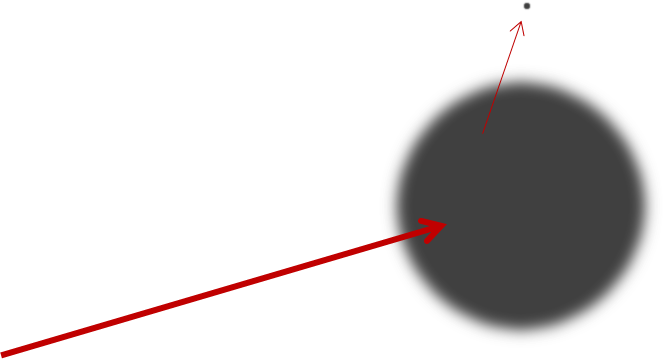
**Getting through stuff**

Alpha, beta and gamma radiation can each force electrons off atoms (or off groups of atoms).

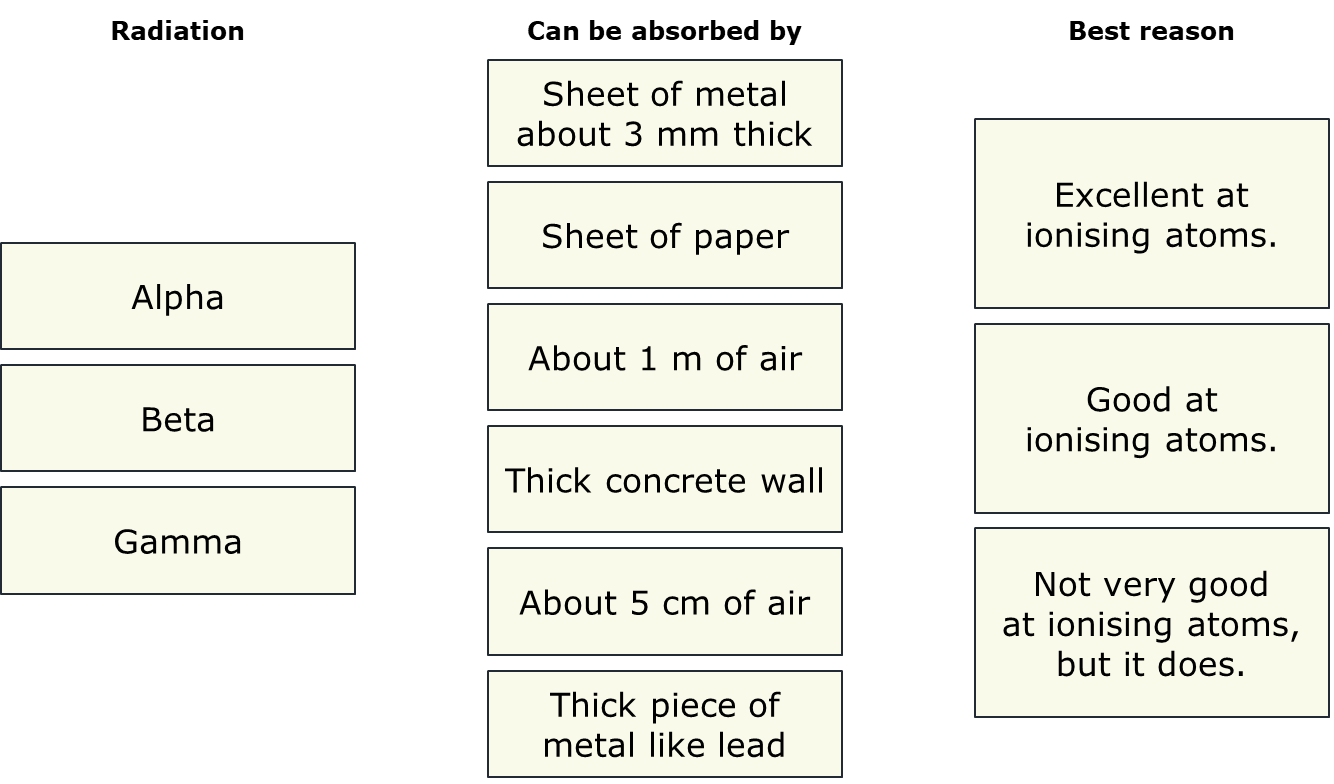
This is called ionisation.

Ionisation also affects the radiation that made it happen.



For each type of radiation pick **two things** that can stop it and a reason to explain why.

*Rule lines between columns to show what you think.*



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

|  |
| --- |
| **Diagnostic question** |
| **Getting through stuff** |

**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: | Linking ideas |
| Key words: | Alpha, beta and gamma radiation, absorption, ionisation |

**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**

This task is intended for discussion in pairs or small groups. It is best done as a pencil and paper exercise.

Students should read the statements and follow the instructions on the worksheet. Listening in to the conversations of each group will often give you insights into how your students are thinking. Each member of a group should be able to report back to the class.

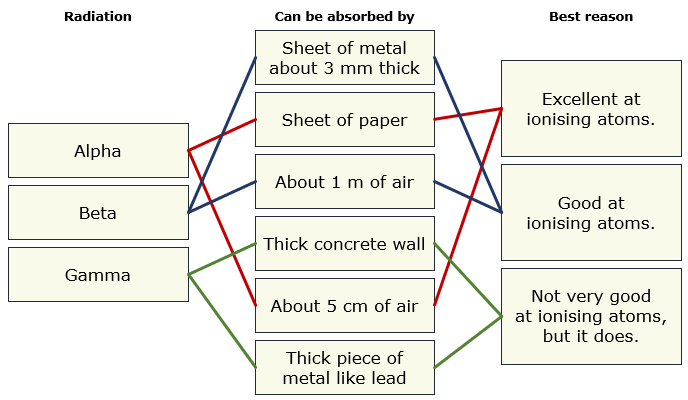
Feedback from each group can be used, with careful teacher questioning, to bring out a clear description or explanation of the science.

*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 the 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.

NB in any class, small group discussions typically improve over time and a persistence with this strategy is often very successful in the medium to long term.

**Expected answers**



**How to respond - what next?**

Alpha particles ionise atoms very easily, and a single alpha particle may ionise in the order of

100 000 atoms whist travelling just a few centimetres through air, and even more whilst travelling a tiny distance through paper. With each collision the alpha particle’s momentum reduces slightly until it no longer has enough to pull electrons off atoms (or groups of atoms). Wherever the alpha particle is when this happens is the point at which it is ‘absorbed’. It is absorbed because it is within the paper or the air.

Beta particles have a much smaller momentum and are absorbed after far fewer ionisations, but they travel further through materials because they do not ionise atoms (or groups of atoms) so readily.

Gamma photons ionise a single atom (or group of atoms), with their energy being transferred to one or more electrons and to the remaining ion. They are far less likely to cause ionisation than alpha or beta, which allows each photon to travel much further through a material, on average, before it is absorbed.

A common misunderstanding is to think of the ionisation of an atom (or groups of atoms) as a physical collision between the radiation and an electron. If this is what students think, then because the alpha particle has much more mass than a beta particle, some may imagine that it is harder to stop and therefore travels further.

It is also common for students to think of radiation as being stopped by a material and bouncing off it like a ball. Again, these students may think that materials to ‘stop’ alpha particles need to be heavier or more dense than materials needed to stop beta particles. These students may also be confused as to why the air ‘stops’ radiation, because air has nothing solid for the radiation to reflect off. This is where an understanding of the process of absorption becomes important for developing a good understanding.

If students have misunderstandings about how the ionising power of each ionising radiation affects its properties, it can help to discuss the process of absorption with students and to give them the opportunity to explain the scientific way of thinking about absorption in their own words.

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.