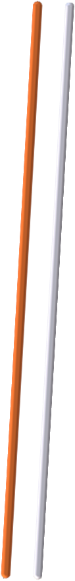
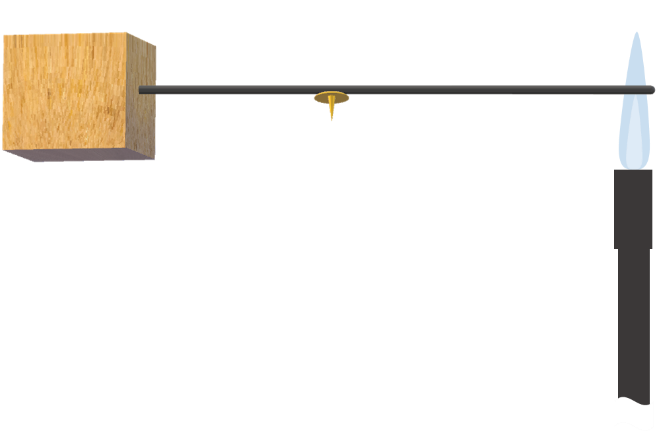
**Free electron model**

Metals are good thermal conductors because the outer electrons of each metal atom are free to move.



Explain why metals are good thermal conductors.

*Pick* ***one*** *statement in each row to explain how.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1 | In a metal, the outer electrons of each metal atom are free to move. | | | |
| 2 | They move about freely in-between metal ions. | They move from one metal atom to the next. | | They each orbit  a metal ion. |
| 3 | When metal is heated some metal ions are made to vibrate more vigorously.  They vibrate against other ions, forcing more and more to vibrate faster. | | | |
| 4 | They also cause the outer electrons to vibrate more vigorously. | | They also cause the outer electrons to move around more quickly. | |
| 5 | These electrons force nearby metal ions to vibrate faster. | | These electrons force metal ions throughout the metal to vibrate faster. | |
| 6 | This greatly speeds up thermal conduction in a metal. | | | |

*Physics > Big idea PMA: Matter > Topic PMA3: Energy of moving particles > Key concept PMA3.1: Transfer of energy by conduction*

|  |
| --- |
| **Response activity** |
| **Free electron model** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Energy is transferred through a solid away from regions of higher temperature as its particles are caused to vibrate more vigorously. |
| Observable learning outcome: | Explain why metals are good thermal conductors. |
| Activity type: | Explanation story |
| Key words: | Thermal conduction, free electron, heat, energy, particle, vibrate |

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

* Diagnostic question: Fast conduction

**What does the research say?**

The notion that heat and cold are material substances that can flow from one place to another seem to be both common and persistent (Engel Clough and Driver, 1985; Hatzikraniotis et al., 2010; Thomaz et al., 1995). Engel Clough and Driver (1985) found that almost all 12- to 16-year-olds understood that ‘heat’ travelled through metals, but often described heat flowing rather than the actual mechanism. Hatzikraniotis et al. (2010) reported that the majority of 13- to 14-year-olds (n=24) described thermal conduction as the flow of hot particles. In their study in Portugal, Thomaz et al. (1995) similarly found that before teaching, 42% of 14- to 15-year-olds (n=79) wrongly thought of ‘heat’ (or ‘cold’) as a substance.

Metals are good thermal conductors because the outer electrons of metal atoms can move freely in-between metal ions. In thinking about how these outer electrons make metals good thermal conductors Pathare and Pradhan (2010) found some second year undergraduate physics students wrongly thought the heating of one end of a metal rod *released* more electrons from atoms to flow along it.

**Ways to use this activity**

This task is intended for discussion in pairs or small groups. It is best done as a pencil and paper exercise.

Students should read the statements and follow the instructions on the worksheet. 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.

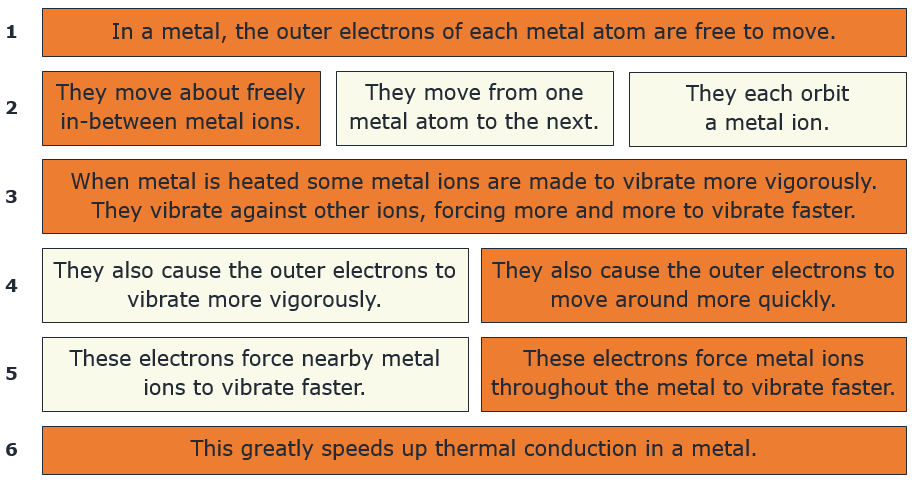
Feedback from each group can be used, with careful teacher questioning, to bring out a clear description or explanation of the science.

*Differentiation*

The quality of the discussions can be improved with a careful selection of groups; or by allocating specific roles to students in the each group. For example, you may choose to select a student with strong prior knowledge as the scribe, and forbid them from contributing any of their own answers. 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**



**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

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