**Metal case**

This refrigerator has a metal case.

It has an earth wire connected to the metal case.

The earth wire is not part of the main circuit.



The mains cable of the fridge has been pulled and the live wire is loose.

It touches the metal case.

What do you think will happen?

For each statement, tick (✓) **one** column to show what you think*.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** | A big current flows through the earth wire at once. |  |  |  |  |
| **B** | The fuse melts when someone touches the fridge. |  |  |  |  |
| **C** | The fridge stops working. |  |  |  |  |

*Physics > Big idea PEM: Electricity and magnetism > Topic PEM8: Mains electricity > Key concept PEM8.1: Electrical safety*

|  |
| --- |
| **Diagnostic question** |
| **Metal case** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Fuses, circuit breakers and earth connections, used correctly, can prevent excess mains current and electric shocks. |
| Observable learning outcome: | Explain how earth wires can protect people from electric shock. |
| Question type: | Confidence grid |
| Key words: | Metal case, short circuit, earth wire, fuse |

**What does the research say?**

It is a common misunderstanding that if the plug connecting an appliance to the mains contains a fuse, then the appliance cannot give a person an electric shock (Goodenough, 2007). This is not true because a current of 0.15 A through a person can kill them in about 0.1 s and the smallest fuse in a mains plug (in the UK) stops current flowing only when it exceeds 3 A.

A residual current circuit breaker (RCCB) would stop current flowing through the person being shocked in about 0.04 seconds. Without a RCCB fitted, a person touching an exposed live connection from the mains could receive a fatal electric shock, which is why electric lawnmowers and hedge-trimmers should always be used with a RCCB, because accidentally cutting trailing wires is relatively common.

However, a fuse can turn off the current *before* a person touches the live metal casing of a faulty appliance, if the appliance is wired correctly. Common causes of a metal casing becoming live is a movement and pulling on connecting cables that cause the live wire to become loose, or physical damage to the appliance. The casing of a metal appliance should be connected to an earth wire. If the live wire touches the casing there will then be a short circuit, a large current will flow, and the fuse will melt, turning off the current. This happens the first time the appliance is turned on after the fault is caused. Some demonstrations, of how a fuse works, risk giving the false impression that excess current only flows and the fuse makes the appliance safe when it is touched by a person (Harrison, 2017).

**Ways to use this question**

Students should complete the confidence grid 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.

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**

Statements A and C are correct; and statement B is wrong.

**How to respond - what next?**

As soon as the live wire touches the metal case it makes a complete circuit with the Earth wire. An excessive current flows and melts the fuse, which turns off the electricity. The metal case no longer has a live connection and is safe to touch without risk of electric shock.

B It is a common misunderstanding that the fuse melts only when a person touches the fridge. There is not a scientific explanation for how that would happen because the short circuit is through the earth wire and not through the person touching the appliance.

If students have misunderstandings about how the earth wire can make an appliance with a metal case safe, it can help to provide students with the opportunity to observe a demonstration of how the earth wire works. Once they have observed this, they could work in pairs or small groups to describe how it works in their own words and perhaps to explain why only appliances with metal cases require earth wires.

The following BEST ‘response activity’ could be used in follow-up to this diagnostic question in order to demonstrate how an earth wire works:

* Response activity: Earthing

**Acknowledgments**

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Image by buntom from Pixabay.

**References**

Goodenough, H. (2007). Electrical safety. *Catalyst.* Oxfordshire: Philip Allan Updates.

Harrison, M. (2017). Demonstrating Earth connections and fuses working together. *Physics Education,* 52(2)**,** 023008.