*Chemistry > Big idea CPS: Particles and structure > Topic CPS8: Ionic bonding*

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| **Key concept (age 14-16)** |
| **CPS8.1: Ionic lattice** |

**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 introducing the idea of an ionic lattice held together by the electrostatic interactions between oppositely charged ions.

The conceptual progression starts by checking understanding of ionic formulae. It then supports the development of understanding of the limitations of dot and cross diagrams in order to enable understanding of ionic bonding as an electrostatic attraction between oppositely charged ions in a lattice.

**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: Ionic lattice**

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| **Learning focus** | Ionic bonding occurs due to the electrostatic attraction between oppositely charged ions in an ionic lattice. | | | | |
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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** | | | | |
| Interpret an ionic formula as representing the ratio of ions.  **P** | Recognise the limitations of what is represented by a dot and cross diagram. | Recognise the uses and limitations of the idea of full outer shells. | Describe ionic bonding as the being the result of electrostatic interactions between oppositely charged ions in a tightly bound lattice. | Recognise that the number of ionic bonds formed by an ion is determined by the arrangement of ions in the lattice.  **B** |
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| **Diagnostic questions** | NaCl | Dot and cross diagram | Full shells | Lattice model | Comparing ions |
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| **Response**  **activities** | Molecule or giant structure? | Making sodium chloride | Revision language | Thinking about ionic bonding | Comparing lattices |

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

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| **NaCl** | **Dot and cross diagram** | **Full shells** | **Lattice model** | **Comparing ions** |
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| Two-tier multiple choice | Confidence grid | Talking heads | Simple multiple choice | Two-tier multiple choice |
| **Molecules or giant structure?** | **Making sodium chloride** | **Revision language** | **Thinking about ionic bonding** | **Comparing lattices** |
| A picture containing text  Description automatically generated | Table  Description automatically generated | Diagram  Description automatically generated | Diagram, text  Description automatically generated | Graphical user interface  Description automatically generated |
| Application and practice | Critiquing a representation | Critiquing language | Talking heads | Challenge to thinking |

**What’s the science story?**

Ionic compounds consist of positively and negatively charged ions that are arranged alternately in a giant structure. This ionic lattice is held together by the electrostatic attraction between oppositely charged ions.

**Earlier development of understanding (BEST 11-14)**

When applying their understanding to novel situations, students of all ages often revert to earlier misunderstandings. Before moving forward it is worthwhile using diagnostic questions from earlier topics to check that students do not have any persistent misunderstandings that can form barriers to learning. Time spent consolidating the scientific understanding of earlier key concepts before moving forward can accelerate progression later.

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| **Key concept CPS2.2: Symbols and formulae**  **Learning focus:** A chemical formula provides information on the composition of a substance.  This key concept:   * Develops students’ ability to move between the symbolic representational level (symbols and formulae) and the sub-microscopic representational level (structure). * Consolidates understanding of chemical formulae beyond simple small molecules to giant structures in which the formula represents a ratio. |

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| **Key concept CPS6.1: Atomic model**  **Learning focus:** The structure of an atom may be represented by an atomic model.  This key concept:   * Develops student thinking about atomic structure in terms of an atomic model that is not a direct representation of reality. |

**What does the research say?**

A key message from the research was that for this topic, misunderstandings can arise from common ways in which ionic bonding is taught in the curriculum. This can lead students to develop an alternative framework of thinking. Rather than viewing ionic bonding in terms of the electrostatic attraction between oppositely charged ions in a lattice some students develop a molecular framework (Taber, Tsaparlis and Nakiboğlu, 2012) in which they consider ionic bonding to only occur between pairs of ions. The authors suggest that this thinking stems from the often-taught idea that ionic bonding arises from the transfer of electrons. This may lead to some students thinking that ion pairs are formed. Even when presented with an ionic lattice some students think that each metal ion can only form an ionic bond with an ion to which it has transferred electrons. Students then do not regard the interaction with other ions as ionic bonding and instead consider the interactions to be just “forces of attraction”.

The progression therefore for checks for understanding about specific commonly taught ideas that are thought to lead to this alternative “molecular” way of thinking. The first diagnostic question checks understanding of a chemical formula for an ionic compound to ensure that students do not think that a formula such as NaCl indicates a small molecule (Taskin and Bernholt, 2012). The progression then aims to ensure that the construction of dot and cross diagrams does not lead to further misconceptions by encouraging student to consider what a dot and cross diagram does and does not help to explain. Finally, understanding of the scientifically acceptable electrostatic framework is explored to ensure that students can move on in their learning whilst holding a scientifically acceptable mental framework of ionic bonding.

**Guidance notes**

Although much of the research suggests that describing ionic bonding as the transfer of electrons leads to misconceptions this description is commonly included in examination specifications. The progression toolkit therefore does include reference to dot and cross diagrams but with a focus on what a dot and cross diagram does and does not help to explain. It is important to clarify this with students as the diagrams themselves are considered to lead to students forming a molecular (rather than electrostatic) framework of thinking about ionic bonding.

**References**

Taber, K. S., Tsaparlis, G. and Nakiboğlu, C. (2012). Student conceptions of ionic bonding: Patterns of thinking across three European contexts. *International Journal of Science Education,* 34(18)**,** 2843-2873.

Taskin, V. and Bernholt, S. (2012). Students' understanding of chemical formulae: A review of empirical research. *International Journal of Science Education,* 36(1)**,** 157-185.