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

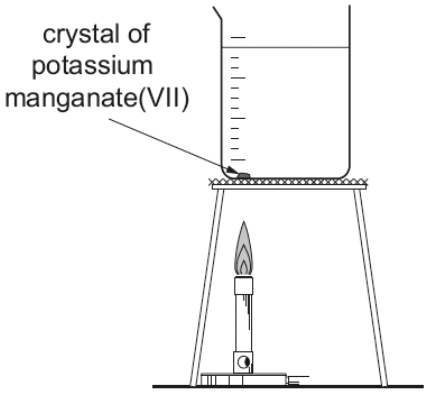
Convection:
2 × 250 cm^3 beaker
1 crystal of potassium manganate(VII)
10 cm^3 glass tube
tripod and gauze
heat proof mat
Bunsen burner
forceps

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

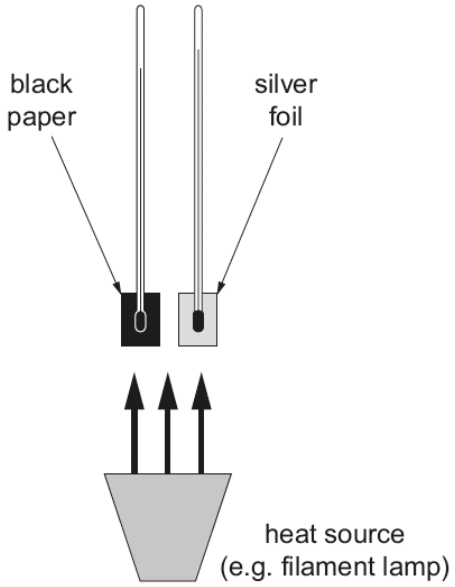
Conduction:
conductive ring
(aluminium, brass, copper and iron)
4 × wooden matches
Vaseline
clamp stand, clamp and boss
Bunsen burner
heat proof mat
stopwatch

Diagram of Apparatus

Convection Experiment

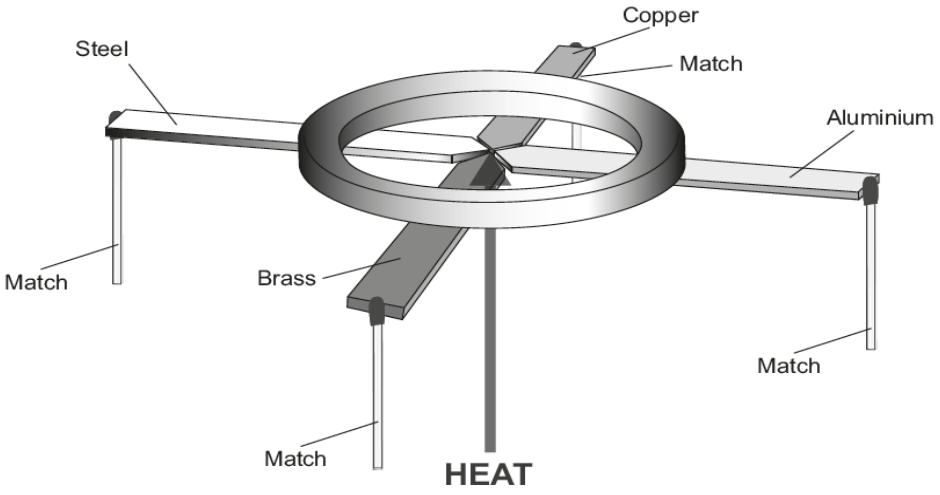


Radiation Experiment



Conduction Experiment

Conductive Ring Experiment



Method

Convection Experiment

1. Fill the beaker to ¾ 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.

Radiation Experiment

1. Use Sellotape to attach a 2 cm strip of black paper to the bulb of one thermometer.
2. In the same way attach a 2 cm strip of silver foil to the bulb of another thermometer.
3. Clamp the 2 thermometers **the same distance away** (about 10 cm) 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.

Conduction 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 which colour is the best absorber of heat.
2. Determine the order of conductivity of the metals.

Risk Assessment

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 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

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

This experiment can be demonstrated if only a limited number of conduction rings are available. A similar practical is undertaken by students in the specified practical in unit 3.1.

The expected order is :	**copper**	**(best conductor),**
	aluminium,	
	brass,	
	steel	**(poorest conductor).**

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.

If run as a class practical, 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. Students should be encouraged to use the smallest amount of Vaseline that is needed to attach each match to the ring.

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.