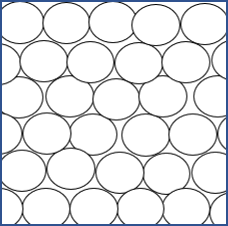
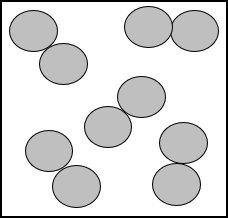
**Element differences**

1. Copper is an element. All its atoms are joined together in a single giant structure.



Chlorine is also an element. Its atoms are joined in pairs. It is made up of lots of separate molecules.



Which statement best explains why chlorine has a lower boiling point than copper?

A Forces of attraction between chlorine atoms are weak.

B Forces of attraction between chlorine molecules are weak.

C Chlorine molecules are further apart than copper atoms.

D Chlorine atoms have a lower mass than copper atoms.

*Chemistry > Big idea CPS: Particles and structure > Topic CPS2: Elements and compounds > Key concept CPS2.1: Atoms and molecules*

|  |
| --- |
| **Diagnostic question** |
| **Element differences** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | The properties of elements and compounds arise from the structural arrangement of their constituent atoms. |
| Observable learning outcome: | Explain differences in melting and boiling points between elements in terms of their structure (separate molecules or a single giant structure). |
| Question type: | simple multiple choice |
| Key words: | atom, molecule, boiling point, force of attraction |

**What does the research say?**

This learning outcome is inspired by the fourth unit developed for a study (Johnson, 2000) into the development of students’ understanding of the concept of substance. In this study elements and compounds were explained in terms of atoms and molecules with both ‘molecular’ and ‘giant’ structures being given as possibilities. This is earlier than these ideas are typically introduced in chemistry courses however the idea is useful in explaining, in general terms, the low and high melting points of different substances.

At this stage, whilst considering changes of state, the emphasis should be on the substance remaining the same. Later, when studying chemical change, students should be more able to recognise that changes in the combination of atoms must result in different properties, and hence new substances. (Johnson, 2002)

**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.

This may be a challenging question for students so having selected their individual answers, students could be encouraged to explain their choice before sharing ideas through a class discussion.

**Expected answers**

B

**How to respond - what next?**

Selection of option A suggests that a student thinks that when a substance changes to the gas state all the atoms separate and spread out.

Based on an introduction to the particle model students may understandably match a diagram of spaced, individual atoms to the gas state. This idea can lead to misconceptions further on in the study of chemistry, so development of an understanding that the molecules of a substance stay as molecules during the change of state is an idea that may need to be reemphasised. It should be made clear to students that if the molecules do not stay together the gas would no longer be the original substance. For example, if water molecules split into separate hydrogen and oxygen atoms the gas would not be water any more.

Option C is a description of the molecules in the gas state and not an explanation. Mass, option D, is not a factor in the comparison of the two elements in the question.

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

* Changing to the gas state

**Acknowledgments**

Developed by Helen Harden (UYSEG).

Images: Helen Harden

**References**

Johnson, P. (2000). Children's understanding of substances, part 1: recognizing chemical change. *International Journal of Science Education,* 22(7)**,** 719-737.

Johnson, P. (2002). Children's understanding of substances, part 2: Explaining chemical change. *International Journal of Science Education,* 24(10)**,** 1037-1054.