**Hot blocks**

Touching hot metal can burn.

The hot metal can damage the cells in your skin.



**a.** If you touched one of these blocks of metal for two seconds, which would burn you the most?

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



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

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

|  |  |  |
| --- | --- | --- |
| **A** | More heat particles flow from the block. |  |
|  |  |  |
| **B** | More energy flows from the block. |  |
|  |  |  |
| **C** | There are more particles in this block that are vibrating. |  |
|  |  |  |
| **D** | The particles in this block are vibrating more quickly. |  |

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

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| **Diagnostic question** |
| **Hot blocks** |

**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 |

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| --- | --- |
| **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 80oC

b. D The particles are vibrating more quickly.

**How to respond - what next?**

Most, if not all, students should choose the correct answer for part a.

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 block to heat the finger.

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

Answer C may indicate that students are thinking about ‘heat particles’ and the understanding of students who give this answer will need to be unpicked to find out.

The particles in the block at 80oC are moving more quickly, on average, than the particles in the other blocks. They can therefore hit skin cells at a higher speed and cause more damage to them. (Strictly, hitting the skin at a higher speed means there is a greater change of momentum of the particles on impact. The force they exert is equal to their rate of change of momentum caused by the collision.)

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 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 into an open hand with increasing vigour as the metal is heated. 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 horseshoe by Cyrille Remacly from Pixabay and hand by Clker-Free-Vector-Images from Pixabay

**References**

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