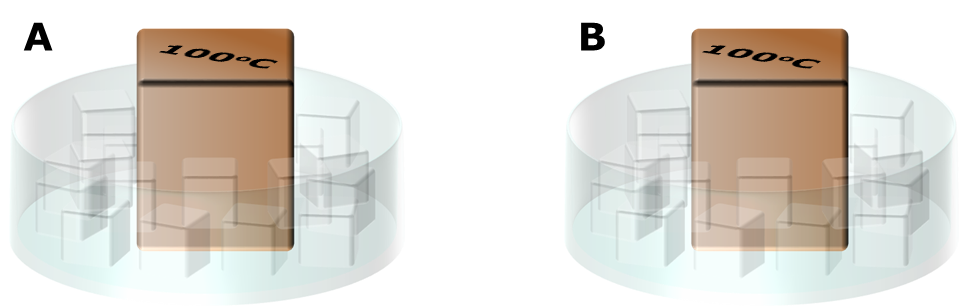
**Metal and ice**

1. Two metal blocks have the same mass.

One block is at 100oC and is made of copper.

The other is also at 100oC and is made of copper.



Copper has a specific heat capacity of 385 J/kg/oC

Which block will melt the most ice in five minutes?

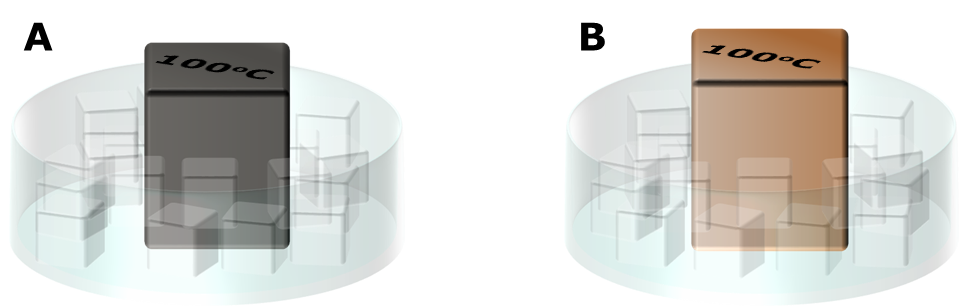
*Put a tick (✓) in the box next to the best answer.*

|  |  |  |
| --- | --- | --- |
| **A** | Block A melts the most ice. |  |
|  |  |  |
| **B** | Block B melts the most ice. |  |
|  |  |  |
| **C** | Both melt the same amount of ice. |  |

2. Two metal blocks have the same mass.

One block is at 100oC and is made of lead.

The other is at 100oC and is made of copper.



Lead has a specific heat capacity of 160 J/kg/oC

Copper has a specific heat capacity of 385 J/kg/oC

Which block will melt the most ice in five minutes?

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

|  |  |  |
| --- | --- | --- |
| **A** | Block A melts the most ice. |  |
|  |  |  |
| **B** | Block B melts the most ice. |  |
|  |  |  |
| **C** | Both melt the same amount of ice. |  |

*Physics > Big idea PMA: Matter> Topic PMA3: Energy of moving particles > Key concept PMA3.2: Specific heat capacity*

|  |
| --- |
| **Diagnostic question** |
| **Metal and ice** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Specific heat capacity is the amount of energy added to the thermal store of a material in order to increase the temperature of 1kg of that material by 1oC. |
| Observable learning outcome: | Describe what a material’s specific heat capacity indicates about the amount of energy transferred as it changes temperature. |
| Question type: | Simple multiple choice |
| Key words: | Energy, temperature, mass, specific heat capacity, thermal store |

|  |  |
| --- | --- |
| **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?**

Most students correctly understand that raising the temperature of a particular object also increases the energy in its thermal store. However, fewer than half (n=342) of 11- to 15-year-olds in a study by Gonen and Kocakaya (2010) understood that, when they are at the same temperature, a larger mass of a material contains more energy in its thermal store than a smaller mass of the same material. It is common for students to think that an object at a higher temperature has more energy in its thermal store than an object at a lower temperature, even when the hotter object has a much smaller mass.

By age 13-14 Adadan and Yavuzkay (2018) found that about 50% of Turkish students (n=305) showed a clear scientific understanding of thermal concepts, increasing to 65% of those age 15-16 (n=213). However, they also found that 10-20% of 13- to 14-year-olds continued to regard heat as a material substance that could flow and that the numbers of those with this misunderstanding did not change much with age.

In addition to mass and temperature, the other factor that affects the amount of energy in the thermal store of a material is the specific heat capacity of the material. This is a measure of the amount of energy needed to raise one kilogramme of a material by one degree C. All sort of factors affect what the specific heat capacity of a particular material is. Never-the-less, specific heat capacity is a value that can be calculated from just a few measurements and then used to predict how a material will respond to heating or cooling.

Herrington (2011) suggests the traditional method of teaching specific heat capacity, which involves learning the related definitions and equations and using equations to determine the specific heat capacity in a laboratory setting contributes to confusion about specific heat capacity. Although students are often able to calculate values with the equation, they often do not often understand what specific heat capacity tells us about a material. Instead it can be more effective to introduce students to the concept of heat capacity and to guide them to make connections to their own personal experiences before introducing definitions and equations.

**Ways to use this question**

Students should complete the question 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 answers to the question will show you whether students understood the concept sufficiently well to apply it correctly.

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**

1. C

2. B

**How to respond - what next?**

Most, if not all, students should choose answer C for question 1 because the two situations presented are identical.

Question 1 has been presented to provide a comparison to question 2, in which two more blocks of equal mass and equal temperature are compared. If students have maintained a misunderstanding that temperature is a measure of energy, then they may predict that each block contains the same amount of energy and will melt equal amounts of ice.

The majority of students however, are likely to recognise that the two blocks are made of different materials and for that reason understand that the blocks may melt different amounts of ice, perhaps without being able to predict which block melts the most ice.

In this example copper has a bigger specific heat capacity than lead, so for equal masses of each metal it requires more energy to increase the temperature of copper by a set amount, and copper releases more energy for each degree C that it cools.

If students have misunderstandings about what a material’s specific heat capacity indicates about the amount of energy transferred as it changes temperature, it is important for them to understand qualitatively how materials with differing specific heat capacities respond to heating and cooling.

The following BEST ‘response activity’ could be used in follow-up to this diagnostic question in order to illustrate clear differences between materials with different specific heat capacities:

* Response activity: Calorimeters

It is worth noting here that the *reasons why* materials have different specific heat capacities to each other is largely beyond the scope of a science course at this level. Some students may feel they do not understand specific heat capacity if they do not understand what causes different materials to have different specific heat capacities. It may be helpful to explain explicitly that specific heat capacity can, at this stage, be thought of as just a useful measurement that enables us to predict how different materials respond to heating or cooling, with its causes being considered in later stages of learning.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

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