**Metallic bonding diagrams**

Three students draw diagrams to show metallic bonding.

A picture containing ball, room

Description automatically generated

Graphical user interface, application

Description automatically generatedGraphical user interface, application

Description automatically generated

Student A Student B Student C

1. What do the following represent in the students’ diagrams:

A picture containing object, clock

Description automatically generated

a ………………………………………………………………………………………………………………………………………………

b………………………………………………………………………………………………………………………………………………

c ………………………………………………………………………………………………………………………………………………

1. Which diagram do you think shows the best representation of metallic bonding?

*Explain your answer*

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*Chemistry > Big idea CPS: Particles and structure > Topic CPS7: Metallic bonding > Key concept CPS7.1: Metallic structure model*

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| **Response activity** |
| **Metallic bonding diagrams** |

**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. |
| Activity type: | Talking heads |
| Key words: | bond, atom, electrostatic |

This activity can help develop students’ understanding by addressing the misunderstandings revealed by the following diagnostic question:

* Chemical bonding

**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 activity**

Students should complete this activity in pairs or small groups, and the focus should be on the discussions. It is through the discussions that students can check their understanding and rehearse their explanations.

Students should work together to answer the questions on either the worksheet or the PowerPoint. Giving each group one worksheet to complete between them is helpful for encouraging discussion, but each member should be able to report back to the class. Listening in to the conversations of each group will often give you insights into how your students are thinking.

Ending with the students completing the worksheet or questions from the PowerPoint individually, might help them to consolidate their learning.

*Differentiation*

You may choose to use simplified worksheets for some students, for example with gaps to fill in so they can focus on the science. In some situations, it may be more appropriate for a teaching assistant to read and/or scribe for one or two students.

**Expected answers**

**1 a** metal (cat)ion, **b** electron, **c** electrostatic force/attraction

**2** The best representation of metallic bonding is drawn by student B because it shows the electrostatic attraction as an all directional force and not as a force of attraction between ion-electron pairs (student C).

**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.