**Pulling electrons**

Some types of electromagnetic radiation can ionise atoms.

An atom is ionised when it loses or gains electrons.

Ionising radiation forces atoms to lose electrons.



Some students are discussing how electromagnetic radiation can ionise an atom.

**Violet:** EM radiation is made of photons.

**Yasmine:** Some photons have more mass than others.

**Xavier:** gamma radiation is more ionising than ultraviolet.

**Zain:** EM radiation bashes into electrons to knock them off an atom.

**Will:** EM radiation is made of oscillating electric and magnetic fields.

 **To answer**

1. Who is right about how EM radiation causes ionisation?
	* *Explain your answer*

2. Who is wrong about how EM radiation causes ionisation?

* + *What would you say to help them understand?*

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| Cards for **Pulling electrons** | **Violet:** EM radiation is made of photons. |
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*Physics > Big idea PSL: Sound, light and waves > Topic PSL7: Electromagnetic waves > Key concept PSL7.2: Electromagnetic spectrum*

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| **Response activity** |
| **Pulling electrons** |

**Overview**

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| Learning focus: | Electromagnetic radiation transfers energy and interacts with matter in different ways, depending on the frequency and matter. Each radiation type can be both helpful and harmful. |
| Observable learning outcome: | Describe some ways in which electromagnetic radiation can interact with matter. |
| Activity type: | Talking heads |
| Key words: | Radiation, matter, oscillating, electric field, magnetic field, photon, electron, ionisation |

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

* Diagnostic question: Electromagnetic interactions

**What does the research say?**

Students often confuse EM radiation with particle radiation, which includes alpha or beta particles (Plotz, 2017). The majority of students aged 12-18 (n=1246) also find it hard to distinguish between ionising and non-ionising radiation (Rego and Peralta, 2006).

Some text books describe ionisation as photons knocking outer electrons off atoms, and the interpretation often made by students is that the photons need to physically collide with electrons, which they don’t. Ionising EM radiation can cause outer electrons to be forced out of atoms, by attraction or repulsion between the electric field of an electron and that of the radiation, in turn affecting bonds and interactions between atoms. Some types of EM radiation are ionising and other types are not.

It is common for students to think that when an object is exposed to radiation that it becomes radioactive. However, this is only true for high-energy gamma radiation that may excite atomic nuclei (Plotz, 2017).

**Ways to use this activity**

This task is intended for discussion in pairs or small groups. It can be done as a pencil and paper exercise or projected onto a screen.

Students should read the statements and follow the instructions on either the worksheet or the PowerPoint. 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**

1. Violet, Will and Xavier are right.

 EM radiation is made of oscillating electric and magnetic fields moving through space in packets called photons. Each photon transfers a fixed amount of energy that depends on its frequency. Gamma photons have more energy than ultraviolet photons and are therefore more ionising.

2. Yasmine and Zain are wrong.

 Yasmine is wrong because photons do not have mass. Rather, they comprise oscillating electric and magnetic fields.

 Zain is wrong because photons separate electrons from atoms by the oscillating electric fields of photons interacting with the fields of electrons in atoms. This usually happens at a distance when photons are ‘near to’ atoms.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images by Peter Fairhurst (UYSEG).

**References**

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

Rego, F. and Peralta, L. (2006). Portuguese students' knowledge of radiation physics. *Physics Education,* 41(3)**,** 259.