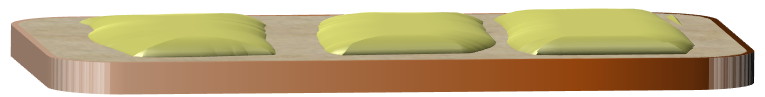
**Cheese on toast**

Kieran uses a hot grill to make cheese on toast.

Under the grill the cheese melts and becomes a liquid.



Which statement best explains why the cheese becomes a liquid?

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

|  |  |  |
| --- | --- | --- |
| **A** | Some of the cheese molecules get smaller. |  |
|  |  |  |
| **B** | Some of the cheese molecules are destroyed. |  |
|  |  |  |
| **C** | The cheese molecules change into water molecules. |  |
|  |  |  |
| **D** | The cheese molecules are more loosely connected to each other. |  |

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

|  |
| --- |
| **Diagnostic question** |
| **Cheese on toast** |

**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 |

|  |  |
| --- | --- |
| **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 cheese molecules are more loosely connected to each other.

**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. A significant minority of students are likely to persist in thinking particles change in the same way as the observed macroscopic properties of the substance.

In Project 2061 (AAAS) the responses of 1105 US students age 14-18 to a question corresponding to this one were as follows:

1. Some molecules get smaller, 11%
2. Some molecules are destroyed, 10%
3. The molecules change into water molecules, 14%
4. The molecules are more loosely connected to each other, 65%

It will be surprising to some that students may think molecules change into water as a substance melts. This misunderstanding may stem from their learning about solids dissolving in water. It is common for students to confuse the terms *dissolving* and *melting*.

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. Evidence from earlier work demonstrates that mass is conserved during a change of state and in the case of melting can be demonstrated by measuring the mass of ice in a sealed container at the start of a lesson and then at the end of the lesson when it has melted.

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

* Response activity: The state we’re in

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG), based on item AM035004 of Project 2061 (AAAS).

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.