

Exercise walk-through

17.1

Nuclear changes and radiation evidence

International Baccalaureate · IB Diploma · Physics · SL

17.1 Nuclear changes and radiation evidence

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS half-life • background radiation

Objective

Nuclear changes and radiation evidence. Supported SL concept preparation; original classroom practice, not an official IB paper or assessed learner work.

1 Key knowledge and worked examples

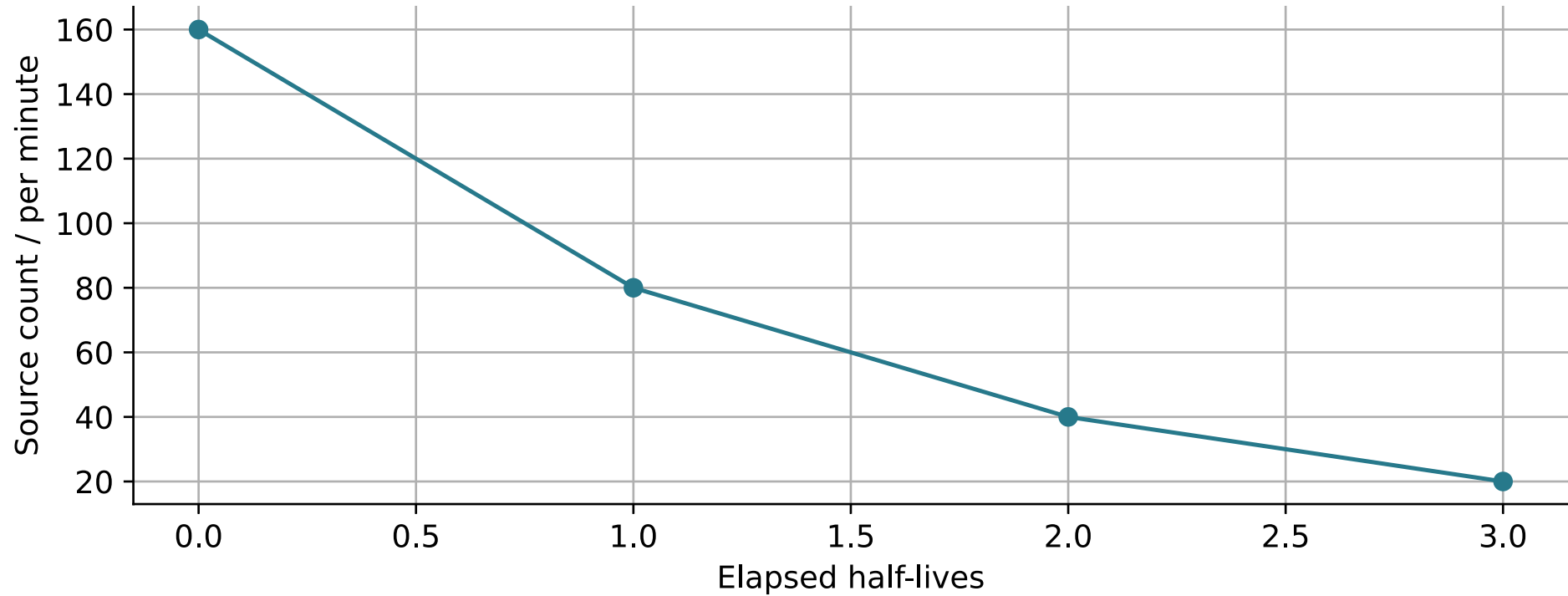
■ What would explain this observation?

- A detector records counts even when the classroom source is removed. Background must be considered before attributing every count to the source.
- Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.

■ 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.



■ **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.
- 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**

- State the known values and their units. Choose the relation because its assumptions

fit this case, then rearrange before substitution.

- 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.

Example:

An initial source count is 160 per minute. Find it after three half-lives. Use the same sequence: known quantities $\rightarrow$ model $\rightarrow$ relation $\rightarrow$ substitution $\rightarrow$ unit and interpretation.

■ 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.

- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

Half-life predicts the exact decay time of an individual nucleus. This claim is false: An irradiated object is not automatically radioactive. A half-life does not predict the exact decay time of one nucleus.

Key:

Nuclear changes and radiation evidence: 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.

Exercises 2.1-2.3

2.1 Which count should be used for source activity? Choose one answer.

- **A** Raw source-plus-background only
- **B** Measured count minus background over equal times
- **C** The largest repeated count only

[1]

2.2 An initial source count is 160 per minute. Find it after three half-lives. Show the relation, substitution and units.

[2]

2.3 Decide whether this claim is true and justify: Half-life predicts the exact decay time of an individual nucleus.

[2]

Exercises 2.1-2.3

2.1 Which count should be used for source activity? Choose one answer.

- **A** Raw source-plus-background only
- **B** Measured count minus background over equal times
- **C** The largest repeated count only

[1]

2.1 B 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.

2.2 An initial source count is 160 per minute. Find it after three half-lives. Show the relation, substitution and units.

[2]

2.2 After three half-lives: $160 \times (1/2)^3 = 20$ counts/min.

2.3 Decide whether this claim is true and justify: Half-life predicts the exact decay time of an individual nucleus.

[2]

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

Exercises 2.4·3.1

2.4 Time for activity or undecayed population to halve: write the technical term. [1]

3 Exam-style questions

3.1 A fictional counter reads 90 counts/min, then 50 after one half-life. Background is constant. Infer background and initial source rate. [4]

Exercises 2.4·3.1

2.4 Time for activity or undecayed population to halve: write the technical term. [1]

3 Exam-style questions

2.4 half-life. half-life means Time for activity or undecayed population to halve.

3.1 A fictional counter reads 90 counts/min, then 50 after one half-life. Background is constant. Infer background and initial source rate. [4]

3.1 $90 - b = 2(50 - b)$, so $b = 10$ counts/min. Source rates are 80 then 40. Background does not decay with the source and must be subtracted; counting uncertainty remains.