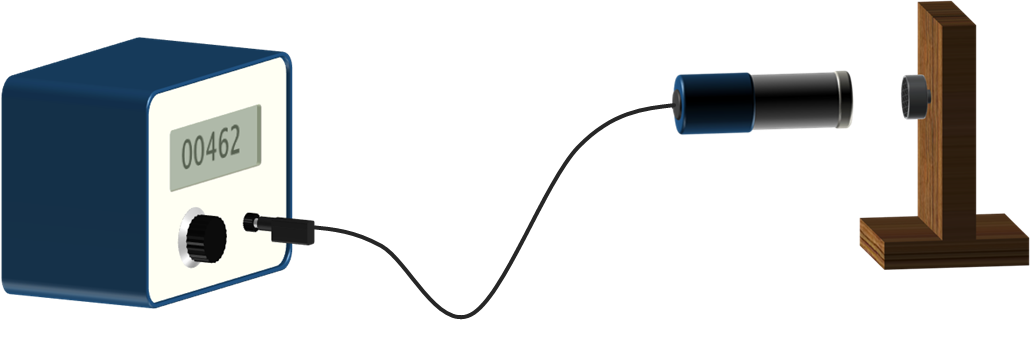
**Radioactive half-life**

Bismuth-212 is a radioactive isotope.

It has a half-life of about one hour.



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

After one hour (**one half-life**), the count rate is half what it was at the start.

What is the definition of radioactive half-life?

*Put a tick (✓) in the box next to the best answer.*

|  |  |  |
| --- | --- | --- |
| **A** | Half the time it takes for a radioactive atom to decay. |  |
|  |  |  |
| **B** | The average time it takes for a radioactive atom to decay. |  |
|  |  |  |
| **C** | The time it takes for half the radioactive atoms to decay. |  |
|  |  |  |
| **D** | The time at which half the radioactive atoms will decay. |  |

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

|  |
| --- |
| **Diagnostic question** |
| **Radioactive half-life** |

**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: | Simple multiple choice |
| Key words: | Half-life, radioactive atom, 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 question 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.

The answers to the question will show you whether students understood the concept sufficiently well to apply it correctly.

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**

C

**How to respond - what next?**

Radioactive half-life is the predicted time it takes for half of a large sample of radioactive nuclei to decay randomly. It is an example of many random events combining to give a predictable outcome.

A Students choosing this option most likely take ‘half-life’ to mean literally ‘half of the life-span’ of each radioactive atom. They are wrongly ascribing the same predictable outcomes of a large number of radioactive atoms to each individual atom, which is a common thing to do.

B This option superficially makes sense, but if half-life is the average lifespan of each radioactive the mathematics imply that: all of them will have decayed after two half-lives, but at random times up to this point; or the large majority decay *before* one half-life and a few do not decay for a long time.

D It is likely that some students will have the naïve misunderstanding that half-life is the time *at which* radioactive atoms decay (either half of them, or all of them). Again, these students are ascribing the predictable properties of the whole to each individual radioactive atom.

If students have misunderstandings about describing half-life in terms of the random nature of radioactive decay, 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**

Hull, M. M. and Hopf, M. (2020). Student Understanding of Emergent Aspects of Radioactivity. *International Journal of Physics and Chemistry Education,* 12(2).

Lijnse, P. L., et al. (1990). Pupils' and mass-media ideas about radioactivity. *International Journal of Science Education,* 12.1.