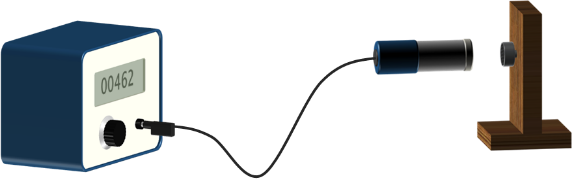
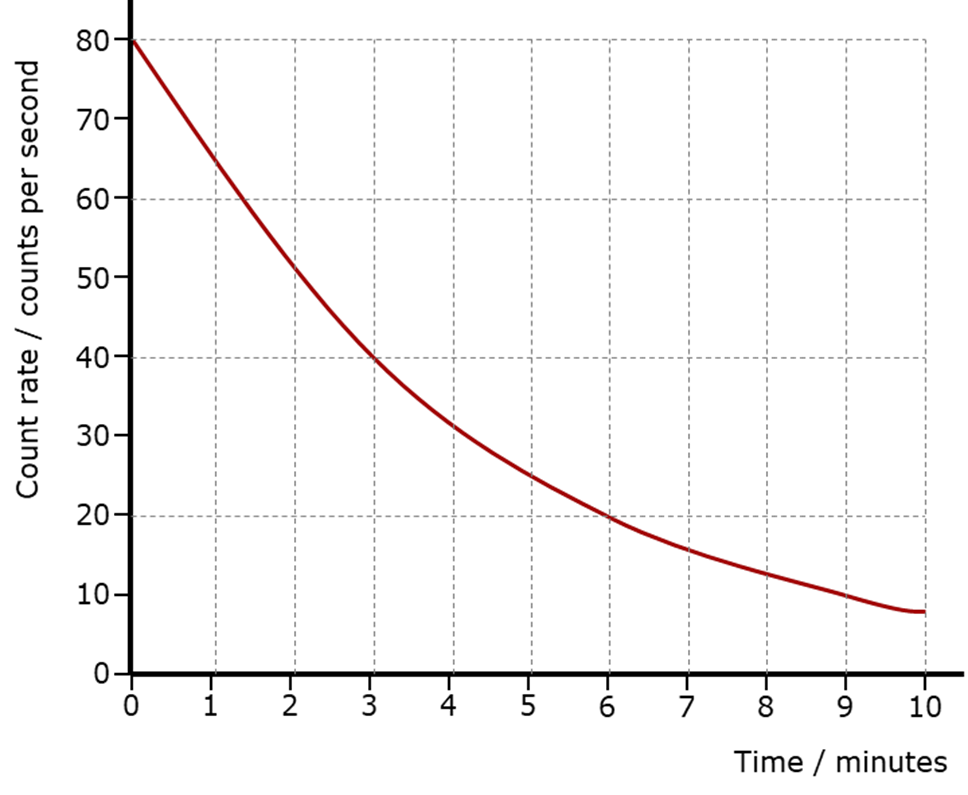
**Radioactive half-life graph**

A radioactive isotope decays quickly into a different stable isotope.

A Geiger-Műller tube is used to measure its radiation.

The count rate is recorded every minute for ten minutes.

A graph is plotted to show what happens.



The statements are about what the graph is showing.

For each statement, tick (✓) **one** column to show what you think*.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** | The half-life of the radioactive isotope is three minutes. |  |  |  |  |
| **B** | The count-rate halves every three minutes. |  |  |  |  |
| **C** | The count-rate halves because the number atoms that are radioactive halves. |  |  |  |  |
| **D** | The count-rate will be zero after about fifteen minutes. |  |  |  |  |

*Physics > Big idea PMA: Matter > Topic PMA5: Nuclear physics > Key concept PMA5.4: Radioactive half-life*

|  |
| --- |
| **Diagnostic question** |
| **Radioactive material** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Radioactive half-life is the predicted time it takes for half of a large sample of radioactive nuclei to decay randomly. |
| Observable learning outcome: | Describe patterns in the random nature of radioactive decay and interpret radioactive half-life graphs. |
| Question type: | Confidence grid |
| Key words: | Half-life, half-life graph, radioactive isotope, Geiger-Műller tube |

**What does the research say?**

Misunderstandings that may stem from a thinking that ‘only clearly determined events can lead to predictable outcomes’ are:

* a radioactive material will be safe and no longer radioactive after one half-life (Lijnse et al., 1990);
* *all* the radioactive atoms will have decayed after one half-life (or after *two* half-lives); and
* half-life is a special time before which, or at which, a particular nucleus decays (Hull and Hopf, 2020).

In each of these examples, students appear to have used the idea that ‘half-life’ is predictable, to develop a misunderstanding that the decay of particular radioactive atoms is also predictable. The last example additionally shows how some students (about a third of a sample of 55 students age 13-14) ascribe the predictive nature of a whole sample to a single radioactive nucleus (Hull and Hopf, 2020). In fact, an individual radioactive nucleus does not have a half-life and its decay is random. Half-life is instead, a *good predictor* of the time it takes for half of a sample of *very many* radioactive nuclei to decay.

**Ways to use this question**

Students should complete the confidence grid individually. This could be a pencil and paper exercise, or you could use an electronic ‘voting system’ or mini white boards and the PowerPoint presentation.

If there is a range of answers, you may choose to respond through structured class discussion. Ask one student to explain why they gave the answer they did; ask another student to explain why they agree with them; ask another to explain why they disagree, and so on. This sort of discussion gives students the opportunity to explore their thinking and for you to really understand their learning needs.

*Differentiation*

You may choose to read the questions to the class, so that everyone can focus on the science. In some situations, it may be more appropriate for a teaching assistant to read for one or two students.

**Expected answers**

Statements A, B and C are right; and statement D is wrong.

**How to respond - what next?**

The half-life of the radioactive isotope is three minutes, because every three minutes (no matter what the starting point on the graph) the count-rate halves, and because the count rate is proportional to the number of radioactive atoms remaining.

A Most students should notice that the count rate falls after the first three minutes, and link this to the half-life.

B It is not obvious from the graph that the count-rate halves *every* three minutes. To work this out, students will need to work out the fall in count rate for a range of different three-minute periods. Those who think this statement is wrong are likely to need support in understanding how to read the graph to work it out. It is common for students to struggle with working out rates from a graph.

C This statement is checking that students have made the connection between count rate and the number of radioactive atoms remaining. If this connection is not overtly clear to students, then it can lead to confusion. A common misunderstanding is for students to think that radiation is made of radioactive particles. Some students may consider the radioactive particles have moved from one place to another.

D The graph looks as if it might reach zero at fifteen minutes, but it won’t. Students who are looking at the graph as just a line, and not as a representation of what is happening, may think that it will. If students understand the random nature of radioactive decay, they should realise that there will always be a proportion of radioactive atoms that do not decay, and that the line will effectively never become zero.

If students have misunderstandings about interpreting radioactive half-life graphs, it can help to model what happens to a radioactive material as it decays. The following BEST ‘response activities’ could be used to do this, in follow-up to this diagnostic question:

* Response activity: Half-life of clay dice
* Response activity: Half-life of pizza

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

Prather, E. (2005). Students' beliefs about the role of atoms in radioactive decay and half-life. *Journal of Geoscience Education,* 53(4)**,** 345-354.