**Blocking paper**

A radioactive source contains some americium-241.

Americium-241 emits alpha radiation and gamma radiation.

A Geiger-Műller tube is used to detect the radiation.

**Predict**

If a sheet of paper is put between the source and the Geiger-Műller tube, what do you think will happen to the count rate?

**Explain**

Why do you think this will happen?

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| **Watch a demonstration** |

**Observe**

When a sheet of paper was placed between the source and the Geiger-Műller tube, describe what happened to the count rate.

**Explain**

Were your prediction and explanation correct?

Try to improve your first explanation to explain what happens more clearly.

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

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| **Response activity** |
| **Blocking paper** |

**Overview**

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| 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. |
| Activity type: | Predict, explain; observe, explain (PEOE) |
| Key words: | Alpha and beta radiation, absorption, ionisation |

This activity can help develop students’ understanding by addressing the sticking-points revealed by the following diagnostic questions:

* Diagnostic question: Getting through stuff
* Diagnostic question: Ionising power

**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 activity**

Students should complete this activity in pairs or small groups, and the focus should be on the discussions. It is through the discussions that students can check their understanding and rehearse their explanations.

To begin, each group should discuss the activity and use their scientific understanding, firstly to predict *what* they think will happen, and then to explain *why* they think they are going to be right. If students in any group cannot agree, you may be able to direct them with some careful questioning.

Students now watch a demonstration. You will need to decide whether it is better for each group to carry out the practical and risk some unexpected observations, or to demonstrate the activity so that everyone *observes* the same thing.

After the practical each group should be given the opportunity to change, or improve their explanation. A good way to review your students’ thinking might be through a structured class discussion. You could ask several groups for their *explanations* and put these on the whiteboard. Then ask other groups to suggest which explanation is the most accurate and the most clearly expressed, and through careful questioning work up a clear ‘class explanation’.

A useful follow up is for individual students to then write down explanations in their own words – without reference to the class explanation on the board (i.e. cover it up).

*Differentiation*

The quality of the discussions can be improved with a careful selection of groups; or by allocating specific roles to students in each group. For example, you may choose to select a student with strong prior knowledge as a scribe, and forbid them from contributing any of their own answers. They may question the others and only write down what they have been told. This strategy encourages contributions from more members of each group.

**Equipment**

For the demonstration:

* Geiger-Műller tube and connecting wire
* Count-meter
* Americium 241-source
* Holder for the source
* Tongs to move the source
* Radiation warning sign(s)

**Technician notes**

The americium-241 is the standard alpha source in a radioactivity kit. It is also a weakly emitting gamma source, and some gamma radiation above the background count should be detectable, although the count rate is likely to be small.

It is worth testing out this investigation in advance, in order to check the expected results are clearly demonstrable.

Teachers using the kit need to be fully trained in using it safely, and rules for using radiation need to be followed.

**Health and safety**

There will be rules in place in each school about which teachers may use radioactive sources and how they may use them. These rules should be checked and followed.

It is usual for students aged 14-16 to be banned from handling radioactive sources.

Practical work should be carried out in accordance with local health and safety requirements, guidance from manufacturers and suppliers, and guidance available from CLEAPSS.

**Expected answer**

Americium-241 emits alpha radiation and also a little gamma radiation.

Alpha radiation is absorbed by about 5 cm of air, so any radiation detected by the counter will be gamma radiation from the source or background radiation. As gamma radiation is not absorbed by a sheet of paper (negligibly), inserting the paper will not change the count-rate.

**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.