

## Investigation of the methods of heat transfer

### Introduction

Heat can be transferred through materials (and indeed empty space) in different ways. This series of experiments explores the methods of heat transfer and aims to develop your understanding of the differences between conduction, convection and radiation.

### Apparatus

#### Convection:

2 × 250cm<sup>3</sup> beaker  
 1 crystal of potassium manganate(VII)  
 10cm<sup>3</sup> glass tube  
 tripod and gauze  
 heat proof mat  
 Bunsen burner  
 forceps

#### Radiation:

filament lamp  
 2 × thermometers  
 1 small piece of black paper  
 1 small piece of silver foil  
 Sellotape  
 stopwatch  
 2 × clamp stand, clamp and boss

#### Conduction:

##### EITHER

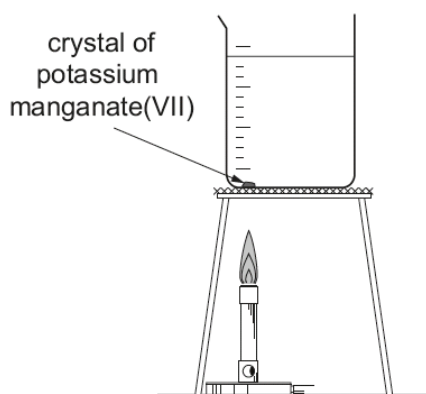
4 × metal rods  
 (aluminium, brass, copper and iron)  
 4 × drawing pins  
 Vaseline  
 tripod  
 Bunsen burner  
 heat proof mat  
 stopwatch

##### OR

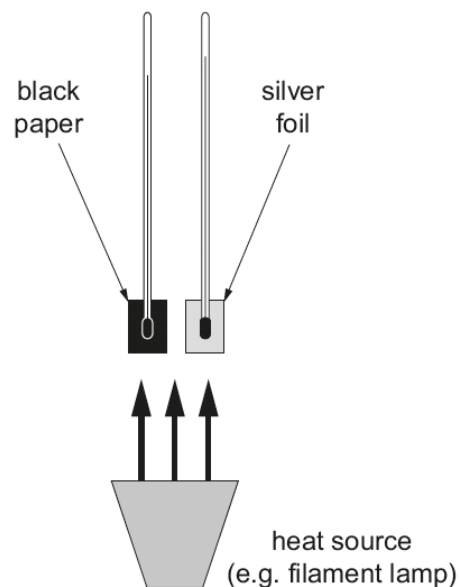
conductive ring  
 (aluminium, brass, copper and steel)  
 4 × wooden matches  
 Vaseline  
 clamp stand, clamp and boss  
 Bunsen burner  
 heat proof mat  
 stopwatch

## Diagram of Apparatus

### Convection Experiment

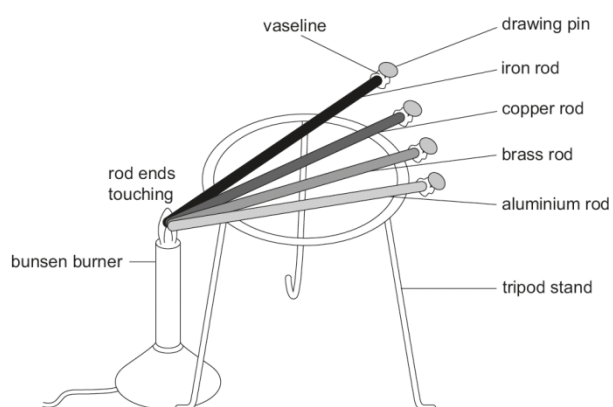


### Radiation Experiment

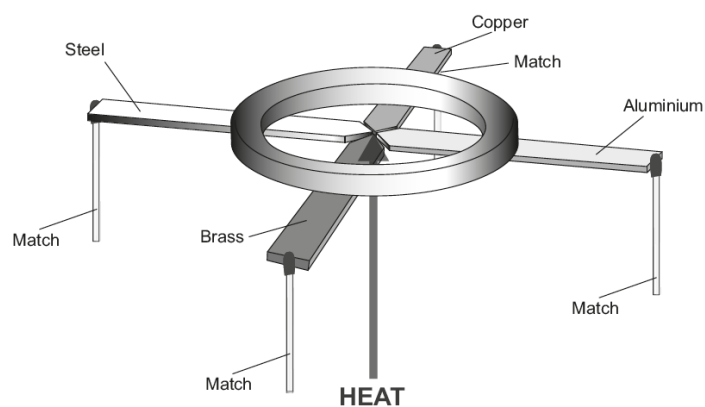


### Conduction Experiment

#### EITHER Metal Rods Experiment



#### OR Conductive Ring Experiment



## Method

### Convection Experiment

1. Fill the beaker to  $\frac{3}{4}$  full of water.
2. Use forceps to pick up a single crystal of potassium manganate(VII) and drop it carefully through the glass tube to one side of the bottom of the beaker.
3. Place your finger on the top of the tube and remove carefully.
4. Light the Bunsen burner well away from the apparatus. Use the gas tap to get the smallest blue flame that you can.
5. Put the small Bunsen flame directly underneath the crystal and record your observations.

## Method

### Radiation Experiment

1. Use Sellotape to attach a 2cm strip of black paper to the bulb of one thermometer.
2. In the same way attach a 2cm strip of silver foil to the bulb of another thermometer.
3. Clamp the 2 thermometers **the same distance away** (about 10cm) from a filament lamp.
4. Record the temperatures shown by the two thermometers.
5. Switch on the lamp and record the temperatures again after 10 minutes.

## Analysis

1. Determine which colour is the best absorber of heat.

## Method

### Conduction Experiment

#### Metal Rods Experiment

1. Set up the apparatus as shown in the diagram above.
2. Attach a drawing pin to the end of each rod with a small blob of Vaseline.
3. The ends of the rods (without the drawing pins) should be brought together so that they can be heated equally (see diagram).
4. Heat the ends of the rods equally with a blue Bunsen flame.
5. Record the time taken for each rod to lose its drawing pin.

### Conductive Ring Experiment

1. Clamp the conductive ring taking care to keep the clamp away from the mid-point of the ring.
2. Attach a wooden match to the outer end of each metal using a small blob of Vaseline.
3. Heat the centre point of the ring with a blue Bunsen flame.
4. Record how long it takes for each metal to lose its wooden match.

### Analysis

1. Determine the order of conductivity of the metals.

### Risk Assessments

#### Convection Experiment

Hazard	Risk	Control measure
Potassium manganate(VII) is harmful/oxidising	Could harm skin if touched	Use tweezers to drop a single crystal through the glass tube to bottom of beaker. Do not handle
Hot apparatus can burn	Burning fingers when moving apparatus	Allow apparatus to cool before any attempt to move it.  Hold tripod at bottom of a leg, Bunsen burner at base and gauze at the corner.

#### Radiation Experiment

Hazard	Risk	Control measure
Hot filament lamp can burn	Burning fingers when moving lamp	Allow lamp to cool before any attempt to move it.

## Conduction Experiment

Hazard	Risk	Control measure
Hot metal rods can burn	Burning fingers when moving rods	Allow the rods to cool thoroughly before attempting to move them from the tripod
Hot tripod can burn	Burning fingers when moving tripod	Allow the tripod to cool. Do not touch the top. Move by holding bottom of a leg
Aluminium melting can burn	Molten aluminium falling on back of hand causing burning/injury	Do not overheat aluminium. Observe aluminium for signs of melting and remove heat. Do not hold the Bunsen when it is directly beneath end of aluminium rod

## Teacher / Technician Notes

### Convection experiment

A small supply of potassium manganate (VII) crystals may be supplied in an evaporating basin (with some forceps) for shared use. Students should take care not to handle the crystals or get them on their clothes as it does stain. Please see the CLEAPPS card 48 on potassium manganate(VII) for further safety advice.

Strong heating does result in all the water becoming coloured very quickly. A small flame allows the convection to be seen much more easily. Students should adjust the gas tap to achieve the smallest blue flame that they can. If the flame goes out they should turn off the gas at the gas tap and then re-light the Bunsen burner and try again.

Students should be encouraged to describe their observations fully. It is not that the water all becomes coloured that is important but rather how this happens. They should be able to observe the convection currents in the water (as the purple colour rises, spreads across and sinks down the other side). They can then be encouraged to discuss / explain their observations.

### Radiation experiment

Infra-red lamps (perhaps used for microscope work) may be used as an alternative to filament lamps in the radiation experiment. The experiment works well if pieces of Sellotape are used to attach the foil/ paper. The temperature of the thermometer with the silver foil rises less despite the fact that the aluminium is a metal and a good conductor of heat. Alternatively, white paper could be used instead of the silver-coloured aluminium foil for a "fairer" experiment. Care should be taken to have the two thermometers (on the bench or clamped) at exactly the same distance from the heat source.

Students could be asked to predict what will happen. Some may suggest that the black paper will get hotter because it “attracts” more heat. This idea will need to be challenged in the discussion following the experiment.

Students should be encouraged to describe and explain their results. They should use relevant scientific terms such as heat waves, infra-red radiation, absorb and reflect.

### Conduction experiment

The expected order is:

<b>copper</b>	<b>(best conductor),</b>
<b>aluminium,</b>	
<b>brass,</b>	
<b>iron/ steel</b>	<b>(poorest conductor).</b>

Some groups may find aluminium to be the best conductor. It is often very close between copper and aluminium. Hopefully, a quick survey of each group’s results will reveal more votes for copper than for aluminium as the best conductor.

The metal rods may roll off the tripod and onto the bench. Thick cloths should be available for the teacher to pick them up and place them onto the heat proof mat to avoid marking the benches.

The Vaseline makes this a potentially messy experiment. Students need access to soap and hot water to remove Vaseline from hands. A plentiful supply of paper towels should be available to wipe Vaseline from benches. Wooden splints may be used to transfer Vaseline from a small pot onto the drawing pin / metal rod. Students should be encouraged to use the smallest amount of Vaseline that is needed to attach each drawing pin to the rod.

This practical works well run as a circus of activities.

## Working scientifically skills covered

### 2. Experimental skills and strategies

Carry out experiments appropriately having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations.

Make and record observations and measurements using a range of apparatus and methods.

### 3. Analysis and Evaluation

Interpret observations and other data including identifying patterns and trends, making inferences and drawing conclusions.

Evaluate data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error.

### 4. Scientific vocabulary, quantities, units, symbols and nomenclature

Use scientific vocabulary, terminology and definitions.