B3: HEAT TRANSFER BY CONDUCTION

Overview

This section is designed to introduce students to the concept of **heat transfer by conduction**. Students are presented with a selection of materials; two metals and two liquids. They are asked to predict whether the substances will **conduct heat** or not before testing them out. To motivate and engage students, the teacher challenges them to use their knowledge of **energy transfer** to **predict**, **observe** and **explain** what happens as they carry out the activities. They are then asked to **compare** their **predictions** with their **observations**. In this way, students are expected to develop an understanding of **heat energy by conduction**.

Suggested approaches:

- These activities can be used either as an **introduction** to **conduction of heat energy** or as a means of revision of material which may have already been covered.
- Encourage students to check out the equipment while you explain briefly what you are going to do.
- Before carrying out the demonstrations, ask students to predict what they think will happen.

B3 ACTIVITY 1: METAL KITCHEN SIEVE

Background

The metal in the sieve conducts so much heat away that the candle wax vapour cannot ignite above the wire mesh. The flame will reach the wire mesh, but does not go through it. The flame only passes through the metal lattice if it is made to glow by strong heating.

Equipment required (per group):

- Candle (lit)
- One metal kitchen sieve
- Metal sieves with smaller and wider meshes
- Access to a strong gas flame

What to do:

1. Ask the students to hold a metal kitchen sieve in a candle flame as in the diagram. Ask them to consider the following questions:
   - ? ***What do you observe about the flame?***
   - ? ***Why might this be?***
   - ? ***What do you think might happen if you used a metal sieve with a wider mesh?***
   - ? ***What might happen if a smaller mesh was used?***
   - ? ***How near to the flame would the mesh need to be in order to affect the flame?***
2. Ask them to hold the sieve with the smaller mesh over the flame and observe what happens.
3. Ask them to hold the sieve with the wider mesh over the flame and observe what happens.
4. Hold the flame from a strong gas flame close to the mesh and ask the students to observe any differences between holding a mesh to a gentle candle flame, and a stronger gas flame.

Figure 9

Resources:

- Click here to view this activity, with a detailed explanation, online.

B3.1 DISCUSSION POINTS: THE FLAME AND WIRE MESH

1. **Predict** what happens when the flame is held close to the wire mesh.

2. Explain what you **observe** in detail.

3. Does the **size of the mesh** matter? Explain your answer.

4. Do you **notice** any difference when holding the flame from a strong gas flame close to the mesh? Comment on what you observe.

5. The Emigrant Flame was lit in New Ross with a flame taken from the Eternal Flame on J. F. Kennedy's grave at Arlington Cemetery. How was this possible?

6. The Olympic Flame is carried by runners from Olympia in Greece to wherever the Olympic Games are being held. What measures are put in place to make this possible?

B3.2 HISTORY NOTE C: THE DAVY LAMP

The Davy lamp is a safety lamp that uses the principles encountered in this exercise. It was invented by Sir Humphry Davy in 1815 and was used by coal miners.

The only light source for the miners was an oil lamp. The greatest hazard of coal mining was a build-up of dangerous gases like methane and carbon monoxide in confined spaces, which would catch fire and cause explosions. The Davy lamp is designed to minimise the possibility of fire. A metal lattice surrounding the naked flame takes up so much heat that the gases in the mine cannot ignite.

More sophisticated safety measures are now used in the mining industry, but the concept behind the Davy lamp is still used when transporting a flame over long distances.

Figure 10

B3 ACTIVITY 2: COIN ON PAPER

Background

Metals are generally considered good **heat conductors**. Paper, on the other hand, will readily burn. But what will happen if paper is placed between a flame and a coin? The metal behaves as a **thermal conductor**, **drawing heat** away from the paper and thus preventing it from burning. Computers depend greatly on such thermal conductors, more commonly referred to as heat sinks. Because the computer's processes generate heat, these 'sinks' are strategically placed to draw this heat and prevent the machine from overheating. Similarly, the water in a car's radiator acts as a thermal conductor absorbing the heat from the engine.

Equipment required (per group):

- Two small squares of thin card or stiff paper
- Coin
- Candle
- Matches
- Tongs
- Timer
- Beaker of water

Figure 11

What to do:

1. Light the candle.

   ? ***How long do you think it will take for one of the small squares to burn if held over the flame? Remember, the hottest part of the flame is just above the tip of the flame.***
2. Hold one of the pieces of card in the tongs and position it just over the tip of the flame. **Time** how long it takes to **start smouldering**. (No need to set it on fire.) Record the time taken and carefully leave the card aside. (Why?)
3. Hold the second piece of card in the tongs, balance the coin on top of the card. Hold the card and coin just over the tip of the flame as shown in Figure 11 and at the same time start the timer.
4. When the timer reaches the same as recorded in step 2, remove the card and examine the side that was nearest to the flame.
5. Compare the state of the two pieces of card.

   ? ***Is there a difference?***

   ? ***Can you explain why?***

Resources:

- There is a video of this activity from Science on Stage.
  Click here to view it in English.
  Click here to view it in Irish.

B3 ACTIVITY 3: THE BALLOON THAT DOES NOT BURST

Background

This activity illustrates the coolant properties of water. Water has a high capacity for heat. In this activity, the water absorbs the heat given out by the candle, so the temperature of water in the balloon will rise while the balloon itself will remain intact!

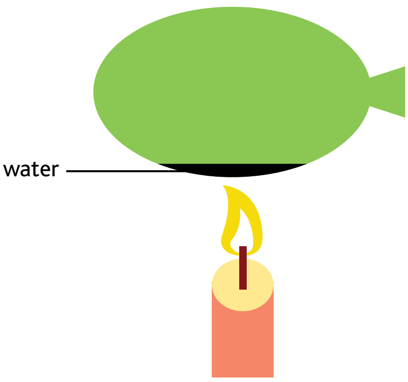

Figure 12: Water in balloon

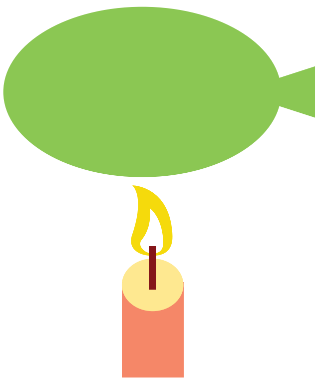

Figure 13: No water in balloon

Equipment required (per group):

- Two identical balloons
- A balloon pump
- Two candles
- Matches
- Access to tap water
- Two plastic lunch bags
- Thermometer

What to do:

1. Place a small amount of water in a balloon, blow it up and seal.
2. Blow up an identical balloon (without putting water in it).
   - ? ***What will happen when burning candles are placed under the two balloons as shown in Figure 12 and Figure 13?***
   - ? ***What did you observe?***
   - ? ***Why was this?***
3. What temperature do you think the water would have to reach before the balloon would melt?
4. Check out this predication by repeating this experiment. This time use plastic lunch bags instead of the balloons. A thermometer inserted in the bags shows the temperature rising.

Resources:

- Click here to view a demonstration of this activity using plastic lunch bags instead of balloons.

B3 ACTIVITY 4: BOILING WATER IN A PAPER CUP

Background

This is another demonstration of the capacity of water to absorb heat energy. The water boils, but the cup is not even scorched. The water absorbs the heat transferred to the paper and begins to boil at a temperature of 100°C. The water does not get any hotter, so the paper does not reach a high enough temperature to burn.

Equipment required:

- Paper cup with small amount of water
- Wooden skewer or similar (i.e. knitting needle)
- Supports as shown in Figure 14
- Thermometer or data logger sensor

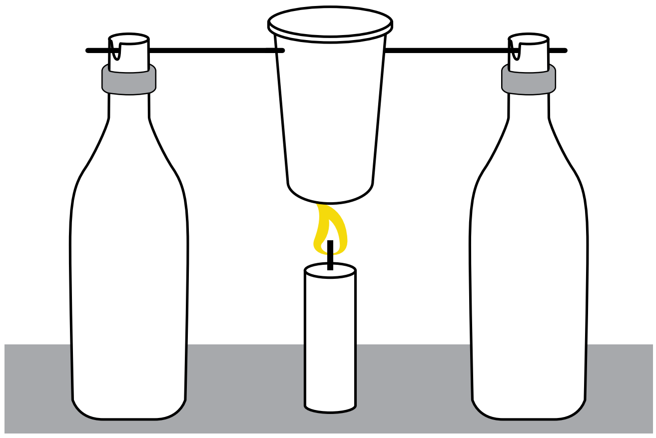

Figure 14

What to do:

1. Put a small amount of cold water in the paper cup.
2. Push the skewer through the rim of the paper cup.
3. Hang it between the two supports as shown in Figure 14.
4. Place the thermometer or data logger in the water and note the initial temperature.
5. **Predict** what will happen when the burning candle is placed under the paper cup.

   ? ***Will the cup burn immediately?***

   ? ***Will the thermometer or data logger register a temperature rise or a fall?***
6. Place the burning candle under the cup.

   Observe what happens and record these observations.
7. After two to three minutes quench the candle.

   Compare your observations with your predictions.

   ? ***Were there any surprising outcomes?***

   ? ***Do you think the outcome would be the same if a polystyrene cup was used instead?***

B3.4 Discussion points: Water Coolant

1. Water is used as a coolant for car engines. List all the advantages of water that make it an ideal coolant.
2. Some industries rely heavily on water as a coolant but this can present problems for local communities. What might these problems be?
3. Research these industries in Ireland.

   ? ***Where are they situated?***

   ? ***Who is tasked with monitoring them?***

   ? ***Why might monitoring be required?***