Unit 12 · Radioactivity

HARDER PRACTICE QUESTIONS

Full marks 50

Write your answers on separate paper. Show your working. Where a nuclear equation is asked for, check that both sides balance.

1 Spot the error [3]

Find the mistake in the working and correct it.

Iodine-131 (Z = 53) gives out a beta particle. (Element 52 is tellurium, Te; element 54 is xenon, Xe.) Binita wrote:

"An electron leaves, so the atomic number and the mass number each go down by 1:
$^{131}_{53}\text{I} \longrightarrow {}^{130}_{52}\text{Te} + {}^{0}_{-1}\text{e}$."

2 Is the chain possible? [4]

Three students describe decay chains that give out only alpha and beta particles.

Rakesh: A = 232, Z = 90 ends at A = 208, Z = 82.

Manisha: A = 238, Z = 92 ends at A = 205, Z = 82.

Rohan: A = 214, Z = 83 ends at A = 206, Z = 82.

i. Which chain cannot happen, and why?

ii. For each of the other two, find how many alpha and beta particles are given out.

3 What does the source give out? [5]

A teacher tests a sealed source with a Geiger–Müller tube 3 cm away, with different things in between. (The counts are made up for this question.)

Between source and tube	nothing	paper	3 mm of aluminium	2 cm of lead
Counts a minute	520	300	60	30

The background alone is 20 counts a minute.

i. Copy the table and add a row with the background taken away.

ii. Which radiations does the source give out? Give the evidence for each.

iii. About how many counts a minute are due to each radiation?

iv. Anusha says, "2 cm of lead left only 30 counts, so with a bit more lead there will be no gamma at all." Correct her.

4 Choose the source [4]

Give a reason for each choice.

A store offers four made-up sources.

Source	Gives out	Time to lose half its activity
P	alpha	400 years
Q	beta	30 years
R	gamma	6 hours
S	gamma	5 years

Which would you choose for:

i. a smoke detector on a ceiling?

ii. a gauge for the thickness of plastic sheet, in use for many years?

iii. a tracer given to a patient for a gamma camera scan?

iv. checking welds in thick steel pipes, on many jobs over several years?

5 Time, distance and lead [4]

A cobalt-60 source gives a dose rate of 90 μSv per hour at 1 m. Pramisha works 3 m from it.

i. Find the dose rate where she works.
ii. How many hours a year can she work there without passing the limit of 20 mSv a year for radiation workers?
iii. A wall of 2.4 cm of lead is then put between her and the source. Find the new dose rate.
iv. Now, how many hours could she work before passing the limit for the public, 1 mSv a year?

6 Estimate it [3]

Each 6.6 cm of concrete cuts the gamma rays of cobalt-60 to half. A radiotherapy room has a concrete wall a little over 1 m thick. Taking it as 1 m, estimate how many halvings it gives, and about what fraction of the gamma rays gets through. Then find the thickness of lead that cuts them to about a thousandth.

7 The nucleus recoils [3]

This uses Unit 11.

A radium-226 nucleus at rest gives out an alpha particle at about 1.5×10^7 m/s and becomes radon-222. Take the masses as 4 u and 222 u. Find the speed of the radon nucleus, and say which way it moves and why.

8 Predict, then explain [3]

Write your prediction first, then explain it.

The experiment with charged plates is always done in a vacuum. Suppose it is done in ordinary air, with the screen 20 cm from the source. Predict which beams reach the screen, and explain. What can you say about the beam that is missing, and how would you show that it had been there?

9 Which explanation fits the evidence? [3]

Rutherford covered uranium with thin aluminium foils, one after another. A table like his might look like this (made-up numbers):

Sheets	0	1	2	3	4	6	8
Radiation (% left)	100	60	38	29	26	25	24

Anil: "There is one kind of ray, and each sheet weakens it by the same fraction."
Radhika: "There are at least two kinds: one stopped by a very thin layer, and a far more penetrating one."
Which explanation fits? Use numbers from the table.

10 Design a fair test [4]

Your teacher has a small sealed gamma source, a Geiger–Müller tube and lead sheets of the same size. Plan a demonstration to test the idea that each extra sheet cuts the gamma rays by the same fraction.

i. What is changed, and what is measured?
ii. Name three things to keep the same.
iii. What must be done with the background, and why?
iv. Name two safety rules, and say what result would support the idea.

11 What if? [3]

Sanjay wants to replace the americium-241 in a smoke detector with a gamma source, “because gamma is more powerful”. Explain step by step how the detector works, and two things that would go wrong.

12 Correct the misconceptions [3]

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

Chiring wrote: “A beta particle is an electron knocked off from around the nucleus. Heating a radioactive sample makes it give out radiation faster. A person who has had radiotherapy is radioactive and should be kept away from children.”

13 Judge the case [3]

In Goiânia, Brazil, in 1987, two men took an abandoned radiotherapy machine apart for scrap and broke open a capsule of cesium-137. Name three rules for storing sources that would have prevented this, and say why the people around them were harmed even though the machine was no longer in use.

14 Think [3]

Radium-226 ($Z = 88$) gives out in turn an alpha particle, an alpha particle, a beta particle and a beta particle. Find the A and Z at the end. Radon-222 has $Z = 86$. What is the end nucleus to radon-222, and how do you know?

15 Make your own [2]

A cobalt-60 source gives 160 μSv per hour at 1 m. Plan how far away a worker should stand and how much lead to use, so that the dose rate is no more than 5 μSv per hour. Use both distance and lead, and show that your plan works.