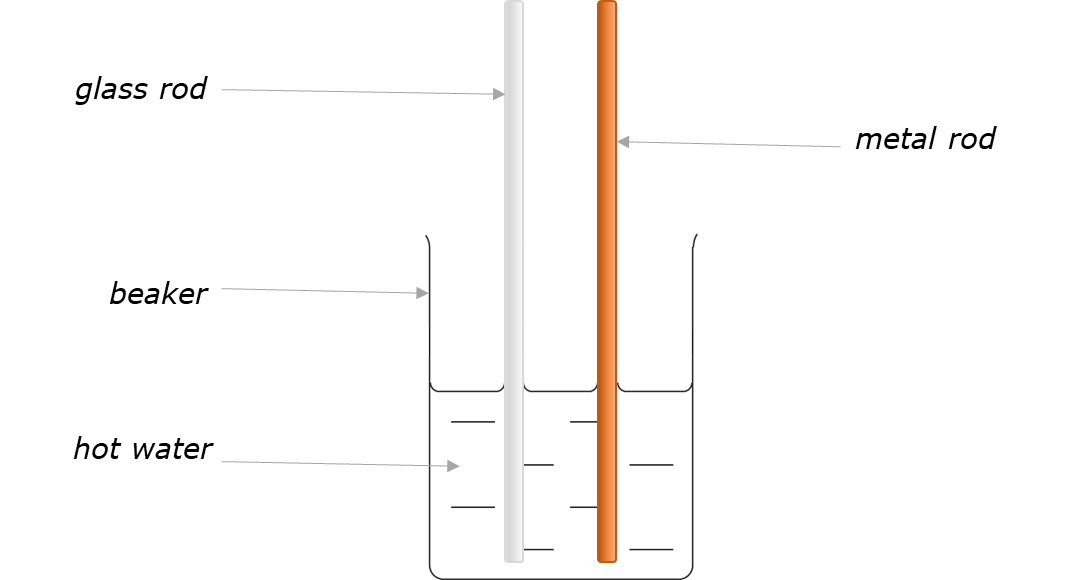
**Hot vibrations**

A metal rod and a glass rod are placed in some very hot water.

A short time later the top of the metal rod is hot.

The top of the glass rod feels cool.



Five of the statements describe thermal conduction in any solid.

Five statements describe thermal conduction in a metal.

1. Sort the statements into two groups.
2. Use the statements to describe how thermal conduction works.

|  |  |
| --- | --- |
| **A.** A metal has free electrons. | **F.** The particles in the hot part of the rod vibrate more quickly. |
| **B.** They bump into particles all along the rod. | **G.** The temperature along the rod goes up quickly. |
| **C.** This makes their neighbours vibrate quickly as well. | **H.** The effect spreads along the rod. |
| **D.** Free electrons can move easily through a metal. | **I.** Heating free electrons makes them move more quickly. |
| **E.** The temperature along the rod goes up slowly. | **J.** Heating a rod at one end gives it energy. |

|  |  |
| --- | --- |
| **A.** A metal has free electrons. | **F.** The particles in the hot part of the rod vibrate more quickly. |
| **B.** They bump into particles all along the rod. | **G.** The temperature along the rod goes up quickly. |
| **C.** This makes their neighbours vibrate quickly as well. | **H.** The effect spreads along the rod. |
| **D.** Free electrons can move easily through a metal. | **I.** Heating free electrons makes them move more quickly. |
| **E.** The temperature along the rod goes up slowly. | **J.** Heating a rod at one end gives it energy. |

*Physics > Big idea PMA: Matter > Topic PMA1: Heating and cooling > Key concept PMA1.3: Thermal conduction*

|  |
| --- |
| **Response activity** |
| **Hot vibrations** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Heating makes the particles in a material move more quickly. Heating raises the temperature quickly throughout a good thermal conductor, and very slowly through a good thermal insulator. |
| Observable learning outcome: | Use the idea of vibrating particles to explain heating by thermal conduction. |
| Activity type: | Sequencing |
| Key words: | Conductor, particle, vibration, free electron |

This activity can help develop students’ understanding by consolidating understanding of thermal conduction in solids, including conduction in metals.

Before using this activity a student model can be used to demonstrate conduction in a solid: students stand in a line shoulder to shoulder, and when a student on one end ‘vibrates’ (s)he jostles the next student and so on until all the ‘particles’ are vibrating.

*It should be noted that although this is usually a slow mode of thermal conduction, in materials with stiff bonds and a regular crystalline structure, like diamond, it can be extremely quick. In fact diamond is a better thermal conductor than a metal.*

To show why metals are very good thermal conductors the idea of ‘free electrons’ should be introduced. In the student model this can be a tennis ball or a sponge that is thrown along the line. It causes the particles it hits to vibrate more vigorously, and so increases the temperature farther along the metal rod quickly.

**What does the research say?**

Textbooks often explain thermal conduction in terms of increased vibration of the particles in a hot region of an object causing their neighbours to vibrate more rigorously, and so on through the material of the object. This explanation does not, however, account for why metals are good conductors whereas non-metals (usually) are not. In fact this model only explains the very slow conduction through insulators (and *one* of the modes of conduction through a conductor). To avoid confusion it is important to explain, at this stage, the more rapid conduction in metals in terms of the movement of free electrons. (Millar, 2011)

**Ways to use this activity**

Students should be shown the student model of conduction to clarify what it is they are trying to explain. You should use carefully selected questions to check your students’ understanding of this.

After the initial teaching, students should complete the sequencing activity in pairs or small groups, and the focus should be on the discussions. The statements are provided as cut-out cards for students to physically organise.

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 explain why the statements were put in the chosen order. Once this activity has been completed it may be helpful to challenge students to independently write down their own explanations.

*Differentiation*

You may choose to use simplified statements for some students, or give them the starting statement to start them off. In some situations it may be more appropriate for a teaching assistant to read the statements with one or two students.

**Expected answers**

1. J, F, C, H, E

Heating a rod at one end gives it energy. The particles in the hot part of the rod vibrate more quickly. This makes their neighbours vibrate quickly as well. The effect spreads along the rod. The temperature along the rod goes up slowly.

2. A, D, I, B, G

A metal has free electrons. Free electrons can move easily through a metal. Heating free electrons makes them move more quickly. They bump into particles all along the rod. The temperature along the rod goes up quickly.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

Millar, R. (2011). Energy. In Sang, D. (ed.) *Teaching Secondary Physics.* London: Hodder Education.