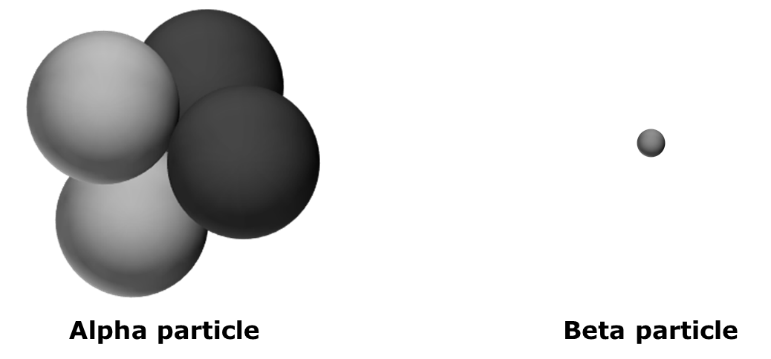
**Ionising power**

Alpha and beta radiation can both ionise atoms (or groups of atoms).

Alpha radiation is better at ionising atoms than beta radiation.



*An alpha particle is about 7300 times heavier than a beta particle.*

*An alpha particle has a charge of +2.*

*A beta particle has a charge of -1.*

What is the best answer to explain why alpha radiation is better at ionising atoms than beta radiation?

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

|  |  |  |
| --- | --- | --- |
| **A** | An alpha particle is larger and has more mass. |  |
|  |  |  |
| **B** | An alpha particle has more mass and a bigger electric charge. |  |
|  |  |  |
| **C** | An alpha particle has a bigger electric charge and is larger. |  |

*Physics > Big idea PMA: Matter > Topic PMA5: Nuclear physics > Key concept PMA5.3: Ionising radiation*

|  |
| --- |
| **Diagnostic question** |
| **Ionising power** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Some forms of radiation can ionise atoms or groups of atoms. Several properties of each form of ionising radiation are determined by its ionising power. |
| Observable learning outcome: | Explain how the ionising power of each ionising radiation affects its properties. |
| Question type: | Simple multiple choice |
| Key words: | Alpha and beta radiation, ionisation, electrostatic force |

**What does the research say?**

In a series of lesson observations of a class of 14 students, age 16-17, Eijkelhof (1990) found that although the teacher consistently referred to the ‘absorption of radiation’, students typically described it as being stopped by a material. This suggests some students may have a mental model of radiation bouncing off of a material.

The relative penetrating powers of alpha, beta and gamma radiation are connected to the probability of each interacting with electrons around the nucleus of an atom. Each interaction is the mechanism by which energy is transferred from alpha, beta or gamma radiation to a material. With each interaction, alpha and beta particles lose some momentum and after many interactions become unable to cause further ionisations. Gamma photons are fully absorbed in a single interaction. Beta particles are more likely than alpha particles to penetrate further into a material, before they lose most of their momentum and become a part of the material, because they are less likely to interact with electrons around atoms’ nuclei.

These ideas can be used to explain the relative dangers of different types of ionising radiation in different situations and to challenge the common misunderstanding that the danger of radiation depends only on the dose and not also on ionising power (Plotz, 2017).

**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**

B

**How to respond - what next?**

An alpha particle is better at ionising because its electric charge is twice as large as that of a beta particle and it has a much greater mass.

This means its electric field is able to interact more strongly with electrons and from a greater distance than a beta particle can. Its larger mass means it is able to ionise many more atoms (or groups of atoms) than a beta particle before it loses the momentum it needs to do so. In air, a single alpha particle can cause in the order of 100 000 ionisations.

It is common for students to think that ionisation is caused only by a physical collision between an alpha or beta particle and an electron.

A Students with this misunderstanding are most likely to choose this option because a larger ball with a bigger mass is more likely to hit and knock off a smaller target, for example a coconut on a coconut shy.

C Some students, that have the same misunderstanding, may be aware that the electrostatic force plays an important role in ionisation. These students are likely to choose option C.

If students have misunderstandings about how the ionising power of each ionising radiation affects its properties, it can help to discuss the process of ionisation with students and to give them the opportunity to explain the scientific way of thinking about absorption, using their own words. A useful analogy might be moving magnets of different strengths past an arrangement of iron balls, which represent electrons around an atom.

Discussing these ideas in pairs or in small groups can encourage social construction of these ideas through dialogue and help consolidate understanding.

The following BEST ‘response activity’ could be used in follow-up to this diagnostic question:

Response activity: Blocking paper

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

Eijkelhof, H. M. C. (1990). *Radiation and risk in physics education.* Rijksuniversiteit Utrecht.

Plotz, T. (2017). Students' conceptions of radiation and what to do about them. *Physics Education,* 52(1)**,** 014004.