**Chemical bonding**

Some students are discussing what a chemical bonding is.

Who do you agree with, and why?

**Kulvinder:** Chemical bonding is an electrostatic interaction between positive and negative charge.

**Omar:** Chemical bonding is what connects a chemical structure.

**James:** A chemical bond is a physical link between atoms.

**Nihil:** A chemical bond is the sharing or transfer of electrons.

**Olivia:** Chemical bonding is an attraction between atoms.

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| Cards for  **Chemical bonding** | **Kulvinder:** Chemical bonding is an electrostatic interaction between positive and negative charge. |
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*Chemistry > Big idea CPS: Particles and Structure > Topic CPS7.1: > Key concept CPS7.1: Metallic structure model*

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| **Diagnostic question** |
| **Chemical bonding** |

**Overview**

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| Learning focus: | A model of metallic structure, made up of positive metal ions surrounded by ‘free’ outer electrons, can explain some properties of metals. |
| Observable learning outcome: | Describe metallic bonding as an all-directional electrostatic interaction. |
| Question type: | Talking heads |
| Key words: | bond, atom, electrostatic |

**What does the research say?**

Cheng and Oon (2016) describe the understanding of metallic bonding expected of Year 10 students in Hong Kong (which is typical for this age group in many countries). The metal is considered to be composed of a lattice of positively charged metal ions with delocalised (‘free’) electrons moving around them. The focus is not only on this sub-microscopic structure but also on the all-directional electrostatic force (metallic bonding).

Zohar and Levy (2019) suggest three categories of thinking about chemical bonding based on this paper.

1. Bonding is thought of as a structure or a physical entity.

The authors suggest that this is the most basic way that students may be thinking about chemical bonds. This could arise from language and a literal interpretation of the word “bond”. The word bond is a metaphor based on the everyday meaning that a bond is a connection. Alternatively, the misunderstanding could arise from the perception that a 3D molecular model is a representation of reality.

1. Bonding is described as a process

Students consider a chemical bond to be a process such as sharing, gaining or losing electrons and ignore the idea of electrostatic forces.

1. Bonding is recognised to be an electrostatic force

The authors suggest that this is the highest level of understanding as electrostatic forces are intangible

It should be noted that as Zohar and Levy (2019) do not describe a bond as an electrostatic attraction. This is because their paper investigates references to electrostatic repulsion in educational material. A more advanced understanding of a chemical bond (which may be helpful to students who plan to study chemistry further) is that it results from a balance between the repulsion of positive nuclei and the attraction between positive nuclei and negative electrons.

**Ways to use this question**

This task is intended for discussion in pairs or small groups. It can be done as a pencil and paper exercise or projected onto a screen.

Students should read the statements and follow the instructions on either the worksheet or the PowerPoint. Listening in to the conversations of each group will often give you insights into how your students are thinking. Each member of a group should be able to report back to the class.

Feedback from each group can be used, with careful teacher questioning, to bring out a clear description or explanation of the science.

*Differentiation*

The quality of the discussions can be improved with a careful selection of groups; or by allocating specific roles to students in each group. For example, you may choose to select a student with strong prior knowledge as the scribe. They may question the others and only write down what they have been told. This strategy encourages contributions from more members of each group.

NB in any class, small group discussions typically improve over time and a persistence with this strategy is often very successful in the medium to long term.

**Expected answers**

Olivia is starting to describe the idea of some sort of attraction but Kulvinder’s answer is more scientific as she identifies the forces involved as electrostatic in origin.

**How to respond - what next?**

A student who agrees with Omar and/or James may have a very basic level of thinking about chemical bonds, regarding them as some sort of physical connection. It may be of benefit to discuss a 3D molecular model and what it does and does not represent.

Agreement with Nihil could indicate that a student has interpreted descriptions of bonding as the sharing, gaining or losing of electrons as being the chemical bond.

If students have misunderstandings about chemical bonding, then they may have difficulties in using a model of metallic structure to explain metallic bonding as an all-directional electrostatic force.

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

* Electrostatic diagrams

**Acknowledgments**

Developed by Helen Harden (UYSEG)

Images: Helen Harden (UYSEG)

**References**

Cheng, M. M. W. and Oon, P.-T. (2016). Understanding metallic bonding: Structure, process and interaction by Rasch analysis. *International Journal of Science Education,* 38(12)**,** 1923-1944.

Zohar, A. R. and Levy, S. T. (2019). Students' reasoning about chemical bonding: The lacuna of repulsion. *Journal of Research in Science Teaching,* 56**,** 881-904.