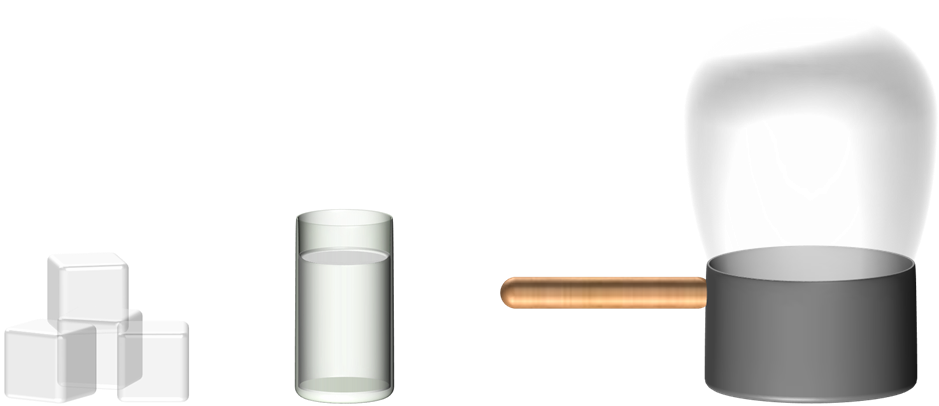
**The state of water**

Water can be in a solid state, a liquid state or a gas state.



Which statement do you think best describes what happens as a substance changes state?

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

|  |  |  |
| --- | --- | --- |
| **A** | The type of molecule of the substance changes. |  |
|  |  |  |
| **B** | The mass of the molecules of the substance changes. |  |
|  |  |  |
| **C** | The shape of the molecules of the substance changes. |  |
|  |  |  |
| **D** | The connection between the molecules of the substance changes. |  |

*Physics > Big idea PMA: Matter > Topic PMA3: Energy of moving particles > Key concept PMA3.3: Specific latent heat*

|  |
| --- |
| **Diagnostic question** |
| **The state of water** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Specific latent heat (of a particular change of state) is the amount of energy needed to change the state of 1 kg of a substance without changing its temperature. |
| Observable learning outcome: | Use the particle model to describe what happens to a substance when it changes state. |
| Question type: | Simple multiple choice |
| Key words: | Particle, molecule, solid state, liquid state, gas state |

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

It is quite possible to introduce specific latent heat in terms of energy transfers without mentioning the particulate model of matter, but it can be helpful to students to make some links between the two sets of ideas (Millar, 2011). This is because the particulate model can be used to explain the *mechanism* of how energy is transferred during a change of state when there is no corresponding change of temperature.

In a very large study of students in the United States, called Project 2061, the American Association for the Advancement of Science (AAAS) found that students age 14-18 held the following misunderstandings about particles during a change of state:

* The identity of the molecules of a substance changes during a phase change. (14% held this misunderstanding)
* Molecules change weight/mass during a phase change. (14%)
* Molecules change size during a phase change. (9%)
* Matter is destroyed during boiling. (7%)
* Matter is destroyed during melting. (10%)
* The molecules of a substance break down into individual atoms when the substance boils. For example, molecules of water become atoms of hydrogen and oxygen when water boils. (34%)

Research by Johnson (1998) shows that students’ particle diagrams often show the spacing for particles in a liquid as being in between the spacing for the solid state and the gas state. It has also shown that students have very little appreciation of the idea of the intrinsic motion of particles.

In order to understand the mechanisms that explain specific latent heat, students need a clear understanding of the motion and arrangement of the particles of a substance in each of its solid, liquid and gas states and to understand that particles in each state are otherwise identical. The BEST chemistry key concept CPS1.1 *Particle model for the solid, liquid and gas states* can be used to review and develop students’ understanding of these ideas.

**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**

D The connection between molecules of the substance changes.

**How to respond - what next?**

This question addresses the understanding that particles do not change during a change of state, rather it is their movement and their connection to each other that changes.

In Project 2061 (AAAS) the responses of 2769 US students age 14-18 to this question were as follows:

* The type of molecules of the substance changes, 15%
* The mass of the molecules of the substance changes, 17%
* The shape of the molecules of the substance changes, 21%
* The connection between molecules of the substance changes, 48%

When explaining changes of state in general terms, rather than for a particular change of state, more students appear to revert to non-scientific explanations. This suggests they have not fully integrated the scientific understanding into their conceptual frameworks.

If students have misunderstandings about using the particle model to describe what happens to a substance when it changes state, it can help to model how the particle model can be used to accurately explain changes of state. The following BEST ‘response activity’ could be used in follow-up to this diagnostic question:

* Response activity: The state we’re in

**Acknowledgments**

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Images: Peter Fairhurst (UYSEG).

**References**

AAAS. *Science Assessment Topic: Atoms, Molecules and States of Matter* [Online]. Available at: <http://assessment.aaas.org/> [Accessed July 2020].

Millar, R. (2011). Energy. In Sang, D. (ed.) *Teaching Secondary Physics.* London: Hodder Education.