**Temperature change**

The *change* of energy in a thermal store can be calculated:

**Change in energy**

**Mass**

**Specific heat capacity**

**Change in temperature**

**=**

**x**

**x**

**ΔE** = **m** x **c** x **ΔΘ**

*Out loud this says: delta E equals m times c times delta theta.*

*Delta (Δ) is a Greek letter that is used as shorthand for writing: a change in.*

|  |  |
| --- | --- |
| ΔE is measured in Joules | J |
| m is measured in kilograms | kg |
| c is measured in Joules per kilogram per degree C | J/kg/oC |
| ΔΘ is measured in degrees C | oC |

A block of metal is heated and its temperature increases.

**1.** What happens to the increase in temperature if the mass of the block is doubled?

ΔE = m x c x ΔΘ

ΔE = **m** x c x ΔΘ

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

|  |  |  |
| --- | --- | --- |
| **A** | Two times bigger. |  |
|  |  |  |
| **B** | Same size. |  |
|  |  |  |
| **C** | Two times smaller. |  |

**2.** What happens to the increase in temperature if the mass of the block is doubled *and* the energy transferred to it is doubled?

ΔE = m x c x ΔΘ

**ΔE** = **m** x c x ΔΘ

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

|  |  |  |
| --- | --- | --- |
| **A** | Four times bigger. |  |
|  |  |  |
| **B** | Two times bigger. |  |
|  |  |  |
| **C** | Same size. |  |
|  |  |  |
| **D** | Two times smaller. |  |

**3.** What happens to the increase in temperature if a block is heated that has half the specific heat capacity?

ΔE = m x **c** x ΔΘ

ΔE = m x c x ΔΘ

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

|  |  |  |
| --- | --- | --- |
| **A** | Two times bigger. |  |
|  |  |  |
| **B** | Same size. |  |
|  |  |  |
| **C** | Two times smaller. |  |

**4.** What happens to the increase in temperature if the mass of the block is doubled *and* a block is used that has twice the specific heat capacity?

ΔE = m x c x ΔΘ

ΔE= **m** x **c** x ΔΘ

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

|  |  |  |
| --- | --- | --- |
| **A** | Four times bigger. |  |
|  |  |  |
| **B** | Two times bigger. |  |
|  |  |  |
| **C** | Same size. |  |
|  |  |  |
| **D** | Two times smaller. |  |
|  |  |  |
| **E** | Four times smaller. |  |

**5.** What happens to the increase in temperature if the mass of the block is doubled *and* the energy transferred to it is four times bigger?

**ΔE** = **m** x c x ΔΘ

ΔE = m x c x ΔΘ

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

|  |  |  |
| --- | --- | --- |
| **A** | Four times bigger. |  |
|  |  |  |
| **B** | Two times bigger. |  |
|  |  |  |
| **C** | Same size. |  |
|  |  |  |
| **D** | Two times smaller. |  |
|  |  |  |
| **E** | Four times smaller. |  |

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

|  |
| --- |
| **Diagnostic question** |
| **Temperature change** |

**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: | Predict how one quantity in the equation ΔE = mcΔΘ is affected by changes to other quantities. |
| Question type: | Simple multiple choice |
| Key words: | Energy change, temperature change, mass, specific heat capacity, thermal store |

**What does the research say?**

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.

One way to think about specific heat capacity is as a measure of how hard it is to change the temperature of a material. For two objects of the same mass, the one with the bigger specific heat capacity will be harder to warm up as it requires more energy to increase its temperature by 1oC.

In this progression toolkit an understanding of the physical meaning of specific heat capacity is developed before introducing its formal definition and the mathematical equation from which it can be calculated. This allows explicit links to be made between students’ physical understanding and the mathematical operations, and this helps students to understand the equation in terms of its implications in the real world (Redish and Kuo, 2015).

This diagnostic question can be used to check whether students have made some of these necessary links.

**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, two times smaller.

2. C, same size.

3. A, two times bigger.

4. E, four times smaller.

5. B, two times bigger.

**How to respond - what next?**

These questions require students to balance the equations, so that if a value on one side increases (or decreases) then the value on the other side must change in the same way. They encourage students to think about what will happen to the temperature of a block when other physical variables are changed and to use their physical experience to work out a sensible answer.

It is common for students who do not fully understand what they are doing to combine the numbers they are given using mathematical functions that have been selected wrongly. The distractors in each of these questions are values obtained when students do this.

If students have misunderstandings about predicting how one quantity in the equation ΔE = mcΔΘ is affected by changes to other quantities, a useful strategy is to guide them through what the (wrong) answer they have chosen means physically to see if it is sensible.

For example a common wrong answer to question 1 is A: the temperature change will be two times bigger. Careful questioning should elicit the understanding that the same amount of energy cannot heat twice the mass to twice the temperature. If there is twice the mass there is only half the energy available to heat the original mass and so the temperature increase is half as big.

Giving students the opportunity to work in pairs or in small groups to explain each example in terms of what is happening physically, can help develop a better understanding by encouraging the social construction of new ideas through dialogue.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

Herrington, D. G. (2011). The heat is on: an inquiry-based investigation for specific heat. *Journal of Chemical Education,* 88(11)**,** 1558-1561.

Redish, E. F. and Kuo, E. (2015). Language of physics, language of math: Disciplinary culture and dynamic epistemol. *Science and Education,* 24**,** 561-590.