Investigation: Thermal Conductivity

Introduction

For understanding the concept of thermal conductivity, let’s take an example - consider walking barefoot on a tiled floor and on a carpet. Which surface feels ‘colder’ to walk on? Walking on a tiled floor ‘feels’ colder than walking on a carpet. The differences in sensations are to do with the composition of both the tiled floor and the carpet. The tiled floor is made up of a different material than the carpet; hence the rate at which heat transfer occurs is not the same for both these surfaces. When heat transfer occurs between two objects that are in contact, we refer to this transfer of heat as *thermal conduction*.

What really happens when you stand barefoot on a tiled floor in winter? Think about the molecules in the two bodies that are in contact – what is their kinetic energy?

In this experiment, we will model and predict quantitatively energy transfer from hot objects by the process of thermal conductivity. Before carrying out the experiment, undertake an internet research activity to find the thermal conductivity values for a range of metals. What do you observe?

1. Questioning and predicting

Think about the following questions to formulate an aim for the investigation that you will undertake:

1. What factors does thermal conductivity depend on?
2. Will heat transfer occur at the same rate for two substances made up of the same material, but of different thickness?
3. Do you think all substances (for example metals) conduct heat at the same rate?

HYPOTHESIS

Thermal conductivity varies/does not vary for different metals.

Different metals conduct heat at (different/same) rates.

2. Planning investigation

This investigation has been planned for you.

In this experiment, we will investigate if different metals conduct heat at different or same rates. To this end, we will use a range of metal wires of same length and thickness, a Bunsen burner, wax blobs and paper clips of equal size, heat proof mat, matches, stop watch, tripod and safety glasses.

Before undertaking any science experiment, it is important to do a risk assessment to assess any risks and devise strategies to mitigate those risks. Complete the table below.

|  |  |
| --- | --- |
| Potential risks  | Strategies to mitigate the risks  |
|  |  |

The steps below outline the procedure for carrying out the experiment.

1. Place the Bunsen burner on a heat proof mat and ensure that the air hole of the Bunsen burner is closed (*Recall* the difference between the safety flame and blue flame of a Bunsen burner.)
2. Place a tripod stand on top of the Bunsen burner.
3. Arrange a range of metal wires on top of the tripod stand ensuring that they all get exposed to the heat from the Bunsen burner in the same way, when we’ll light the Bunsen burner in Step 5.
4. Place a wax blob at the end of each wire and attach a paper clip to each blob of wax.
5. Have a stop watch ready (you can use one on your phone) and light the Bunsen burner.
6. Record the time taken for the wax to melt resulting in the paper clip to fall from each wire. When will you stop recording the time? When the Wax starts melting or when the paper clip falls?

3. Conducting investigation

Record your results in the table below.

|  |  |
| --- | --- |
| Metals  | Time (s) |
|  |  |
|  |  |
|  |  |

Is your experiment ‘reliable’? Why/why not?

Can you think of any errors that likely affected your results?

How can you improve the experiment?

4. Processing and analysing

Plot the results on a graph paper or in Microsoft Excel. Will you make a line graph or a column/ bar graph? What graph would best represent your results?

What were the independent, dependent and control variables in your experiment?

Is your experiment valid?

5. Problem solving

Refer to the worksheet on Energy Transfer, and work with the following equation:

$$P=\frac{Q}{t}=\frac{kA∆T}{d}= \frac{kA(T\_{2}- T\_{1})}{d}$$

What do the different components of the thermal conduction equation mean?

As an extension to this experiment, plan another investigation to test if same metals with varying thickness conduct heat at the same time. What could be your hypothesis?

Thermal conductivity varies/does not vary for same metals with varying thickness

Same metals with varying thickness conduct heat at (different/same) rates.

6. Conclusions

Fill in the blanks with one or many words.

Different metals conduct heat at \_\_\_\_\_\_\_\_\_\_\_\_ rates.

Thermal conductivity is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ for different metals.

Thermal conductivity \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ for same metals with varying thickness.

Same metals with varying thickness conduct heat at \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ rates.