HEAT

THE NATURE OF HEAT

- **Heat**: the form of energy which can make the _____ of an object change /increase
- **Unit of heat energy**: _____
- **Temperature**: a measure of how ____ is an object
- **Thermometer**: measuring temperature in _____(°C)
- **Source of Heat**:

1. Electrical (toaster)
2.
3.
4.

- **Uses of Heat**: _____
- **Problems of Heat**: _____
- **The Kinetic Theory and Heat**:
  1. All matter is: made up of _____ that are in constant _____
  2. Particles in a solid vibrate about _____ positions
     Particles in a liquid _____
  3. Particles in a gas _____

THE TRANSFER OF HEAT

- **3 Methods of Heat Transfer:**

- **Conduction**:
  1. Occurs mostly in solid/liquid/gas (circle right one)
  2. Heat passes from particle to particle by _____
  3. Metals are good _____.
  4. Plastic and foam are examples of _____.

- **Convection:**
  1. Occurs in solid/liquid/gas (circle right one)
  2. Hot sections of the fluid are less _____ than cooler sections.
  3. This causes hot sections of fluid to _____ and cold sections of the fluid to _____.

- **Radiation:**
  1. Unlike convection and conduction, radiation does not need _____ to transfer heat
  2. Example of radiation heat transfer: _____
  3. Good absorbers and radiators are _____ in colour.

EFFECTS OF HEAT AND ENERGY

1. A solid or liquid that is heated will _____ in size.
2. The word used for increasing in size is _____ while getting smaller is called _____.
3. Draw a diagram to show how a thermostat works.

- **Thermometers**: work because a liquid (alcohol) _____ when heated. An alcohol is used instead of water because _____

- **Changes of State**:

Liquid to gas is called: _____
Liquid to solid is called: _____
Gas to liquid is called: _____
Solid to liquid is called: _____
Solid to gas is called: _____

HEAT TRANSFER

Heat can be transferred by conduction, convection and radiation. Conduction and convection occur through materials. Radiation does not need any material to go through, not even air.

Ways of warming up

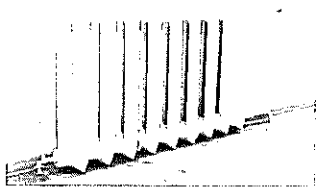
Heat is thermal energy. There are three ways that heat can be transferred from place to place: **conduction**, **convection** and **radiation**. You have experienced all three.

1 Conduction

On a cold day, you can warm your hands by touching a warm object. This is an example of heating by conduction.

2 Convection

A hot-water heater works mainly by convection. The hot metal pipes heat the air in contact with them. The hot air rises, creating what is known as a convection current. Eventually, this moving hot air will warm the whole room.

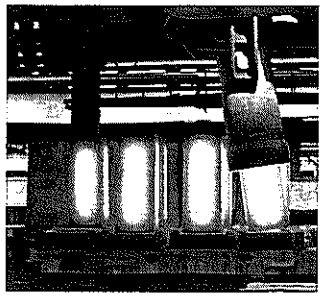


Hot-water heaters warm the air in a room by convection.

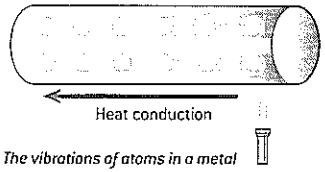
3 Radiation

You can warm yourself through radiation. You experience radiation from the Sun. Even in the middle of winter when the air around you is cold, you will feel warmth if you stand in sunshine.

Conduction – heating by direct contact



A crane lifts blocks of hot iron from a blast furnace, which converts iron ore into iron at temperatures of up to 2000°C.



The vibrations of atoms in a metal rod conduct heat away from the Bunsen burner.

Firefighters need to keep heat away from their bodies. They wear clothes that insulate and protect them from the fierce heat of fires.

Metals, such as copper, iron and brass, are excellent conductors of heat. The atoms in metals are aligned in a regular pattern, with each atom close to its neighbours. Heating a metal makes its atoms vibrate more quickly. The atoms pass on their vibrations to other atoms, passing the heat through the metal by conduction. Heat energy is conducted from the hot part of an object to the cold part.

Insulators

Non-metals and gases are usually poor conductors of heat. Plastic and wood are non-metals, and air is a gas. All of these are poor conductors of heat – they are **insulators**.

Clothes act as insulators, trapping warmth near our body in cold conditions and keeping heat out in hot environments. In cold weather, clothes trap air warmed by your body. They also act as a barrier, stopping wind and cold air currents replacing the warm air near your skin.

Wind chill is the way in which you feel colder when you have skin exposed to moving air. For example, if you are outside when the temperature is 10°C, a gentle wind may make you feel as if the temperature is actually 5°C, and a stronger wind may make you feel as if the temperature is 0°C.

Water conducts heat better than air does, so wet clothes do not insulate as well as dry clothes. The wet clothes conduct heat from your body. Additionally, there is the cooling effect of water evaporating.

EXPERIMENT #18

INVESTIGATING HEAT CONDUCTION

AIM: TO INVESTIGATE HOW HEAT SPREADS ALONG A METAL

MATERIALS

- Hot plate
- Wooden block
- Metal rod (about 30 cm long)
- Wax candle
- Matches
- Greaseproof paper
- Ruler
- Felt-tip pen
- Stopwatch

METHOD

1. Starting 5 or 6 cm from the end of the metal rod, make a pen mark every 1 cm for a length of 10 cm.
2. Place the rod on a piece of greaseproof paper. Light the candle and carefully pour a drop of wax on the rod at each mark. Leave the wax to set.
3. Place the unmarked end of the rod on the hotplate, with the marked end on the wooden block.
4. Place a sheet of paper on the bench underneath the rod to catch drips of wax and begin heating. Start the stopwatch immediately and record how long it takes for the wax to drip off each mark.

RESULTS

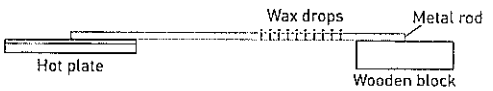
1. Record your data in a suitable table.
2. Construct a graph of time taken to melt the wax (vertical axis) against distance from the heated end (horizontal axis).

DISCUSSION

1. How do you think the heat was carried along the rod to each blob of wax?
2. Explain the shape of your graph.

CONCLUSION

Write a conclusion for this experiment that addresses the aim.



conduction the direct transfer of heat through a substance

convection the transfer of heat through movement of a gas or liquid

insulator a substance that does not readily allow the passage of heat

radiation the emission or transmission of energy in the form of waves through space or through a material

1. List the three ways that heat can be transferred.
2. How do you heat an object by conduction?
3. How do you heat an object by convection?

Describe the behaviour of atoms that allows objects to conduct heat.

4. Name two conductors and two insulators.

HOT AIR RISING

Rising convection currents of warm air, known as thermals, help hang-gliders fly.

Convection transfers heat through the movement of warm, low-density liquids and gases.

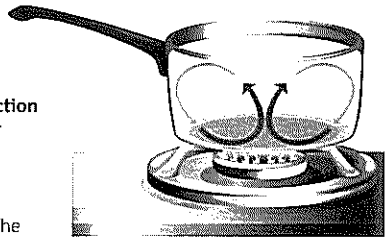
Convection – movements of gases and liquids

Hot air rising from a heater or a hot plate is an example of heating by convection.

Liquids and gases expand when they are heated. Their particles move faster when they are heated than they do when they are cold. As a result, the particles take up more volume. The spaces between the particles increase.

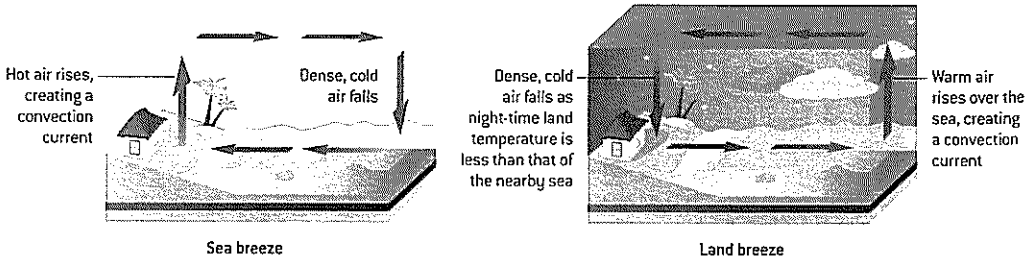
Air close to a heater warms and becomes less dense and rises. The denser cold air falls. This process sets up convection currents that transfer heat from place to place. **Convection currents** move hotter and colder particles within a gas or liquid.

Convection also causes sea breezes. A sea breeze is one that blows from the sea to the land. The Sun heats the beach and nearby land, and the warmed ground heats the air above it by conduction. The warmed air is less dense than the cooler air above it, so it rises. This air is then replaced by cooler air, drawn in from over the sea.



Heating a saucepan full of water sets up convection currents. Conduction transfers heat from the hot saucepan to the water molecules touching the metal. The heated water (shown in red) is less dense – it rises. The cooler water (shown in blue) sinks.

THE CIRCULATION OF AIR IN A SEA BREEZE



Sea breeze

Land breeze

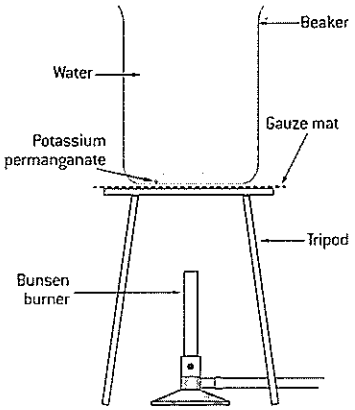
EXPERIMENT #19

INVESTIGATING HEAT CONVECTION

AIM: TO INVESTIGATE HEATING WATER BY CONVECTION

MATERIALS

- Bunsen burner
- Tripod
- Water
- Heatproof mat
- 600 mL beaker (Pyrex)
- Potassium permanganate crystals (or a few drops of food colouring)
- Dropper or pipette



METHOD

1. Set up the equipment as shown.
2. Fill the beaker with water. Place a few crystals of potassium permanganate on the bottom edge of the beaker. (Alternatively, add a drop of food colouring to the bottom of the full beaker using a dropper or pipette.)
3. Heat the water gently over the Bunsen burner and observe the movement of the coloured water. If possible, use a small flame and no heatproof mat between the burner and the beaker.
4. Observe the path that the coloured water takes.

RESULTS

Draw a labelled diagram showing the movement of the coloured water.

DISCUSSION

1. Describe the movement of the coloured water.
2. Why do you think the coloured water moved like this?
3. What was happening to the molecules of water when the water was being heated?

CONCLUSION

What have you observed about heating water by convection?

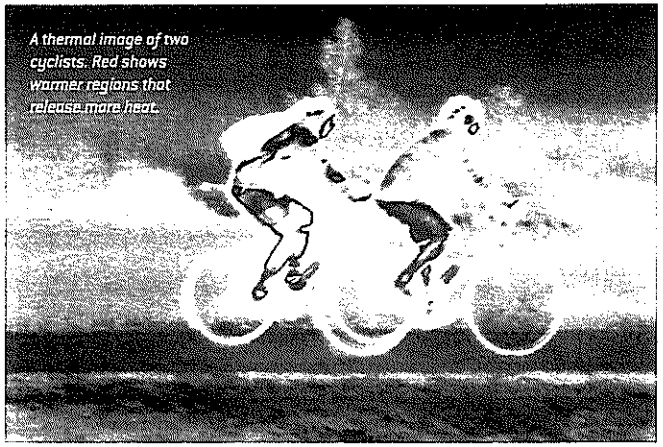
LOOK IT UP

convection current the transfer of heat by movement of heated fluid into an area of cooler fluid

CHECK IT OUT

1. What is convection and why does it occur?
2. Explain why convection cannot occur within solids.
3. Why is heating a liquid or gas from below more effective than heating it from above?
4. How does convection cause sea breezes?
5. Modern saucepans have a copper bottom, steel sides, a plastic handle and a glass lid. Describe why each of these materials is used in these ways.

RADIATION



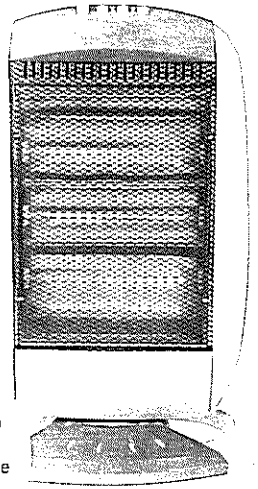
A thermal image of two cyclists. Red shows warmer regions that release more heat.

All objects release and take in thermal (infrared) radiation. Infrared radiation can travel through space.

Heat

Hot objects emit more **infrared radiation** than cold objects. The vibrating atoms release infrared waves. .

Infrared radiation is a form of electromagnetic radiation. It does not require particles in liquids or gases so it can pass through a vacuum. We can feel the heat of the Sun, which is 150 million kilometres away from the Earth, because the Sun's infrared radiation travels through space.



The hot wires in this heater contain rapidly vibrating atoms, which release infrared radiation that we feel as heat.

Ask a scientist

Dr Niraj Lal

Dr Niraj Lal, working to turn more energy from the solar spectrum into electricity.

Dr Niraj Lal studied physics at the Australian National University (ANU). He worked as a travelling science presenter to primary school children across regional Western Australia. He then obtained a PhD in physics from the University of Cambridge in the United Kingdom.

Niraj has returned to ANU to study and develop high-efficiency solar cells. Solar cells turn sunlight into electricity. Light with enough energy knocks electrons from the materials in the solar cells and creates an electric current.

Niraj has recently studied solar cells consisting of two layers – a high-efficiency silicon cell beneath a cheap, thin film of another semiconductor. This upper film is a material called perovskite – calcium titanium oxide.

The advantage of a two-layer solar cell is that it can turn more wavelengths of light into electricity. The lower layer converts wavelengths that don't activate the top layer. These dual cells can turn more than 30 per cent of the Sun's visible light energy into electricity.

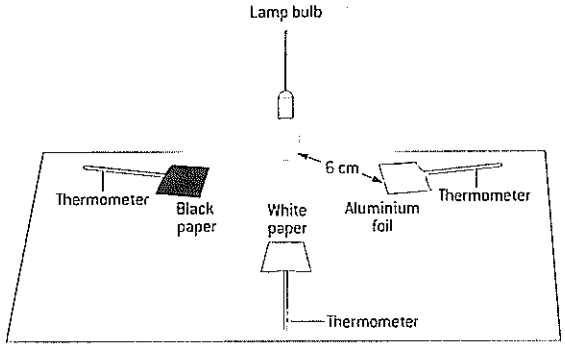
A video interview with Dr Niraj Lal is available on your obook / assess.

INVESTIGATING HEAT RADIATION

AIM: TO INVESTIGATE HEATING BY RADIATION

MATERIALS

- 3 cm squares of black paper, white paper and aluminium foil
- 3 thermometers
- Lamp or sunlight
- 3 stopwatches



METHOD

1. Place the bulbs of the thermometers under the different materials and then place them in the Sun (or under a lamp, ensuring that they are all about 6 cm from the lamp).
2. Construct a table to record the temperature of each thermometer every minute for 10 minutes.
3. Construct graphs of the change in temperature (vertical axis) against time (horizontal axis) for the different materials.

RESULTS

List the materials from best to poorest absorbers of infrared radiation.

DISCUSSION

1. Why do you think the best absorber behaved as it did?
2. Why do you think the poorest absorber behaved as it did?
3. From your knowledge of the electromagnetic spectrum, which coloured paper is likely to absorb more heat: red or blue? Explain your answer.

CONCLUSION

What have you observed about absorption of infrared radiation by different materials?

infrared radiation part of the electromagnetic spectrum; detected as warmth

1. What are two other names for infrared radiation?
2. What causes infrared radiation?
3. What is the main difference between the way in which infrared radiation and sound are transmitted?

4.1 Unit review

Remembering

1 **State** the temperature on the Fahrenheit, Celsius and Kelvin scales at which water freezes.

2 **Recall** how heat transfers by selecting the correct alternative in each statement below.
- a Heat always flows from an object of higher temperature to one of *lower/higher* temperature.
- b Insulators are *good/poor* conductors of heat.
- c Gases are *good/poor* conductors of heat.
- d On a warm day, a house is warmer upstairs because of *conduction/convection* currents.
- e The element of a hot water system will be located near its *top/base* and the heat is spread by convection.

3 **List** three insulators.

Understanding

4 **Describe** how heat is conducted along a metal rod.

5 Figure 4.1.2 on page 100 shows saucepans X and Y of water being supplied with equal amounts of heat energy. **Explain** why the temperature rise in saucepan X is greater.

6 A wetsuit traps a layer of water between the wearer and the fabric of the suit.
- a **State** whether water is a good or poor conductor of heat.
- b **Explain** how this design helps to keep the wearer of the suit warm.

7 **Explain** why the vents for a ducted heating system are usually placed near the floor and not the ceiling.

8 You lose a lot of heat from your head. For most people, their hair protects them from losing too much heat from their heads.
- a **Explain** why hair is an effective insulator.
- b **Describe** a hair style that would give you excellent insulation.

Applying

9 Heat transfer can occur by conduction, convection or radiation. **Identify** the main method of heat transfer in each situation below.
- a Your feet get hot when you are walking on sand at the beach.
- b Your back feels warm when you are sitting in the sun.
- c You boil water in an electric kettle.
- d You feel cold when you dive into a swimming pool.
- e You feel warm air as you walk into a school disco held in a hall.

Analysing

10 **Compare** heat and temperature.

11 **Compare** the Fahrenheit, Celsius and Kelvin temperature scales.

12 Two identical bathtubs are filled to the same level with water. The particles in bathtub A move with greater speed than the particles in bathtub B. **Analyse** this situation to answer the following.
- a **State** in which bathtub the water will be at a higher temperature.
- b **State** which bathtub has more heat energy.
- c As the water cools, each bath loses heat energy. **List** three places this heat energy could go.

Evaluating

13 Figure 4.1.17 shows the experimental set-up for a radiation experiment. The same sized black and white cardboard squares are attached to two thermometers close to an incandescent globe.

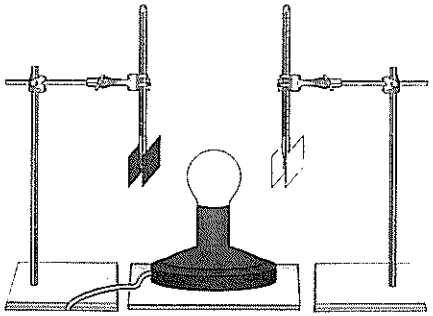


Figure 4.1.17

- a **Propose** what the student performing the experiment is trying to test.
- b **State** three variables that must be controlled to ensure a fair test.
- c **Predict** which thermometer will show the highest reading after 5 minutes.
- d **Discuss** reasons for your answer to question c.

14 **Propose** reasons why it is important for babies to wear a hat on a cool and windy day.

15 You walk barefoot on carpet in the living room of your house and your feet feel warm, yet when you walk into the bathroom and stand on the ceramic tiles your feet feel cold. The carpet and tiles are at the same temperature. **Propose** an explanation for why this is the case.

16 On a hot day, you have a choice of travelling in a red car, a white car or a black car, all of the same model. All have been parked in the sunlight for three hours.
- a **Identify** which car you would choose.
- b **Justify** your choice.

Creating

17 **Construct** a new type of suit that will keep you warm in cold conditions. On your diagram, **label** what it is made from and how it keeps the heat in.

Inquiring

1 Some animals help regulate their body temperature by heat loss through their ears. Research how animals absorb and emit heat. Prepare a multimedia presentation about the process used by three different animals.

2 Research the structure of double-glazed windows. Explain how these prevent heat loss.

3 Research how a thermos is designed to prevent heat loss. Explain how this happens, using labelled diagrams to assist your response.

4 Discover more about your body's largest organ—your skin. Create a poster with text in which you discuss either:
- a different skin conditions (such as acne, warts, dermatitis, freckles and moles), or
- b different forms of skin cancer, facts about each, what they look like, and how to prevent it.

5 Design and conduct an investigation into the cooling effect of a fan or an airconditioner on a warm glass of water. You could investigate how the effectiveness of the cooling device varies as the glass is positioned further away, or when the device is operated on different power settings.

6 Some manufacturers of mood rings claim that these rings can reveal a person's mood. Investigate and assess these claims.

Feeling chilly?
Naked mole rats are the only known mammals not in control of their body temperature. Their bodies are warmed to the temperature of their burrows, about 30°C.