**Metallic structure diagrams**

Some students have drawn diagrams to show how they think about the structure of a metal.

A picture containing ball

Description automatically generated

A picture containing light

Description automatically generated

B

A

A close up of a logo

Description automatically generatedA picture containing drawing

Description automatically generated

D

C

1. Whose thinking do you most agree with?

Explain your answer.

1. Whose thinking do you disagree with?

Explain your answer.

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

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| **Diagnostic question** |
| **Metallic structure 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: | Recognise that a model of metallic structure consists of a regular arrangement atomic nuclei and inner electrons (positively charged ions) and ‘free’ outer electrons that are not bound to a particular nucleus. |
| Question type: | Talking heads |
| Key words: | Electron, metal, ion |

**What does the research say?**

Taber and Coll (2002) report that some students describe metallic bonding as involving a ‘sea of electrons” but that they had learnt this as a term, rather than understanding the model. Some students seemed to have been influenced by the ‘sea’ metaphor to the extent that they drew diagrams of the ‘sea’ as a vast excess of electrons.

Other research (de Posada, 1999) into the presentation of metallic bonding in textbooks found that several metaphors are used in relation to metallic bonding including electron ‘sea’ and also the idea of a metallic ‘lattice’. The authors caution that as students use these terms in everyday contexts, they can form fixed ideas that are then difficult to shift. The diversity of models used in the books was also a potential source of challenge for students with some diagrams showing a particulate representation of electrons but others a delocalised electron cloud. Some diagrams confusingly mixed the two by showing particulate electrons in a shaded area labelled as the electron ‘sea’.

**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**

The diagram by student A has a balance of positive and negative charge and pictures the electrons in particle form which is consistent with the model of the atom commonly taught to the 14 to 16 age group.

**How to respond - what next?**

Student C’s thinking does not include any negative charge at all. Agreement with this way of thinking could suggest a literal interpretation of the idea that metallic structure is made up of positive metal ions surrounded by a ‘sea of electrons.

A student who most agrees with student B’s thinking may also have been influenced by references to a ‘sea of electrons. The student may be taking the metaphor more literally than it is intended by representing the structure with a vast number of electrons.

Agreement with the thinking of student D may also indicate misunderstanding about a ‘sea of electrons’ as it could be representing the electrons as being in the sea. Alternatively, it may be indicating a continuous area of negative charge. This is inconsistent with the model of the atom commonly taught at this age which treats electrons as being particles.

If students have misunderstandings about the idea of a ‘sea of electrons’ it may help to encourage students to reflect on the metaphorical language used. The following BEST ‘response activities’ could be used in follow-up to this diagnostic question:

* Sea of electrons

**Acknowledgments**

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Images: Helen Harden (UYSEG)

**References**

de Posada, J. é. M. (1999). The presentation of metallic bonding in high school science textbooks during three decades: Science educational reforms and substantive changes of tendencies. *Science Education,* 83**,** 423-447.

Taber, K. S. and Coll, R. K. (2002). Chemical Education: Towards Research-based Practice. In Gilbert, J. K., DeJong, O., Justi, R., Treagst, D. F. & Van Driel, J. H. (eds.) *Chemical Education: Towards Research-based Practice.* Dortrecht: Kluwer Academic Publishers.