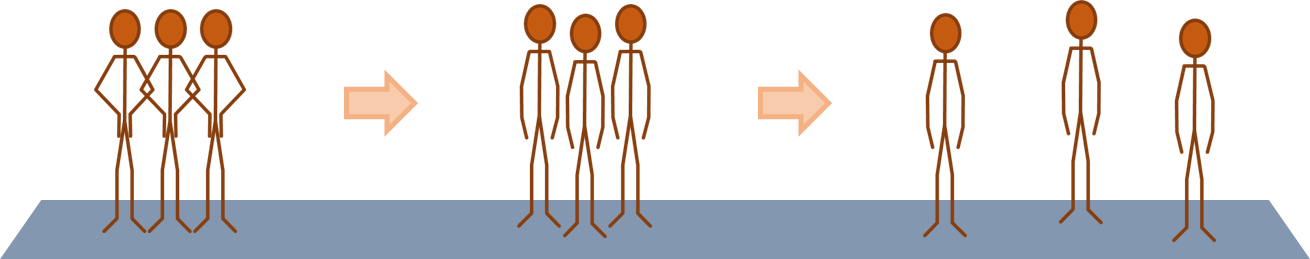
**The state we’re in**

Some students are modelling changing states.

They want to show how solids melt and how liquids boil.



**To answer**

1. State three ways in which this is a good representation of changing states.

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1. State three ways in which this is not an accurate representation of changing states.

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1. Use the particle model to describe how solids melt and liquids boil.

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

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| **Response activity** |
| **The state we’re in** |

**Overview**

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| 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. |
| Activity type: | Critiquing a representation |
| Key words: | Particle, molecule, solid state, liquid state, gas state |

This activity can help develop students’ understanding by addressing the sticking-points revealed by the following diagnostic questions:

* Diagnostic question: Cheese on toast
* Diagnostic question: Boiling water
* Diagnostic question: The state of water

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| --- | --- |
| **P** | **PRIOR UNDERSTANDING**  This activity explores 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 boil. (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 activity**

Students should complete this activity in pairs or small groups, and the focus should be on the discussions. It is through the discussions that students can check their understanding and rehearse their explanations.

Philosophically science can be said to be a description of the ‘best model’ we have for the world. In this activity students should identify ways in which this particular model is a good representation of the real world, and ways in which it is not.

Students should work together to answer the questions on either the worksheet or the PowerPoint. Giving each group one worksheet to complete between them is helpful for encouraging discussion, but each member should be able to report back to the class. Listening in to the conversations of each group will often give you insights into how your students are thinking.

Ending with the students completing the worksheet or questions from the PowerPoint individually, might help them to consolidate their learning.

*Differentiation*

You may choose to use simplified worksheets for some students, for example with gaps to fill in so they can focus on the science. In some situations it may be more appropriate for a teaching assistant to read and/or scribe for one or two students.

**Expected answers**

1. This is a good representation of changing states because:

* The particles are physically the same in each state.
* In the solid and liquid states the particles are very close together.
* In the solid the particles are fixed in place, but they are free to move in the liquid and gas states.
* The particles in the gas state have large spaces between them and can be squashed much more closely together.

2. This is not an accurate representation of changing states because:

* There are unimaginably large numbers of particles in a real solid, liquid or gas.
* In reality the particles in a liquid are still loosely connected to each other.
* In reality the particles in a gas are much further apart.
* The movement of the particles in each state is not shown.

3. As a substance melts its particles begin to vibrate so much that the connections between them become much looser. The particles are able to move around because they are no longer held in a fixed position, but loose connections still hold them closely together. The particles themselves do not change.

As a substance boils its particles begin to move so quickly that they become separated from each other. As they bump into each other they push apart and the gas fills much more space than the liquid. The particles themselves do not change.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

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.