Unit 24 · Radioactivity and Nuclear Reactions

HARDER PRACTICE QUESTIONS

Full marks 33

Write your answers on separate paper. Show your working. Take $\ln 2 = 0.693$ and Avogadro's number as 6.02×10^{23} per mole.

1 Spot the error [3]

Find the mistake in the working and correct it.

A substance has a half-life of 5 days. Asked what fraction of it has **decayed** after 15 days, Rita wrote:
"15 days is 3 half-lives, so the fraction is $(1/2)^3 = 1/8$."

2 Read the data [4]

Arjun measured the count rate near a short-lived source. With no source near, the counter gave 20 counts a minute.

t (min)	0	4	8	12	16	20
Count rate (per min)	420	250	152	96	64	45

i. Why must 20 a minute be taken off every reading?
ii. Find the source's own count rate at each time.
iii. Find the half-life.
iv. What would the counter read after a long time?

3 Predict, then explain [3]

Write your prediction first, then explain it.

A GM tube counts 300 a minute from an unknown source (background already taken off). A sheet of paper put in front cuts it to 120; 5 mm of aluminium instead of the paper cuts it to 115; 5 cm of lead cuts it to 40. Predict which radiations the source gives out. Then explain.

4 Show that [3]

Show that the time for a sample's activity to fall to a tenth is about 3.3 half-lives, whatever the substance. How long is this for cobalt-60 (half-life 5.3 years)?

5 A real setting [3]

A cancer hospital's cobalt-60 machine (half-life 5.3 years) must have its source replaced when the activity has fallen to 70 % of what it was new. Roughly how often must it be replaced? As the source weakens, what must the staff do to give each patient the same dose?

6 Which explanation fits? [2]

A count rate from a source is 100 a second, but readings taken one second apart go 94, 108, 97, 103, 91. Bina says the counter is faulty. Kamal says radioactive decay is random. Who is right? Why?

7 Correct the misconceptions [3]

The paragraph has three mistakes. Write each mistake and correct it.

Nirjala wrote: "After two half-lives a radioactive sample has all decayed. A beta particle is an electron from the atom's outer shell. A gamma ray makes the nucleus lighter by four."

8 Work backwards [3]

In 24 hours, 7/8 of a sample of a radioactive isotope decays. Find its half-life, its decay constant and its mean life.

9 Compare [4]

Source A starts with 8.0×10^{12} atoms and a half-life of 2.0 hours; source B with 4.0×10^{12} atoms and a half-life of 6.0 hours.

i. Which is more active at the start? By how many times?

ii. After how long are their activities equal?

10 Design it [3]

A doctor wants a tracer to inject and follow with a camera outside the body. From the table, which would you choose, and why not the others: radon-222 (α, 3.8 days), iodine-131 (β, 8.0 days), cobalt-60 (β and γ, 5.3 years), technetium-99m (γ, 6 hours)?

11 Make your own [2]

Write a problem whose answer is “the half-life is 6 days”, using a fraction of a sample left after some time. Solve it to show it works.