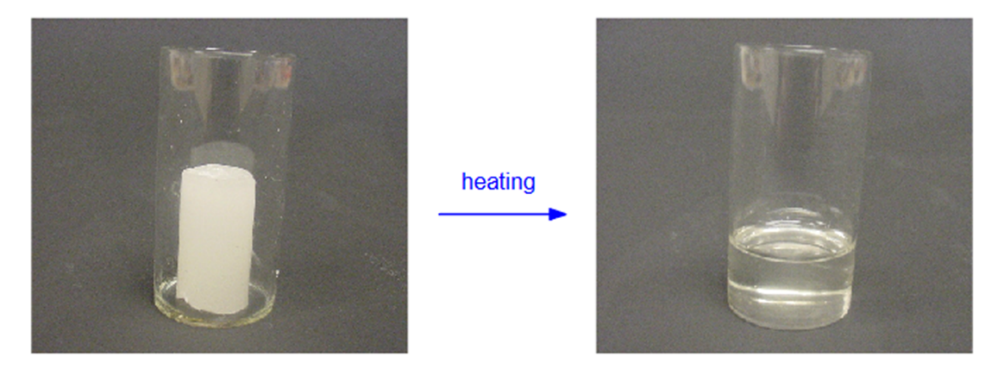
**Explaining melting**

1. These pictures show wax that has melted on heating.



Which best explains the change from solid to liquid?

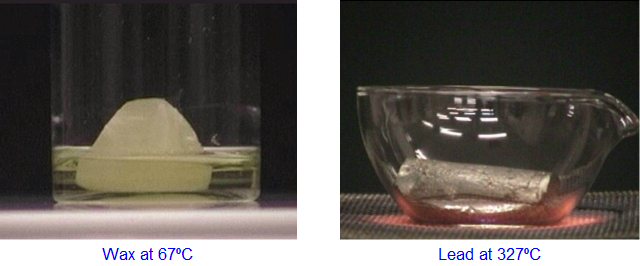
A The particles move apart.

B The wax around the particles melts.

C Solid particles (hard) change to liquid particles (runny).

D The particles start to move about from place to place, keeping close together.

1. Lead must be heated to a higher temperature than wax before it melts.



Which best explains why lead melts at a higher temperature?

A Lead is harder and stronger than wax.

B Lead is a better conductor of heat.

C Lead particles are closer together than wax particles.

D The attraction between lead particles is stronger.

*Chemistry > Big idea CPS: Particles and structure > Topic CPS1: Substances and mixtures > Key concept CPS1.1 Particle model for the solid, liquid and gas states*

|  |
| --- |
| **Diagnostic question** |
| **Explaining melting** |

|  |  |
| --- | --- |
| Learning focus: | Understand a basic particle model of matter that can explain the properties of substances in the solid and liquid states. |
| Observable learning outcome: | Use the particle model to explain why substances have different melting points. |
| Question type: | simple multiple choice |
| Key words: | solid, liquid, melt, state, particle |

**What does the research say?**

Research by Johnson and Papageorgiou (2010) recommends that the particle model is used to explain why substances melt at different temperatures. These differences arise from differences between the forces of attraction between particles. The state of a substance results from how these forces of attraction compare with the energy of the movement of the particles (which depends upon the temperature). When a substance melts the particles have sufficient energy to overcome these forces and move, whilst still staying close together.

It should be noted that use of the term ‘attraction’ is inconsistent with later understanding of a chemical bond as a balance between attraction and repulsion. For this reason, Johnson suggests that alternative terminology, such as ‘ability to hold’ may be preferable.

Teaching students to classify substances as being solids, liquids or gases can lead to the misunderstanding that solids, liquids and gases are different types of substance. This approach, that focuses on the particles, reinforces that it is one substance that changes state and that the temperature at which this happens is dependent upon the forces of attraction between the particles.

**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.

**Expected answers**

1 D 2 D

**How to respond - what next?**

Question 1 addresses the explanation for melting; that is the essential difference between the solid and liquid states.

Particle spacing can be overemphasised at the expense of particle movement in explaining the difference between the solid and liquid states leading to the selection of option A. The key difference between the solid and liquid states is in the movement of the particles – fixed places versus moving from place to place. The increase in particle spacing when a substance changes from the solid to liquid state is quite small (very minor compared to the change from liquid to gas).

Option B suggests the student still thinks of particles as being embedded within a continuous substance. Option C implies that the student is attributing macroscopic properties to individual particles.

Question 2 addresses the explanation for why substances have different melting points. It targets the idea of the strength of attraction between particles.

Since undue significance is commonly given to spacing, option C is likely to be attractive to many students. Option A gives a macroscopic property which is plausibly associated with melting point but is not an explanation. Option B gives a property which taps into confusion surrounding heat and temperature.

A good response to finding a misunderstanding, could be to teach the idea to the class and then give the students an activity in which they can practise using the concept so that they can consolidate their understanding. Responses often work best when the activities involve paired or small group discussions, which encourage social construction of new ideas through dialogue. In particular, students need to consider differences in the force of attraction between particles.

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

* Particle explanations - melting

**Acknowledgments**

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Images: ASK

**References**

Johnson, P. and Papageorgiou, G. (2010). Rethinking the Introduction of Particle Theory: A Substance-based framework. *Journal of Research in Science Teaching.* 42(2) 130-150