

12! Heat energy transfer

Answers

Heat and internal energy (PB page 131)

- 1 The full kettle holds a larger mass of water which can hold a larger amount of internal energy. More thermal energy needs to be supplied to reach a certain temperature, such as the boiling point.
- 2 The pan full of water, because of its much greater mass.

How heat energy travels

(PB pages 133, 134 and 135)

- 3 a) The pin nearest the candle will fall off first, then the pin next to it and so on until all the pins have fallen. This will happen because the heat is conducted along the rod and as the rod gets hot it melts the wax holding the pin to the rod, and the pin falls.
b) Rods of different materials but the same length and thickness can be set up with pins. The pins should be at the same distances along each rod and set up with the same amount of wax. The rods should be presented in turn to the candle (care being taken to make sure that the size of the flame is the same each time). The time for each pin to fall should be recorded for each rod.
- 4 a) The players passing the ball, because in conduction the particles in a substance pass heat energy to each other.
b) A defender running with the ball, because in convection the particles receive heat energy and take it with them.
- 5 The hot air above the burning coal rises and carries the particles of soot with it. The upward force of the moving air is greater than the weight of the individual soot particles so they move upwards.
- 6 a) During the day the air above the land will warm faster than the air above the sea. This warmer air will rise and the cooler air from the sea will move in over the land. The wind will blow in across the promenade from the sea.
b) At night the air above the warm surface of the sea rises and the air above the cooler surface of the land moves in to take its

place. This causes the wind to blow out across the promenade from the land.

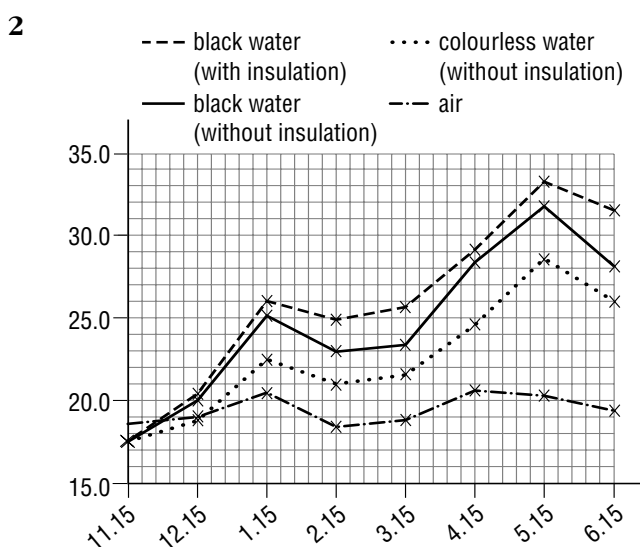
- 7 The heat travels as electromagnetic waves; particles are not involved.
- 8 Black surfaces radiate and absorb heat the most rapidly; dark colours radiate and absorb heat more rapidly than lighter colours; light shiny surfaces radiate and absorb heat the most slowly.

The Thermos flask (PB page 135)

- 1 Conduction and convection
- 2 The shiny walls absorb and radiate heat energy slowly. If they were black they would absorb and radiate much more heat energy and so the hot contents of a flask would lose more heat. The cold contents of a flask would gain more heat.
- 3 The air above the liquid surface would be warmed and carry heat energy away by convection. The particles that evaporate into the air take their internal energy with them, so reducing the total internal energy of the liquid.

End of chapter questions (PB page 137)

- 1 No, because the volume of the tray was 2500 cm^3 , which is 1000 cm^3 greater than the volume of the water.



- 3 The temperature rose least in the colourless water and rose most in the black water with insulation. The maximum temperature of the colourless water was 4.7 degrees lower than the maximum temperature reached by the black water with insulation. The black water with insulation was always warmer than the

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black water without insulation after the experiment began.

The temperature of all types of water followed the pattern of the air temperature until 4.15 pm when the drop in air temperature in the following hour was not followed but the temperature of all three types of water continued to rise. After a further larger drop in air temperature in the last hour the temperature of the trays of water fell.

- 4 The purpose of the ink was to raise the temperature of the water because a black surface absorbs more radiant heat than a colourless water surface. The purpose of the vermiculite was to hold the heat in the water. It is an insulator which reduces heat loss through the walls of the tray by conduction.
- 5 13.0 degrees above air temperature (or 15.7 degrees above starting temperature) at 5.15 pm in the black tray with insulation.
- 6 The temperature of the air and the three trays followed the same trend. The tray with black ink and insulation warmed up fastest and held its heat better than the other two trays. The tray with no ink and no insulation warmed up slowest and held its heat least well.

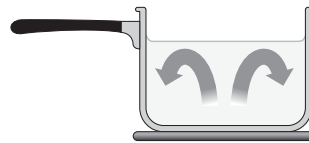
All the trays trapped heat energy from the Sun but the tray with black ink and insulation trapped the most and the tray with no ink and no insulation trapped the least.

End of chapter test

WORKSHEET 12.2 (TRB page 81)

- 1 The total kinetic energy of the atoms and molecules of the substance
- 2 They move faster and further than before.
- 3 a) A thermometer, B electric heater, C joulemeter
- b) Measuring the amount of thermal energy given to a substance
- c) No
- 4 It is passed from one particle in the substance to the next.
- 5 It occurs easily in solids, less easily in liquids, and hardly at all in gases.
- 6 In a vacuum, such as in outer space
- 7 Metals
- 8 The thermal energy is carried away by the particles of the substance changing position.

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- 10 In solids and in a vacuum (outer space)
- 11 Electromagnetic waves
- 12 In air and in a vacuum (and some can pass through solids such as glass)
- 13 A black surface
- 14 A light shiny surface

Activities

Activity 12.1 Investigating the heating of different volumes of water

Heat and internal energy (PB page 131)

Ask the pupils to devise an investigation to see how providing the same amount of heat energy to different volumes of water affects the temperature of the water. When you have checked and approved the pupils' plans, allow them to carry out their investigation. Look for a link between the temperature rise and the internal energy of the water in their conclusion to the investigation.

Preparation

- Top-pan balance

For each class group:

- Beaker
- Measuring cylinder
- Tripod and gauze
- Bunsen burner
- Thermometer
- Stopclock
- Cloth or other means of handling hot beaker

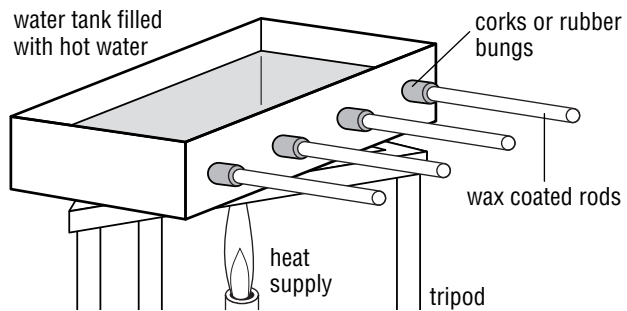
Safety

- Eye protection is needed.
- Care is needed when handling hot beakers.
- Make sure that the tripods have cooled down before clearing them away.

Activity 12.2 Demonstration of conduction

Conduction (PB page 132)

Set up the experiment shown below.



Coat the rods with paraffin wax. Take care to coat them all to the same thickness. The wax melts below 100°C so if the water in the tank is allowed to boil, the wax on the rods will partially melt. The rod made from the best conductor will have the greatest length of molten wax on its surface.

While the rods are beginning to conduct heat you could discuss the importance of conduction in selecting materials for various applications. For example, in the design of pans and pan handles.

After the demonstration has been running for a few minutes the pupils may be invited to measure the length of molten wax on each rod. The results may be tabulated on the chalkboard and pupils asked to rank the rods in order of their ease of conduction of heat.

Preparation

- Water tank
- Heat supply
- Waxed rods of different materials (all of the same dimensions)
- Tripod
- Corks or rubber bungs

Safety

- Care should be taken with the boiling water.
- Eye protection is needed.
- Dripping hot wax should be caught in a tray.
- Make sure that the tripod has cooled down before clearing away.

Activity 12.3 Investigating conduction in metals

Conduction (PB page 132)

This activity is a development of the answer to question 3b) on page 133. The pupils are given rods or wires of different metals and asked to devise a way of comparing how they conduct heat. The rods or wires of each metal should all be of the same dimensions. You could suggest that the rods or wires may be supported by a tripod. The pupils should suggest that a piece of wax is added to each rod or wire at a certain point from one end and that the rod or wire is heated with a Bunsen burner. The time taken for the wax to melt is then a record of the speed of conduction of heat through the metal.

Preparation

For each class group:

- Rods or wires of different metals (same dimensions)
- Tripod
- Bunsen burner
- Small pieces of wax to stick on the rods
- Half-metre rule
- Stopclock
- Cloth or tongs for handling hot items

Safety

- Eye protection is needed.
- Care should be taken when handling wires and rods that have been heated.

Activity 12.4 Investigating conduction through fabrics

Conduction (PB page 132)

The Thermos flask (PB page 135)

Present the pupils with a range of fabrics and ask them to compare the conduction of heat through them so that the fabrics can be suggested for clothing in hot and cold climates. The pupils should suggest measuring the rate at which a container of hot water cools down when its sides and bottom are covered with the material and a lid is made from the material (through which a hole is made to allow the thermometer to be inserted into the water).

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Preparation

For each class group:

- Beaker or calorimeter
- Thermometer
- Measuring cylinder
- Source of hot water (e.g. kettle, hot tap)
- Range of materials (e.g. denim, corduroy, wool, polyester), scissors, ruler, needle and thread

Safety

- Care should be taken with the hot water.

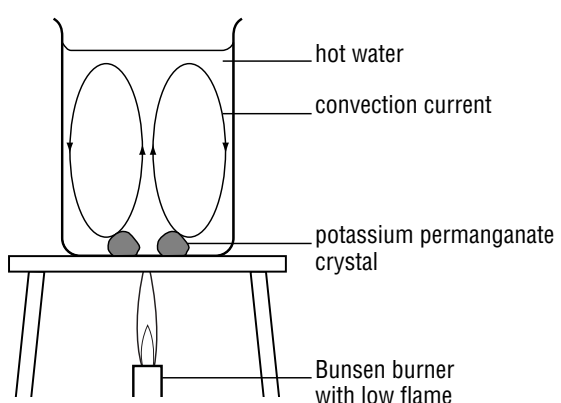
Activity 12.5 Demonstration of convection currents in liquids

Convection (PB page 133)

Heat water in a beaker to 90 °C over a weak source of heat (low Bunsen or hot plate). Then, using tweezers or a narrow glass tube, place two or three crystals of potassium permanganate onto the base of the beaker. Streams of purple will be seen to leave the crystals. Their path shows the flow of the liquid around the beaker (see diagram below) – the hotter liquid rising and the cooler liquid flowing downwards towards the base.

Preparation

- Beaker
- Heat source
- Potassium permanganate crystals
- Tweezers/narrow glass tube



Safety

- Care should be taken with the hot water and the heat source.
- Pupils should observe from a distance.

Activity 12.6 Testing convection in air

Convection (PB page 133)

WORKSHEET 12.1 Testing convection in air (TRB page 80)

You may like to use this activity with younger pupils. Issue the worksheet and let them make the paper spiral and test it over a radiator. Do not let them test it over a heat source that has a flame.

Preparation

- Class set of worksheet
- Access to a radiator

For each class group:

- Square of paper
- Scissors
- Thread

Activity 12.7 Investigating radiation from two surfaces

Radiation (PB page 134)

The pupils are given a calorimeter with a shiny surface and a calorimeter with a black surface and asked how they would compare the radiation of heat from each one. They should mount each calorimeter on a cork block and put a certain volume of water at about 60 °C in each. A thermometer should be suspended in the water in each calorimeter and the temperature recorded every minute for 15 minutes.

Preparation

- Supply of hot water (about 60 °C)

For each class group:

- Calorimeter with shiny surface
- Calorimeter with black surface
- Two cork (or polystyrene) blocks/mats
- Two thermometers (or temperature sensors)
- Two clamps and stands
- Stopclock

Safety

- Care should be taken with the hot water.