

Worksheet 4.4: Half-Life Calculations (Activity & Count-Rate decline)

PhysicsSheets

Specification: GCSE Physics (AQA 4.4.2.3 / Edexcel SP15)

Core Half-Life Equations:

$$A = A_0 \left(\frac{1}{2}\right)^n \quad (\text{Remaining Activity/Count-Rate} = \text{Initial Activity/Count-Rate} \times (1/2)^{\text{number of half-lives}})$$

$$n = \frac{t}{t_{1/2}} \quad (\text{Number of half-lives} = \text{Total time} / \text{Half-life period})$$

Rearranged Forms:

$$A_0 = \frac{A}{\left(\frac{1}{2}\right)^n} \quad \left| \quad \left(\frac{1}{2}\right)^n = \frac{A}{A_0} \quad \left| \quad t = n \times t_{1/2} \quad \left| \quad t_{1/2} = \frac{t}{n}\right.\right.$$

Units:

A (Remaining activity/count-rate) in **Becquerels (Bq)** or **counts/second**

A_0 (Initial activity/count-rate) in **Becquerels (Bq)** or **counts/second**

n (Number of half-lives) is **dimensionless**

t (Total time elapsed) and $t_{1/2}$ (Half-life period) must be in **consistent units** (e.g., both in seconds, both in hours, etc.)

Section A: Formula Recall, Units & Conversions

1. State the correct SI unit and its symbol for each variable in the half-life formula:

a) Activity (A or A_0): _____

b) Time (t or $t_{1/2}$): _____

2. Rearrange the formula $A = A_0 \left(\frac{1}{2}\right)^n$ to make A_0 the subject.

3. Rearrange the formula $n = \frac{t}{t_{1/2}}$ to make $t_{1/2}$ the subject.

4. Perform the following unit conversions. Show your working where appropriate.

a) Convert 2.5 kBq to Becquerels (Bq).

b) Convert 30 minutes to seconds.

c) Convert 0.004 Bq to milliBecquerels (mBq).

d) Convert 2.5 years to days (assume 1 year = 365 days).

e) Convert 72 hours to days.

Section B: Practice Calculations

5. Answer the following questions, showing all your working clearly.

a) A radioactive isotope has an initial activity of 800 Bq and a half-life of 2 hours. Calculate its activity after 6 hours.

- b) A sample of Iodine-131 has an initial activity of 1200 Bq. Its half-life is 8 days. What will its activity be after 24 days?

- c) A radioactive source has an activity of 50 Bq after 40 minutes. If its half-life is 10 minutes, what was its initial activity?

- d) A sample of a radioactive isotope has an initial count-rate of 640 counts/second. After 45 seconds, its count-rate has fallen to 80 counts/second. Calculate the half-life of this isotope.

Section C: Challenge Context & Multi-step Problems

6. A medical tracer containing a radioactive isotope is injected into a patient. The initial activity of the tracer is 2.4 MBq. The half-life of the isotope is 6 hours.

- a) Calculate the activity of the tracer remaining in the patient after 18 hours. Give your answer in Bq to an appropriate number of significant figures.

- b) The medical procedure requires the tracer's activity to fall below 150 kBq before the patient can be discharged. Calculate the minimum total time, in hours, the patient must wait before discharge. Explain why choosing an isotope with a very short half-life for medical tracers is important.
