**Most ionising**

Gamma photons (for example) are different to ultraviolet photons.

Some types of photons are more ionising than others.



**a.** Which statement about ionising radiation is correct?

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

|  |  |  |
| --- | --- | --- |
| **A** | Infrared is more ionising than ultraviolet. |  |
|  |  |  |
| **B** | Ultraviolet is more ionising than X-rays. |  |
|  |  |  |
| **C** | Gamma radiation is more ionising than ultraviolet. |  |
|  |  |  |
| **D** | Microwave radiation is more ionising than ultraviolet. |  |

**b.** What is the best reason for your answer to ***part a***?

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

|  |  |  |
| --- | --- | --- |
| **A** | It has a longer wavelength. |  |
|  |  |  |
| **B** | It has a higher frequency. |  |
|  |  |  |
| **C** | It causes more heating. |  |
|  |  |  |
| **D** | It is more radioactive. |  |

*Physics > Big idea PSL: Sound, light and waves > Topic PSL7: Electromagnetic waves > Key concept PSL7.2: Electromagnetic spectrum*

|  |
| --- |
| **Diagnostic question** |
| **Most ionising** |

**Overview**

|  |  |
| --- | --- |
| 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: | Explain why some types of electromagnetic radiation are more ionising than others. |
| Question type: | Two-tier multiple choice |
| Key words: | Radiation, ionisation, photon, frequency, wavelength, radioactive |

**What does the research say?**

The majority of students aged 12-18 (n=1246) find it hard to distinguish between ionising and non-ionising radiation (Rego and Peralta, 2006). 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 question**

Students should complete the questions 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 follow on question will give you insights into how they are thinking and highlight specific misconceptions that some may hold.

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**

a. C

b. B

**How to respond - what next?**

Gamma is more ionising than ultraviolet because it has a higher frequency. A useful analogy is the transmission of a pulse of several wavelengths along a rope or spring. A higher frequency pulse requires more energy to initiate the pulse and it transfers more energy than a lower frequency pulse.

Part a: Not all forms of radiation are ionising. Radio waves, microwaves, infrared and visible light are usually thought of as non-ionising.

 Some students may consider heating to be caused by ionisation and therefore select either option A or D. Others may think that option C is correct (which it is) because they are familiar with gamma radiation from radioactive decay and associate it with radioactivity.

Part b: Across the EM spectrum, wavelength decreases as frequency and photon energy increases.

Some students may choose option A because they have confused these relationships and believe a bigger wavelength is linked to greater photon energy.

Those choosing option C may associate heating with ionisation rather than heating with an increase in the movement of particles within matter.

Those choosing D may misunderstand the meaning of radioactivity and are confusing EM radiation created by radioactive decay with radioactive particles – which are unstable and may decay.

If students have misunderstandings about explaining why some types of electromagnetic radiation are more ionising than others, it can help to provide students with the opportunity to research different types of EM radiation and to investigate the mechanisms by which each type interacts with matter – and how the patterns of wavelength, frequency and photon energy vary across the EM spectrum.

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

* Response activity: Ready, steady, poster

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: 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.