A picture containing indoor, table, sitting, vase

Description automatically generated**Metal properties.**

Metals can conduct electricity. Some metals are better electrical conductors than others.

Metals are malleable meaning that they can be hammered into shape.

A picture containing ball

Description automatically generated

A student draws a model of the structure of a metal.

Which properties of a metal can this model explain?

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** | A metal conducts electricity. |  |  |  |  |
| **B** | A metal is malleable. |  |  |  |  |
| **C** | Some metals are better electrical conductors than others. |  |  |  |  |

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

|  |
| --- |
| **Diagnostic question** |
| **Metal properties** |

**Overview**

|  |  |
| --- | --- |
| 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: | Evaluate the metallic structure model in terms of its ability to explain physical properties of metals. |
| Question type: | Confidence grid |
| Key words: | Malleable, electrical conductor, model |

**What does the research say?**

Cheng and Oon (2016) introduce their paper on understanding of metallic bonding with a quote from Gilbert (2004) which describes the learning of school science as the progressive study of different models of physical phenomena.

A paper (Harrison and Treagust, 1996) uses a system devised by Grosslight et al. (1991) to categorise different levels of thinking about models.

Level 1- Thinking of models as simple copies of reality

Level 2- Recognising that models have an explicit purpose which affects how the model is constructed and that the model does not have to correspond with reality

Level 3 – Recognising that a model serves the development and testing of ideas.

Students at level 3 would be able to construct and manipulate multiple models.

Students are usually introduced first to a basic particle model and only later to models of chemical bonding. As students progress, they are required to change the model that they are using. Understanding that models have an explicit explanatory purpose may help students to make this transition. More advanced chemistry requires a more advanced explanatory model.

As well as thinking using an appropriate model for a purpose, an expert chemist, according to Johnstone (1991) can fluently switch between thinking at a macroscopic level, sub-microscopic level and symbolically. This three-level way of thinking is summarised in the paper as Johnstone’s triangle. The mental models required to think about chemical bonding all require a sub-microscopic way of thinking.

**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**

The model can be used to provide an explanation for why metals conduct electricity (A).

It can also explain why metals are malleable (B) although this can also be explained using the particle model.

The model does not explain why some metals are better electrical conductors than others.

**How to respond - what next?**

A student who thinks that the metallic structure model is a replication of reality may think that either all or none of the properties can be explained by the model.

A student who appreciates that a mode has explanatory purpose should recognise that this model may explain some properties of metals but not others.

It should also be noted that some students may still hold misunderstandings about the nature of electric current which could impede their answering of this question. It may help to revisit ideas from key concept PEM1.2: Electric current.

If students have misunderstandings about models having an explanatory purpose, they could be asked to compare the particle model with the model of metallic structure to think about what each can and cannot explain.

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

* Explaining metals

**Acknowledgments**

Developed by Helen Harden (UYSEG).

Images:

Copper boiler image by [Momentmal](https://pixabay.com/users/Momentmal-5324081/?utm_source=link-attribution&utm_medium=referral&utm_campaign=image&utm_content=2630690) from [Pixabay](https://pixabay.com/?utm_source=link-attribution&utm_medium=referral&utm_campaign=image&utm_content=2630690)

Metallic structure diagram by Helen Harden (UYSEG)

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