

Physics &gt; Big idea PMA: Matter &gt; Topic PMA5: Nuclear physics

## Key concept (age 14-16)

### PMA5.3: Ionising radiation

#### Progression toolkit: Ionising radiation


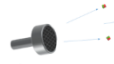

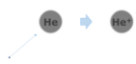
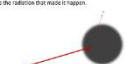
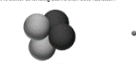




Learning focus	Some forms of radiation can ionise atoms or groups of atoms. Several properties of each form of ionising radiation are determined by its ionising power.				
As students' conceptual understanding progresses they can:	<div> <div>CONCEPTUAL PROGRESSION</div> <div></div> </div>				
	Describe the difference between radioactive particles and radiation. <b>P</b>	Describe what happens when radiation causes ionisation.	Explain why ionising radiation does not make objects radioactive*.	Explain how the ionising power of each ionising radiation affects its properties.	Explain radioactive contamination and how it differs from irradiation.
Diagnostic questions	Radioactive sources	Alpha ionisation	Radiation remains	Getting through stuff	Radioactive contamination
	Alpha particles			Ionising power	
Response activities		Beta ionisation	Irradiation	Blocking paper	Fukushima

Key:

**P** Prior understanding from earlier stages of learning

**B** Bridge to later stages of learning

*\*An exception to this rule is the example of high-energy gamma photons that may excite atomic nuclei.*

Radioactive sources	Alpha particles	Alpha ionisation	Radiation remains	Getting through stuff																																														
<p><b>BEST</b> STUDENT WORKSHEET</p> <p><b>Radioactive sources</b></p> <p>Radioactive sources are often used to demonstrate radioactivity. A warning sign alerts people to the dangers of what is inside.</p>  <p>All in the gaps to describe radioactive sources.</p> <p>You should only use the words <b>radioactive particles</b> or <b>radiation</b>.</p> <p>Each radioactive source contains _____.</p> <p>The alpha source emits alpha particles. Alpha particles are _____.</p> <p>The beta source emits beta particles. Beta particles are _____.</p> <p>The gamma source emits gamma photons. Gamma photons are _____.</p> <p>Each radioactive source is stored in a metal box made of lead. The lead box absorbs _____.</p> <p>_____ can decay and emit _____.</p> <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from <a href="http://www.BestEvidenceScienceTeaching.org">www.BestEvidenceScienceTeaching.org</a>. © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>	<p><b>BEST</b> STUDENT WORKSHEET</p> <p><b>Alpha particles</b></p> <p>Alpha particles are emitted by some radioactive isotopes. As it decays it emits alpha particles.</p>  <p>Resources and answer keys</p> <p>1. What is the best label to describe alpha particles? Put a tick (✓) in the box next to the best answer.</p> <p>A. Radioactive material <input type="checkbox"/></p> <p>B. Radioactive particles <input type="checkbox"/></p> <p>C. Radiation <input type="checkbox"/></p> <p>2. What is the best description of what alpha particles can do? Put a tick (✓) in the box next to the best answer.</p> <p>A. They can emit radiation. <input type="checkbox"/></p> <p>B. They can make atoms lose outer electrons. <input type="checkbox"/></p> <p>C. They can make atoms radioactive. <input type="checkbox"/></p> <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from <a href="http://www.BestEvidenceScienceTeaching.org">www.BestEvidenceScienceTeaching.org</a>. © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>	<p><b>BEST</b> STUDENT WORKSHEET</p> <p><b>Alpha ionisation</b></p> <p>Alpha particles are emitted by some radioactive isotopes. They move at high speed and can ionise atoms or groups of atoms.</p>  <p>What does an alpha particle do when it ionises an atom?</p> <p>For each statement, tick (✓) one column to show what you think.</p> <table border="1"> <tr> <th></th> <th>I am sure this is right</th> <th>I think this is right</th> <th>I think this is wrong</th> <th>I am sure this is wrong</th> </tr> <tr> <td>A. It can force off an outer electron.</td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> </tr> <tr> <td>B. It can force an electron off the nucleus.</td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> </tr> <tr> <td>C. Its electric charge can pull electrons off.</td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> </tr> <tr> <td>D. A direct hit is not needed.</td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> </tr> </table> <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from <a href="http://www.BestEvidenceScienceTeaching.org">www.BestEvidenceScienceTeaching.org</a>. © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>		I am sure this is right	I think this is right	I think this is wrong	I am sure this is wrong	A. It can force off an outer electron.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	B. It can force an electron off the nucleus.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	C. 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The atom gains an electric charge. <input type="checkbox"/></p> <p>B. The atom gains radiation. <input type="checkbox"/></p> <p>C. Energy is transferred to a moving electron. <input type="checkbox"/></p> <p>D. It decays. <input type="checkbox"/></p> <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from <a href="http://www.BestEvidenceScienceTeaching.org">www.BestEvidenceScienceTeaching.org</a>. © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>	<p><b>BEST</b> STUDENT WORKSHEET</p> <p><b>Getting through stuff</b></p> <p>Alpha, beta and gamma radiation can each have different effects on atoms (or off groups of atoms). This is called ionisation. Ionisation also affects the radiation that made it happen.</p>  <p>For each type of radiation pick two things that can stop it and a reason to explain why. Draw lines between columns to show what you think.</p> <table border="1"> <thead> <tr> <th>Radiation</th> <th>Can be absorbed by</th> <th>Best reason</th> </tr> </thead> <tbody> <tr> <td>Alpha</td> <td>Sheet of metal about 3 mm thick</td> <td>Excellent at ionising atoms.</td> </tr> <tr> <td>Beta</td> <td>Sheet of paper</td> <td>Good at ionising atoms.</td> </tr> <tr> <td>Gamma</td> <td>About 1 m of air</td> <td>Not very good at ionising atoms, but it decays.</td> </tr> <tr> <td></td> <td>Thick concrete wall</td> <td></td> </tr> <tr> <td></td> <td>About 5 cm of air</td> <td></td> </tr> <tr> <td></td> <td>Thick piece of metal like lead</td> <td></td> </tr> </tbody> </table> <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from <a href="http://www.BestEvidenceScienceTeaching.org">www.BestEvidenceScienceTeaching.org</a>. © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>	Radiation	Can be absorbed by	Best reason	Alpha	Sheet of metal about 3 mm thick	Excellent at ionising atoms.	Beta	Sheet of paper	Good at ionising atoms.	Gamma	About 1 m of air	Not very good at ionising atoms, but it decays.		Thick concrete wall			About 5 cm of air			Thick piece of metal like lead	
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Focused cloze	Simple multiple choice	Confidence grid	Two-tier multiple choice	Linking ideas																																														
<p><b>BEST</b> STUDENT WORKSHEET</p> <p><b>Ionising power</b></p> <p>Alpha and beta radiation can both ionise atoms (or groups of atoms). Alpha radiation is better at ionising atoms than beta radiation.</p>  <p>Alpha particle Beta particle</p> <p>An alpha particle is about 1000 times heavier than a beta particle. An alpha particle has a charge of +2. A beta particle has a charge of -1.</p> <p>Why is 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.</p> <p>A. An alpha particle is larger and has more mass. <input type="checkbox"/></p> <p>B. An alpha particle has more mass and a bigger electric charge. <input type="checkbox"/></p> <p>C. An alpha particle has a bigger electric charge and is larger. <input type="checkbox"/></p> <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from <a href="http://www.BestEvidenceScienceTeaching.org">www.BestEvidenceScienceTeaching.org</a>. © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>	<p><b>BEST</b> STUDENT WORKSHEET</p> <p><b>Radioactive contamination</b></p> <p>Radioactive contamination can be dangerous. Contaminated materials can cause harm. They need to be dealt with safely.</p>  <p>a. Which of these are examples of radioactive contamination? Put a tick (✓) in the box next to the best answer.</p> <p>A. W and Y <input type="checkbox"/></p> <p>B. W, X and Y <input type="checkbox"/></p> <p>C. X and Z <input type="checkbox"/></p> <p>D. Z <input type="checkbox"/></p> <p>W. Ration gas trapped in a room. Radioactive gas found naturally in some types of rock.</p> <p>X. Beta particles are absorbed by an aircraft's wing. Beta radiation is shown through aircraft wings to assist its flight.</p> <p>Y. Nuclear bomb tests can release a lot of radioactive material into the air. Most is blown away by the wind.</p> <p>Z. Gamma radiation is absorbed by cancer cells. Gamma radiation is shown through cancer cells to kill them.</p> <p>b. What is the best reason to explain how something is contaminated? Put a tick (✓) in the box next to the best answer.</p> <p>A. Radioactive particles move into it. <input type="checkbox"/></p> <p>B. Radiation moves into it. <input type="checkbox"/></p> <p>C. Radioactive particles change it, so it becomes radioactive. <input type="checkbox"/></p> <p>D. Radiation changes it, so it becomes radioactive. <input type="checkbox"/></p> <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from <a href="http://www.BestEvidenceScienceTeaching.org">www.BestEvidenceScienceTeaching.org</a>. © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>	<p><b>BEST</b> STUDENT WORKSHEET</p> <p><b>Beta ionisation</b></p> <p>Beta particles are emitted by some radioactive isotopes. They move at high speed and can ionise atoms or groups of atoms.</p>  <p>Some of these statements about beta ionisation are correct and some are wrong. Use the correct statements to explain how beta particles can cause ionisation.</p> <p>Start with: An argon atom has no overall charge.</p> <table border="1"> <tr> <td>If it brushes into an outer electron.</td> <td>Because it has the same number of electrons as protons.</td> </tr> <tr> <td>It can push an electron off an argon atom.</td> <td>Because it has the same number of electrons as neutrons.</td> </tr> <tr> <td>A direct hit is not needed.</td> <td>A beta particle is radioactive.</td> </tr> <tr> <td>A beta particle is a very, very fast electron with a negative charge.</td> <td>Its electric field repels electrons from a distance.</td> </tr> </table> <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from <a href="http://www.BestEvidenceScienceTeaching.org">www.BestEvidenceScienceTeaching.org</a>. © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>	If it brushes into an outer electron.	Because it has the same number of electrons as protons.	It can push an electron off an argon atom.	Because it has the same number of electrons as neutrons.	A direct hit is not needed.	A beta particle is radioactive.	A beta particle is a very, very fast electron with a negative charge.	Its electric field repels electrons from a distance.	<p><b>BEST</b> STUDENT WORKSHEET</p> <p><b>Irradiation</b></p> <p>Food is sometimes exposed to gamma radiation. This process is called irradiation. Irradiation can destroy organisms on food that may cause food poisoning. Irradiation can extend shelf life and keep food fresh for longer.</p>  <p>Some students are discussing irradiation.</p> <p>Vivienne: It will make the strawberries a little bit radioactive.</p> <p>Yamela: The strawberries will be changed a little bit by the radiation.</p> <p>Wanda: Gamma radiation will ionise atoms and destroy harmful bacteria.</p> <p>Wanda: After some time, there will be no gamma radiation in the strawberries.</p> <p>Yamela: It can kill insects on the strawberries.</p> <p>For answer</p> <p>1. Who is right about irradiation?</p> <p>2. Explain your answer.</p> <p>3. Write a warning about irradiation.</p> <p>4. What would you say to help them understand?</p> <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from <a href="http://www.BestEvidenceScienceTeaching.org">www.BestEvidenceScienceTeaching.org</a>. © University of York Science Education Group. Distributed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>	<p><b>BEST</b> STUDENT WORKSHEET</p> <p><b>Blocking paper</b></p> <p>A radioactive source contains some americium (Am). Americium can emit alpha radiation and gamma radiation. A Geiger-Müller tube is used to detect the radiation.</p>  <p>Predict</p> <p>If a sheet of paper is put between the source and the Geiger-Müller tube, what do you think will happen to the count rate?</p> <p>Explain</p> <p>Why do you think this will happen?</p> <p>Watch a demonstration</p> <p>Observe</p> <p>When a sheet of paper was placed between the source and the Geiger-Müller tube, describe what happened to the count rate.</p> <p>Explain</p> <p>How your prediction and explanation connect?</p> <p>To improve your first explanation to explain what happens more clearly.</p> <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from <a href="http://www.BestEvidenceScienceTeaching.org">www.BestEvidenceScienceTeaching.org</a>. © University of York Science Education Group. 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Simple multiple choice	Two tier multiple choice	Explanation story	Talking heads	PEOE																																														


## Fukushima

BEST

STUDENT WORKSHEET

### Fukushima

In 2011, there were three explosions at the Fukushima nuclear power station in Japan. An earthquake in the Pacific Ocean caused a tsunami and, a short time later, a giant tsunamis high wall of water hit the power station. This triggered a chain of events, leading to the explosions and the radioactive contamination of the surrounding area.



A deep flowing radioactive contamination spread the power station three weeks after the explosions.

The safe limit of exposure to radiation is about 1000 mSv/year. In 2011, the limit was exceeded in 2011.

Some students are discussing radioactive contamination around Fukushima.

**David:** A huge amount of radioactive material was blasted into the air.

**Ella:** The radiation was blown across the area by the wind.

**Henry:** Radiation from the power station made the air radioactive.

**Fiona:** Radioactive particles from the power station can be breathed in.

**Grace:** Over time, the contamination will get less and less.

**To answer:**

1. Who is right about the radioactive contamination around Fukushima?  
*Circle your answer.*
2. Who is wrong about the radioactive contamination around Fukushima?  
*What would you say to help them understand?*

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## Talking heads