counts measured over the same time interval.
- Watch for: an irradiated object is not automatically radioactive.

Write from 80 counts per minute

- An initial source count is 320 per minute.
- Find the count after two half-lives. Half-life does not time one nucleus.

Write from two half-lives

- A source reads 160 counts per minute above background.
- After two half-lives: 160 → 80 → 40 – each halving is independent of the last.

Write from a background-subtracted table

- Raw readings are 110 then 60, with background 10.
- Corrected: 100 then 50 – exactly one half-life; the raw ratio $60 \div 110 \approx 0.55$ would misjudge the decay.

Write from a decay-curve read

- A corrected count rate is 400 per minute and halves every 8 minutes.
- At 24 minutes: $400 \to 200 \to 100 \to 50$ – three half-lives, three halvings, and the curve never reaches zero.