**Electron diagram**

Some students look at a page from a textbook.

**Electron arrangements**

The diagram below shows the arrangement of electrons in an argon atom.

The electrons are arranged in three electron shells with the nucleus in the centre.

A close up of a screen

Description automatically generated

Some students discuss what this diagram shows.

Who do you agree with, and why?

**Evie:** The diagram shows what an atom really looks like.

**Toby:** The circles are the shells.

**Jasmine:** The diagram is a tool to help you to work out things about atoms.

**Libby:** The nucleus is protected by the electron shells.

**Leo:** The diagram shows what scientists think is the structure of an atom.

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| Cards for  **Electron diagram** | **Toby:** The circles are the shells. |
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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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| **Diagnostic question** |
| **Electron diagram** |

**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 diagram of electron arrangement is a model and not a copy of reality. |
| Question type: | Talking heads |
| Key words: | nucleus, electron, model |

**What does the research say?**

Research into students’ mental models (see key concept notes) of atoms (Harrison and Treagust, 1996) found that metaphors used in teaching, such as ‘electron shell’ tended to conjure up in the minds of students quite different models to those intended by the teacher.

The students in the study all responded as though an electron shell was an actual physical entity that offered some form of protection. The authors recommend that a metaphor should only be used if its intended meaning is clearly explained.

The paper also refers to the three levels of thinking about models described by Grosslight et al (1991).

The authors suggest that students functioning at the most basic level, think of models as copies of reality. At the next level of thinking students recognise that the models are not copies of reality. The students understand that a model can help to explain ideas that they are learning about and that a model has limitations. Students with the most advanced thinking about models are able to work with multiple models.

The paper recommends that science curricula include explicit instruction in scientific modelling in particular to help ensure that students do not think that models are copies of reality.

**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**

Although Jasmine does not use the word “model” she is the only student to recognise that the diagram has a purpose rather than showing any form of reality.

**How to respond - what next?**

A student who agrees with Evie may have insufficient understanding of the idea of a model. It may help the student to understand that a model is designed for a specific purpose, in this case explaining ideas that will be taught to their age group.

A student who agrees with Leo may again be thinking that the diagram represents reality, and a reality that has been ‘discovered’ by scientists. The model commonly used in textbooks at this level is in fact more closely linked to Bohr’s model of the atom which has since been supplanted by a quantum mechanical model by scientists.

A student who agrees with Toby and/or Libby maybe interpreting the ‘electron shell’ metaphor in a literal sense.

If students have misunderstandings about the ‘electron shell’ metaphor it may help to discuss ways in which the metaphor is similar and different to the model.

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

* Electron shells

**Acknowledgments**

Developed by Helen Harden (UYSEG)

Images: Helen Harden (UYSEG)

**References**

Grosslight , L., et al. (1991). Understanding models and their use in science: Conceptions of middle and high school students and experts. *Journal of Research in Science Teaching,* 28**,** 799-822.

Harrison, A. G. and Treagust, D. F. (1996). Secondary students' mental models of atoms and moelcules: Implications for teaching chemistry. *Science Education,* 80(5)**,** 509-534.