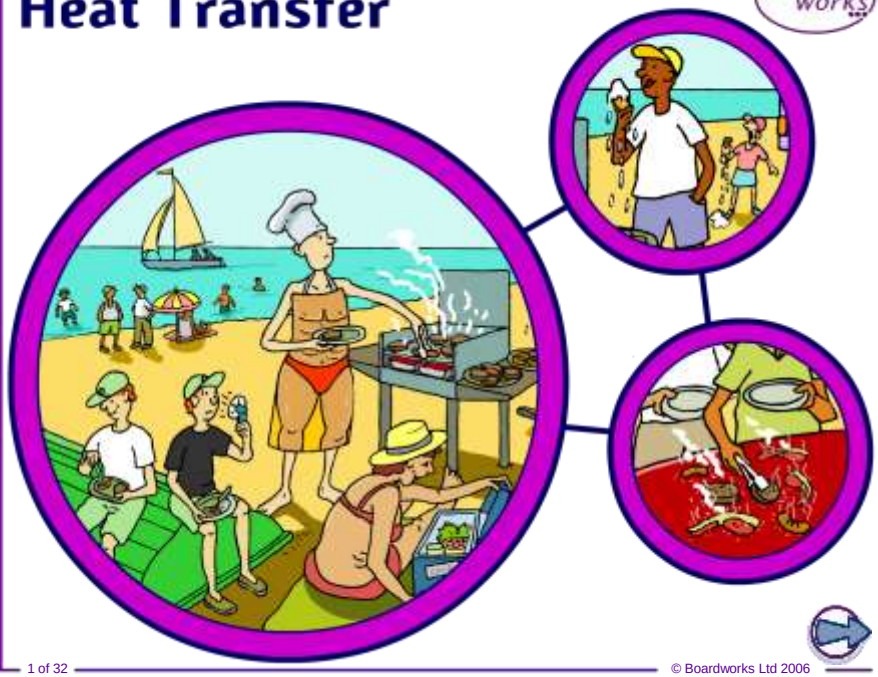
GCSE Science

Heat Transfer



Contents

Heat Transfer

How is heat transferred?

Where and how is heat transfer taking place at this seaside?

Why does heat transfer happen?

Heat is a type of energy called **thermal energy**.

Heat can be **transferred** (moved) by three main processes:

1. **conduction**
2. **convection**
3. **radiation**

During heat transfer, thermal energy **always** moves in the same direction:

HOT → **COLD**

Heat energy only flows when there is a temperature difference from a **warmer** area to a **cooler** area.

Why do objects get hotter or colder?

Temperature is a measure of how hot an object is.

Heat transfer only takes place when there is a **temperature difference**. The heat energy flows from a warmer area to a cooler area.

Why does an ice lolly melt on a warm tongue?

There is a temperature difference between the tongue and the lolly, so heat energy flows from the warm tongue into the cold ice lolly.

This heat transfer means that the ice lolly melts as it gets warmer, and the warm part of the tongue touching it gets cooler.

How might climate change cause the polar ice caps to melt?

How does energy affect materials?

Do different materials need the same amount of energy to increase their temperature by the same amount?

To increase the temperature of 1 kg of **water** by 1°C, requires **4200 J**.

To increase the temperature of 1 kg of **copper** by 1°C, requires **390 J**.

Water and copper require different amounts of energy because they have different values for a property called **specific heat capacity**.

It is the amount of energy required to increase the temperature of 1 kg of a material by 1°C.

So, the specific heat capacity for water is 4200 J/kg°C and for copper is 390 J/kg°C.

What is specific heat capacity?

The **specific heat capacity** of a material is the amount of energy required to raise 1 kg of the material by 1 °C.

It can be used to work out how much energy is needed to raise the temperature of a material by a certain amount:

energy = mass x specific heat capacity x temperature change

- Energy is measured in joules (J).
- Mass is measured in kilograms (kg).
- Temperature change is measured in °C.
- Specific heat capacity is measured in J/kg°C.

Specific heat capacity example

Using the specific heat capacity of water (4200 J/kg°C), how much energy is needed to increase the temperature of 600 g of water by 80°C in a kettle?

Note: mass = 600 g = 0.6 kg

energy = mass x specific heat capacity x temperature change

energy = 0.6 x 4200 x 80

= 201 600 J

Heat Transfer

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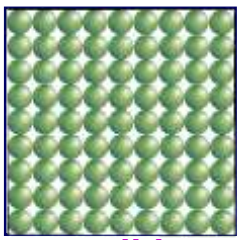
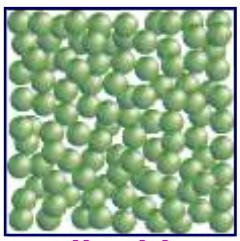
What is conduction?

How are the particles arranged in a solid, a liquid and a gas?



solid



liquid

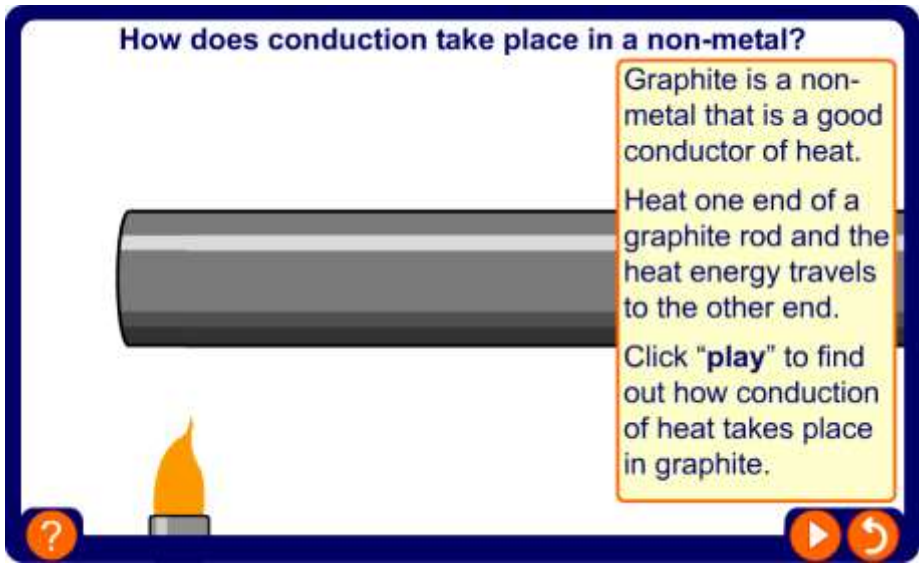
gas

Particles that are very close together can transfer heat energy as they vibrate. This type of heat transfer is called **conduction**.

Conduction is the method of heat transfer in **solids** but not liquids and gases. Why?

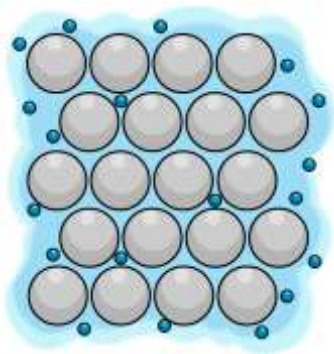
What type of solids are the best conductors?

How do non-metals conduct heat?



How do metals conduct heat?

Metals are good conductors of heat. The outer electrons of metal atoms are not attached to any particular atom. They are free to move between the atoms.



heat

When a metal is heated, the free electrons gain kinetic energy.

This means that the free electrons move faster and transfer the energy through the metal.

This makes heat transfer in metals very efficient.

Insulators do not have free electrons and so they do not conduct heat as well as metals.

Heat Transfer

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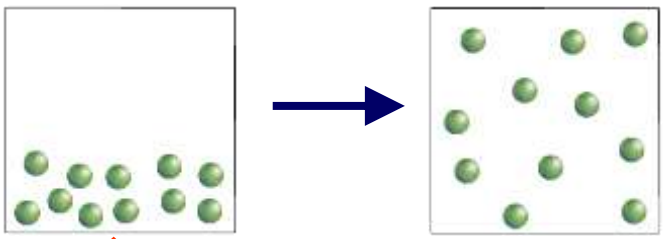
What happens a fluid is heated?

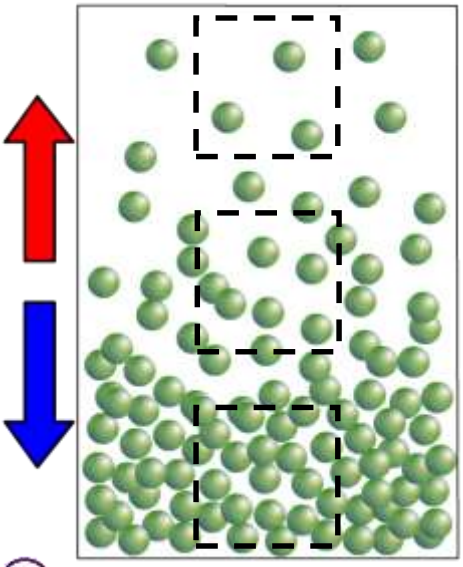
Liquids and gases can both flow and behave in similar ways, so they are called **fluids**.

What happens to the particles in a fluid when it is heated?



The heated fluid particles gain energy, so they move about more and spread out. The same number of particles now take up more space, so the fluid has become **less dense**.

What is convection?



Warmer regions of a fluid are **less dense** than cooler regions of the same fluid.

The **warmer** regions will **rise** because they are less dense.

The **cooler** regions will **sink** as they are more dense.

This is how heat transfer takes place in fluids and is called **convection**.

The steady flow between the warm and cool sections of a fluid, such as air or water, is called a **convection current**.

How does convection in a liquid occur?

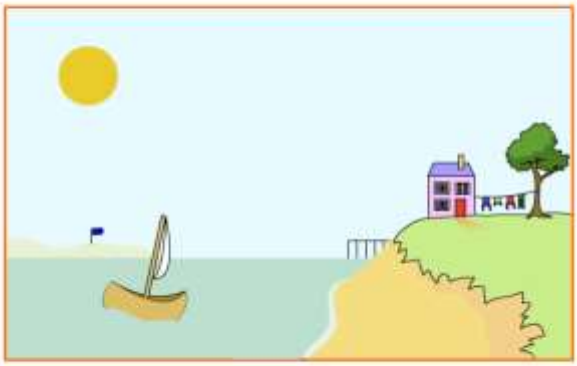
How does convection heat water in a kettle?

The heat source in an electric kettle is a heating element at the bottom of the kettle.

Click "**play**", or the "**on**" button, to find out how convection makes it possible for this heating element to heat all the water in the kettle.

How does convection in a gas occur?

Why is it windy at the seaside?



It is often very windy on the coast, at the boundary between land and sea.

Click "**play**" to find out how a seaside breeze is created by convection currents in air.

How does convection in a gas occur?

Why is it windy at the seaside?

It is often very windy on the coast, at the boundary between land and sea.

Click "**play**" to find out how a seaside breeze is created by convection currents in air.

Why is convection important in fridges?

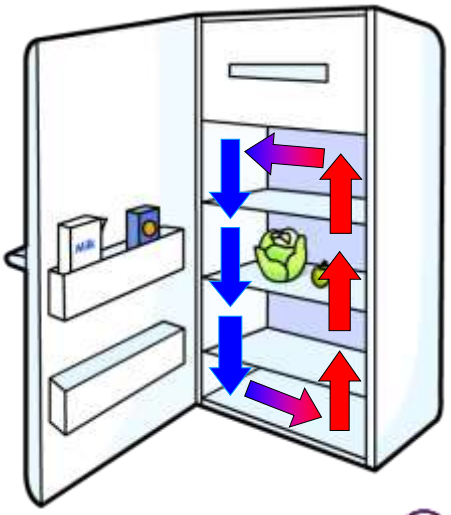
Why is the freezer compartment at the top of a fridge?

The freezer compartment is at the top of a fridge because cool air sinks.

The freezer cools the air at the top and this cold air cools the food on the way down.

It is warmer at the bottom of the fridge.

This warmer air rises and so a **convection current** is set up inside the fridge, which helps to keep the fridge cool.



Conduction and convection – summary

What are the missing words about conduction and convection?

1. Heat always moves from [?] areas to [?] areas.

2a. Conduction in non-metals occurs because vibrating atoms hit neighbouring atoms and cause them to [?] faster.

2b. Metals are better [?] than non-metals because they have [?] electrons that are able to move and transfer the heat.

3a. When a fluid is heated it [?]

solve

Heat Transfer

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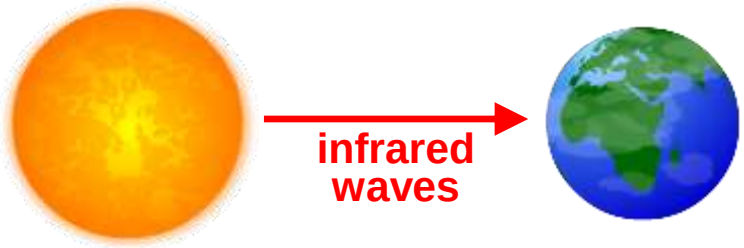
How does heat travel through space?

The Earth is warmed by heat energy from the Sun.

How does this heat energy travel from the Sun to the Earth?



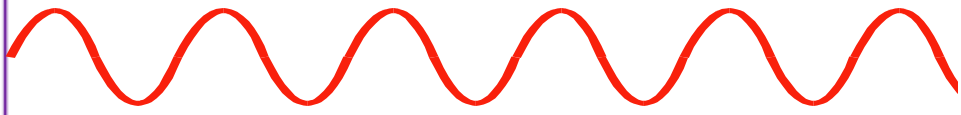
There are no particles between the Sun and the Earth, so the heat **cannot** travel by conduction or by convection.

The heat travels to Earth by **infrared waves**. These are similar to light waves and are able to travel through empty space.

What are infrared waves?

Heat can move by travelling as **infrared waves**.

These are electromagnetic waves, like light waves, but with a longer wavelength.



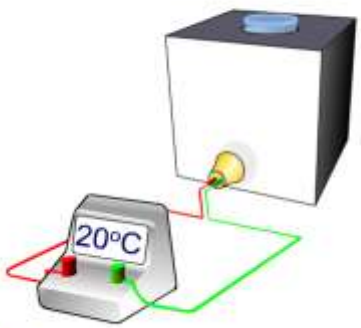
This means that infrared waves act like light waves:

- They can travel through a vacuum.
- They travel at the same speed as light – 300,000,000 m/s.
- They can be reflected and absorbed.

Infrared waves heat objects that **absorb** them and are also known as **thermal radiation**.

Investigating thermal emission

Do all surfaces emit the same amount of thermal radiation?



Surface of cube emitting thermal radiation	Final temp.
silver	°C
matt black	°C
white	°C
shiny black	°C

Emitting thermal radiation

All objects **emit** (give out) some thermal radiation.

Certain surfaces are better at **emitting** thermal radiation than others.

best emitter → **worst emitter**

matt black		white	silver

Matt black surfaces are the best emitters of radiation.

Shiny surfaces are the worst emitters of radiation.

Which type of kettle would cool down faster: a black kettle or a shiny metallic kettle?

Investigating thermal absorption

Do all surfaces absorb the same amount of thermal radiation?

Surface on test tube absorbing thermal radiation	Final water temp.
silver	°C
matt black	°C
white	°C
shiny black	°C

Absorbing thermal radiation

Infrared waves heat objects that **absorb** (take in) them.

Certain surfaces are better at **absorbing** thermal radiation than others. Good emitters are also good absorbers.

Matt black surfaces are the best absorbers of radiation.

Shiny surfaces are the worst emitters because they reflect most of the radiation away.

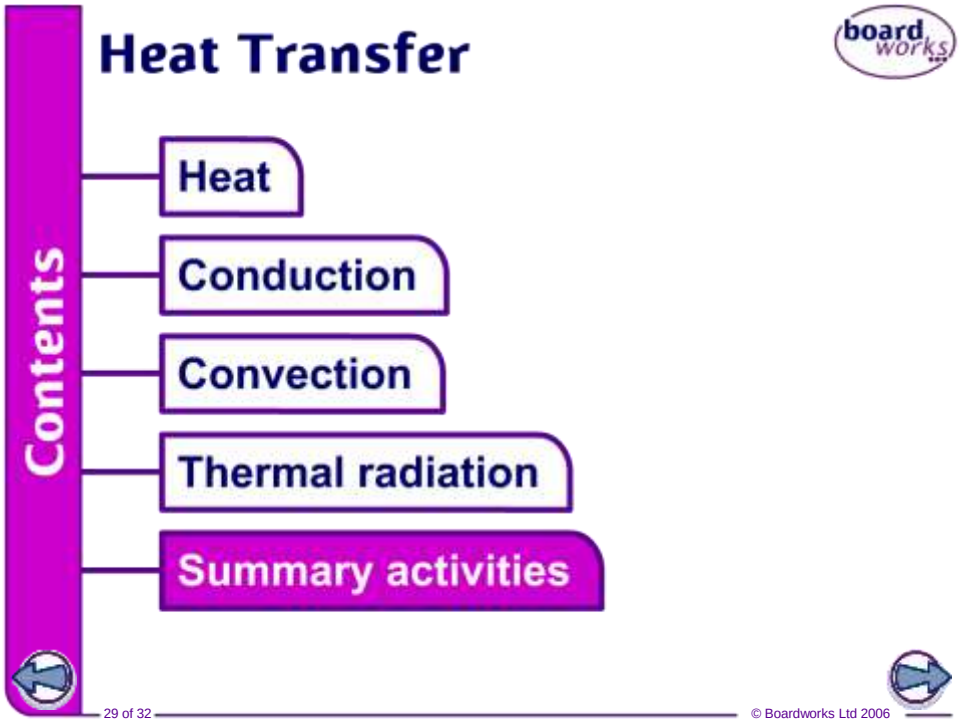
Why are solar panels that are used for heating water covered in a black outer layer?

Infrared radiation – true or false?

Are these statements about infrared radiation true or false?

1.	Infrared radiation travels in straight lines.	
2.	Infrared radiation can travel through a vacuum.	
3.	Infrared radiation requires particles to travel.	
4.	Infrared radiation can travel through thick walls.	
5.	Matt surfaces are best at emitting infrared radiation.	
6.	Infrared radiation travels at the speed of light.	
7.	Shiny surfaces are best at emitting infrared radiation.	

true false solve



Glossary

- **absorber –** A material that takes in thermal radiation.
- **conduction –** The method of heat transfer in solids.
- **conductor –** A material that lets heat flow through it.
- **convection –** The method of heat transfer in fluids, which occurs because hot fluids are less dense than cold fluids.
- **emitter –** A material that gives out thermal radiation.
- **free electrons –** Electrons in a metal that are free to move through the metal.
- **heat transfer** – The flow of heat energy from a hotter area to a colder area.
- **radiation –** Heat energy transferred by infrared waves. This method of heat transfer does not need particles.


Anagrams
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How quickly can you unscramble anagrams of words about
h e a t
t r a n s f e r ?
start
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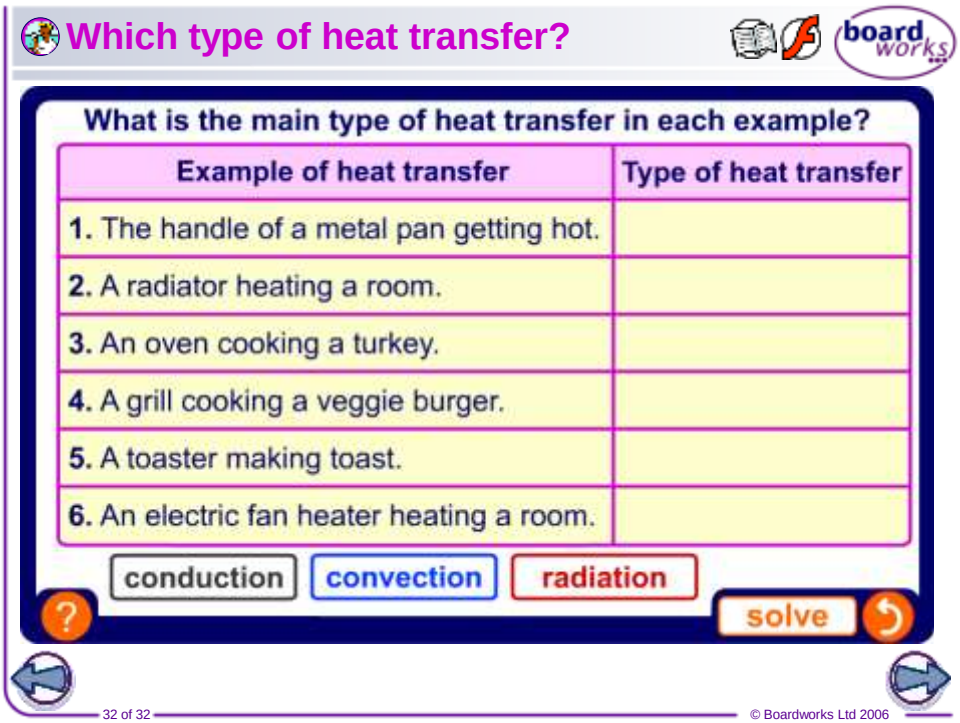
Which type of heat transfer?
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What is the main type of heat transfer in each example?
Example of heat transfer
Type of heat transfer
1. The handle of a metal pan getting hot.
2. A radiator heating a room.
3. An oven cooking a turkey.
4. A grill cooking a veggie burger.
5. A toaster making toast.
6. An electric fan heater heating a room.
conduction
convection
radiation
solve
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Multiple-choice quiz