**Hot iron**

Touching an iron in the wrong place can burn.

The hot metal on it can damage the cells in your skin.

**a.** If you touched the hot metal on an iron, what length of time would damage your skin the most?

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

|  |  |  |
| --- | --- | --- |
| **A** | 1 second. |  |
|  |  |  |
| **B** | 2 seconds. |  |
|  |  |  |
| **C** | 3 seconds. |  |
|  |  |  |
| **D** | The same damage for 1, 2 or 3 seconds. |  |

**b.** What is the best reason for your last answer?

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

|  |  |  |
| --- | --- | --- |
| **A** | More energy flows from the metal. |  |
|  |  |  |
| **B** | More heat particles flow from the metal. |  |
|  |  |  |
| **C** | Particles in the metal are vibrating against the skin for longer. |  |
|  |  |  |
| **D** | Particles in the metal are vibrating the same each time. |  |

*Physics > Big idea PMA: Matter > Topic PMA3: Energy of moving particles > Key concept PMA3.1: Transfer of energy by conduction*

|  |
| --- |
| **Diagnostic question** |
| **Hot iron** |

**Overview**

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| --- | --- |
| Learning focus: | Energy is transferred through a solid away from regions of higher temperature as its particles are caused to vibrate more vigorously. |
| Observable learning outcome: | Describe how the sensation of hotness is caused by vibrating particles. |
| Question type: | Two-tier multiple choice |
| Key words: | Heat, energy, particle, vibrate |

|  |  |
| --- | --- |
| **P** | **PRIOR UNDERSTANDING**  This diagnostic question probes understanding of ideas that are usually taught at age 11-14, to aid transition from earlier stages of learning. |

**What does the research say?**

The notion that heat and cold are material substances that can flow from one place to another seem to be both common and persistent (Engel Clough and Driver, 1985; Hatzikraniotis et al., 2010; Thomaz et al., 1995). Engel Clough and Driver (1985) found that almost all 12- to 16-year-olds understood that ‘heat’ travelled through metals, but often described heat flowing rather than the actual mechanism. Hatzikraniotis et al. (2010) reported that the majority of 13- to 14-year-olds (n=24) described thermal conduction as the flow of hot particles. In their study in Portugal, Thomaz et al. (1995) similarly found that before teaching, 42% of 14- to 15-year-olds (n=79) wrongly thought of ‘heat’ (or ‘cold’) as a substance.

**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** 3 seconds

b. **C** Particles in the metal vibrate against the skin for longer.

**How to respond - what next?**

Most, if not all, students should choose the correct answer for part a. A few may choose answer D because they think that all the damage is caused instantly on first contact.

In part b, it would be expected that about half of students choose answer A or B, if they have not learnt about thermal conduction in earlier lessons. Both of these answers indicate the misunderstanding that something is flowing from the metal to heat the finger.

Answer A simply gives a name to the observation that something from the metal has burnt the finger, but it does not describe the *mechanism* for how this has happened. Answer B is more naïve because it gives ‘heat’ the material form of a fluid. Students choosing answer B are likely to have a deeper misunderstanding about the particle model of solids.

Answer D indicates that students understand that particles in a solid vibrate at the same rate, on average, when the metal is at a particular temperature. These students are probably linking the damage caused to the vigour of particles’ vibrations and not to the duration of contact.

The particles are vibrating with the same vigour each time, so it is the duration of contact that makes the difference, with extra damage continuing to be caused throughout.

If students have misunderstandings about how the sensation of hotness is caused by vibrating particles, it can help to model what is happening in order to illustrate what is happening on a sub-microscopic scale. The first step in doing this is to clarify with students that they understand the particle structure of a solid. Careful questioning should elicit the understanding that a metal block comprises of metal particles (ions) that are vibrating about fixed positions and that they vibrate more quickly when the metal is hotter. The effect that these can have on another material, that is touching the surface of the metal, can be graphically demonstrated by pounding a fist vigorously into an open hand for different lengths of time. The fist represents a vibrating metal ion hitting the surface of the hand.

Asking students to write down (or draw) individual explanations can help consolidate understanding and can be a quick check for persisting misunderstanding.

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

* Response activity: Feel the heat

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG), with iron by PublicDomainPicturesfrom Pixabay and hand by Clker-Free-Vector-Images from Pixabay

**References**

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