Chapter 2: Energy transfer by heating

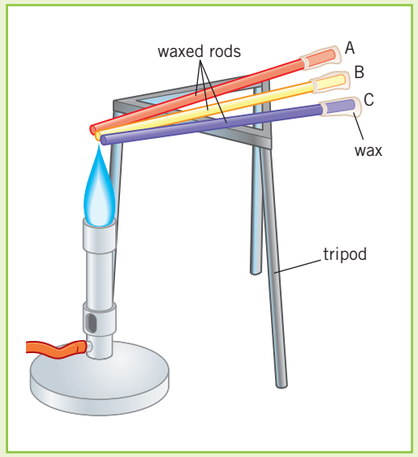
Knowledge organiser

Thermal conductivity

The **thermal conductivity** of a material tells you how quickly energy is transmitted through it by thermal conduction.

You can test the thermal conductivity of rods made of different metals using this experimental set-up. Each rod must have the same diameter and length, and the same temperature difference between its ends.

One end of each rod is covered in wax and the other ends are heated equally. The faster the wax melts, the higher the thermal conductivity of the metal.



Insulating buildings

Heating bills can be expensive so it is important to reduce the rate of heat loss from buildings.

Some factors that affect the rate of heat loss from a building include:

1. the thickness of its walls and roof
2. the thermal conductivity of its walls and roof.

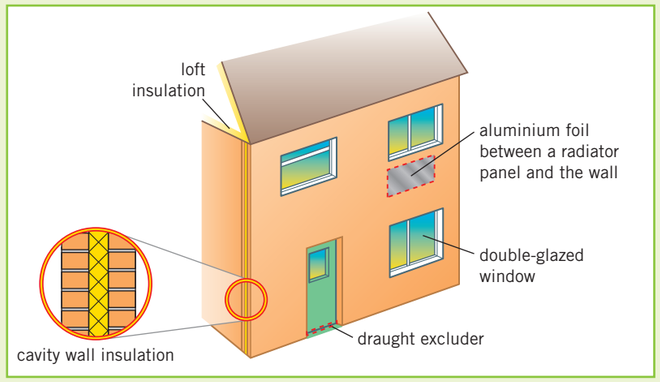
lower thermal conductivity = lower rate of heat loss

The thermal conductivity of the walls and roof can be reduced by using **thermal insulators**.

A thermal insulator is a material which has a low thermal conductivity. The rate of energy transfer through an insulator is low.

The energy transfer per second through a material depends on:

1. the material's thermal conductivity
2. the temperature difference between the two sides of the material
3. the thickness of the material.



Infrared radiation

Infrared radiation is part of the **electromagnetic spectrum**.

All objects **emit** (give out) and **absorb** (take in) infrared radiation.

The higher the temperature of an object, the more infrared radiation it emits in a given time.

A good absorber of infrared radiation is also a good emitter.

For an object at a constant temperature:

- infrared radiation emitted = infrared radiation absorbed
- infrared radiation is emitted across a continuous range of wavelengths.

An object's temperature will increase if it absorbs infrared radiation at a higher rate than it emits it. This rule applies to the planet Earth.

Black bodies

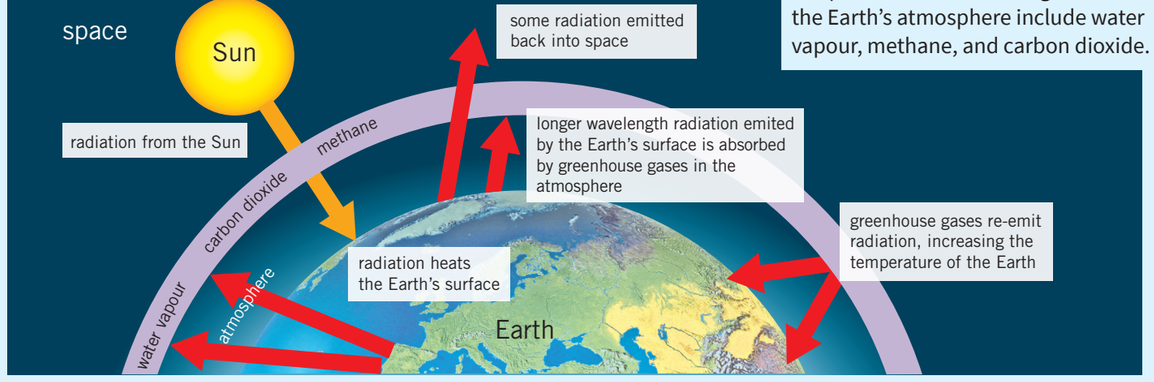
A **black body** is a theoretical object that absorbs 100% of the radiation that falls on it.

A perfect black body would not reflect or transmit any radiation, and would also be a perfect emitter of radiation.

Radiation and the Earth's temperature

The temperature of the Earth depends on lots of factors, including the rate at which visible light and infrared radiation are reflected, absorbed, and emitted by the Earth's atmosphere and surface.

Greenhouse gases absorb infrared radiation emitted by the surface of the Earth and prevent it escaping into space. They then re-emit the infrared radiation back towards the surface of the Earth, increasing the Earth's temperature. Greenhouse gases in the Earth's atmosphere include water vapour, methane, and carbon dioxide.



Human activities such as burning fossil fuels, deforestation, and livestock farming are increasing the amount of greenhouse gases in the Earth's atmosphere. This is causing the Earth's temperature to increase – a major cause of climate change.

Specific heat capacity

When a substance is heated or cooled the temperature change depends on:

- the substance's mass
- the type of material
- how much energy is transferred to it.

Every type of material has a **specific heat capacity** – the amount of energy needed to raise the temperature of 1 kg of the substance by 1 °C.

The energy transferred to the thermal store of a substance can be calculated from the substance's mass, specific heat capacity, and temperature change:

change in thermal energy (J) = mass (kg) × specific heat capacity (J/kg°C) × temperature change (°C)

$$\Delta E = m\, c\, \Delta\theta$$

This equation will be given to you on the equation sheet, but you need to be able to select and apply it to the correct questions.

Key terms

Make sure you can write a definition for these key terms.

absorb | black body | electromagnetic spectrum | emit | greenhouse gas | infrared radiation | specific heat capacity | thermal conductivity | thermal insulator

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Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	P2 questions	Answers
1	What does a material's thermal conductivity tell you?	how well it conducts heat
2	Which materials have low thermal conductivity?	thermal insulators
3	Give three factors that determine the rate of thermal energy transfer through a material.	thermal conductivity of material, temperature difference, thickness of material
4	What factors affect the rate of heat loss from a building?	thickness of walls and roof, thermal conductivity of walls and roof, the temperature difference between the two sides of the wall/roof
5	Define specific heat capacity.	amount of energy needed to raise the temperature of 1 kg of a material by 1 °C
6	What is infrared radiation?	type of electromagnetic radiation
7	What is the relationship between the temperature of an object and its emission of infrared radiation?	the higher the temperature of an object, the more infrared radiation emitted in a given time
8	What can you tell about an object that absorbs and emits infrared radiation at the same rate?	it is at a constant temperature
9	Compare the amount of infrared radiation emitted and absorbed by an object that is increasing in temperature.	more infrared radiation absorbed than emitted
10	What is a black body?	theoretical object that absorbs 100% of the radiation that falls on it, does not reflect or transmit any radiation, and is also the best emitter of radiation
11	Name three greenhouse gases.	water vapour, carbon dioxide, methane
12	What human activities increase the levels of greenhouse gases released?	(for example) deforestation, burning fossil fuels, livestock farming
13	Why do greenhouse gases increase the Earth's temperature?	Earth's surface absorbs and re-emits radiation from the Sun, which greenhouse gases then absorb – they re-emit this radiation back towards Earth's surface
14	To determine the specific heat capacity of a substance, what do you need to measure?	The mass, temperature rise, and the time taken

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