*Chemistry > Big idea CPS: Particles and structure > Topic CPS5: Evaporation*

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| **Key concept (age 11-14)** |
| **CPS5.1: Explaining evaporation** |

**What’s the big idea?**

A big idea in chemistry is that all matter is made up of atoms. The collective, structural arrangement and behaviour of the atoms explains the properties of different substances.

**How does this key concept develop understanding of the big idea?**

This key concept helps to develop the big idea by extending the particle model in order to explain how evaporation occurs below boiling point.

The conceptual progression starts by checking macroscopic understanding of evaporation of different liquids and at different temperatures. It then supports the development of thinking about evaporation at the sub-microscopic particle level in order to enable understanding of why evaporation can take place below the boiling point of a substance.

**Using the progression toolkit to support student learning**

Use diagnostic questions to identify quickly where your students are in their conceptual progression. Then decide how to best focus and sequence your teaching. Use further diagnostic questions and response activities to move student understanding forwards.

**Progression toolkit: Explaining evaporation**

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| **Learning focus** | Evaporation takes place at any temperature between melting and boiling point. | | | | |
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| **As students’ conceptual understanding progresses they can:** | **C o n c e p t u a l p r o g r e s s I o n** | | | | |
| Recognise that evaporation occurs in different liquids, not just water.  **P** | Predict that evaporation will occur in liquids with a temperature that is less than or greater than that of the surroundings. | Describe where in a liquid evaporation takes place. | Distinguish boiling from evaporation. | Use the idea that particles have a range of energies to explain how evaporation occurs below boiling point.  **B** |
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| **Diagnostic questions** | Different liquids | Evaporating temperatures | Location of evaporation | Boiling or evaporation? | Evaporating particles |
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| **Response**  **activities** |  | Garden problem | Surface area | Observations | Evaporation rate |

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| Key: | | | |
| **P** | Prior understanding from earlier stages of learning | **B** | Bridge to later stages of learning |

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| **Different liquids** | **Evaporating temperatures** | **Location of evaporation** | **Boiling or evaporation?** | **Evaporating particles** |
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| Simple multiple choice | Simple multiple choice | Simple multiple choice | Confidence grid | Simple multiple choice |
| **Garden problem** | **Surface area** | **Observations** | **Evaporation rate** |  |
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| Talking heads, discussion | Predict, explain, observe, explain | Application and practice | Clarifying, focussed cloze |  |

**What’s the science story?**

The atoms (or molecules) that make up a substance are constantly moving but they do not all have the same kinetic energy. There is a distribution of energies. Some atoms (or molecules) will have enough energy to overcome the forces of attraction holding the atoms (or molecules) together and escape to mix with the air. This allows evaporation to take place below the boiling point of a substance.

**What does the research say?**

As part of research into chemistry misconceptions Kind (2004) observes that novices in chemistry have limited experience with a variety of different substances. This may give explain the finding by Coştu and Ayas (2005) that a number of students only associated evaporation with water and not with other liquids.

Later research (Jasien, 2013) found that those students who recognised that a liquid did not need to be warm in order to evaporate (or boil) used examples of a range of different substances in their explanation. For example, alcohol evaporating at room temperature, liquid nitrogen boiling when extremely cold or simply that common gases such as oxygen have already boiled at room temperature.

Other misconceptions identified by Coştu and Ayas (2005) include the idea that the process of evaporation is related to the temperature difference between the liquid and its environment. According to some students, if the temperature of the liquid is less than the surroundings then evaporation will occur, otherwise it will not. In addition, some students were found to think that evaporation occurred in all parts of the liquid rather than just at the surface.

In order to explain evaporation at the particle level Johnson (2012) suggests introducing students to the idea that whilst temperature relates to the average energy of the particles, individual particles may, at any one time, have different amounts of energy. Higher energy particles located at the surface that happen to be moving in an outwards direction may have sufficient energy to overcome any forces of attraction and move into the air. An explanation of how evaporation can occur below boiling point requires the consideration of the ‘air’ particle as well. Energy is transferred to the water particles when air particles collide with them. Hence evaporation may occur below the boiling point of a substance.

**Guidance notes**

A full explanation of evaporation may be found in the book Teaching Secondary Chemistry (Johnson, 2012).

It is worth clarifying the difference between boiling and evaporation. Evaporation can take place at any temperature between melting and boiling point. There are no bubbles. In contrast, boiling takes place at a specific temperature (the boiling point of a substance) and bubbles form of the substance in the gas state.

In terms of particles, evaporation occurs when particles leave one by one from the surface to create a mixture with air particles. In order for boiling to take place enough particles must have sufficiently high energy in order to overcome any forces of attraction at the same time, enabling the creation of a bubble of the substance in the gas state. This only occurs when the temperature reaches the boiling point.

**References**

Coştu, B. and Ayas, A. (2005). Evaporation in different liquids, secondary students' conceptions. *Research in Science and Technological Education,* 23(1)**,** 75-97.

Jasien, P. (2013). Roles of terminology, experience and energy concepts in student conceptions of freezing and boiling. *Journal of Chemical Education,* 90**,** 1609-1615.

Johnson, P. (2012). Introducing particle theory. In Taber, K. (ed.) *ASE Science Practice: Teaching Secondary Chemistry.* New edition ed. London, UK: Hodder Education.

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