**Dot and cross diagram**

A textbook shows a dot and cross diagram for sodium chloride.

Graphical user interface, application

Description automatically generated

**1**. What does the dot and cross diagram show?

*For each statement, tick (✓)* ***one*** *column to show what you think.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** | An ionic bond |  |  |  |  |
| **B** | The formation of an Na+ ion and a Cl- ion. |  |  |  |  |
| **C** | The formation of sodium chloride. |  |  |  |  |
| **D** | The formation of an NaCl molecule. |  |  |  |  |
| **E** | The ratio of Na+ to Cl- ions. |  |  |  |  |

*Chemistry > Big idea CPS: Particles and structure > Topic CPS8: Ionic bonding > Key concept CPS 8.1: Ionic lattice*

|  |
| --- |
| **Diagnostic question** |
| **Dot and cross diagram** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Ionic bonding occurs through the electrostatic attraction between ions in an ionic lattice. |
| Observable learning outcome: | Recognise the limitations of what is represented by a dot and cross diagram. |
| Question type: | Confidence grid |
| Key words: | ion, ionic bond |

**What does the research say?**

Taber and Coll (2002) comment that diagrams often show reactants as separate atoms and that this simplification, which fails to represent the molecular or lattice structures, may lead to misconceptions. Students may think of elements in reactions as being present as separate atoms and the compounds formed as being made of molecules. The misconception that ionic lattices contain molecular species is considered to be very common.

Another paper (Taber, Tsaparlis and Nakiboğlu, 2012) describes the implications of a student holding the idea that an ionic bond is formed by the process of electron transfer between particular atoms. Misconceptions that can arise from this idea include the idea that ionic compounds are made of ion-pair molecules, that ions can only be bonded to ions with which electron transfer has taken place and that interactions with other adjacent ions cannot be proper ionic bonds and are “just” forces of attraction.

**Ways to use this question**

Students should complete the confidence grid 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.

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.

*Differentiation*

You may choose to read the questions to the class, so that everyone can focus on the science. In some situations, it may be more appropriate for a teaching assistant to read for one or two students.

**Expected answers**

A dot and cross diagram shows the ratio of ions in an ionic compound.

**How to respond - what next?**

A student who thinks that the dot and cross diagram shows the formation of an NaCl molecule (option D) may have misunderstandings about the giant lattice structure of an ionic compound. A student who think the diagram shows the formation of sodium chloride may have a similar misunderstanding.

The diagram could be interpreted as showing the formation of an Na+ ion and a Cl- ion in terms of counting of electrons but this does not show what actually happens during a chemical reaction. If a student thinks that option B is correct it may be helpful to ask further questions to find out more about their thinking.

A student who thinks that the diagram shows the formation of an ionic bond (option A) may think that the actual transfer of an electron is necessary for bond formation rather than the electrostatic attraction between oppositely charged ions.

If a student is not confident that the diagram shows the ratio of ions it may help to look at a range of dot and cross diagrams for other ionic compounds (such as MgCl2).

If students have misunderstandings about the dot and cross diagram showing the formation of sodium chloride it may help to encourage students to sketch some basic particle diagrams for the process in which sodium (in the solid state) reacts with chlorine molecules. It should become clear that there are a lot more than one atom of each element reacting.

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

* Making sodium chloride

**Acknowledgments**

Developed by Helen Harden (UYSEG).

Images: Helen Harden (UYSEG)

**References**

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