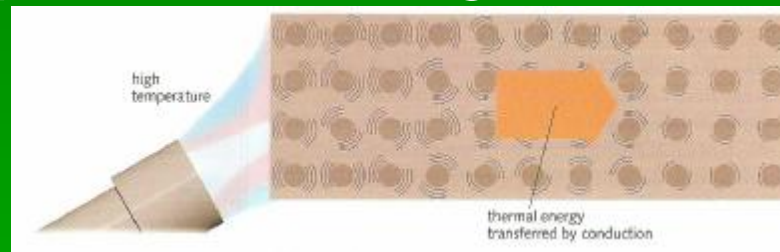


Thermal conduction

All materials are made up of tiny, moving particles (atoms and molecules). The higher the temperature, the faster the particles move.

If one end of a metal bar is heated, the other end eventually becomes too hot to touch. Thermal energy is transferred from the hot end to the cold end as the faster particles pass on their extra motion to particles all along the bar. The process is called **conduction**.



More thermal energy is transferred every second if:

- the temperature difference across the ends of the bar is increased
- The cross-sectional area of the bar is increased
- The length of the bar is reduced

$$\Delta Q / \Delta t = k S (T_2 - T_1) / l$$

Where Q – heat (J)

t – time (s)

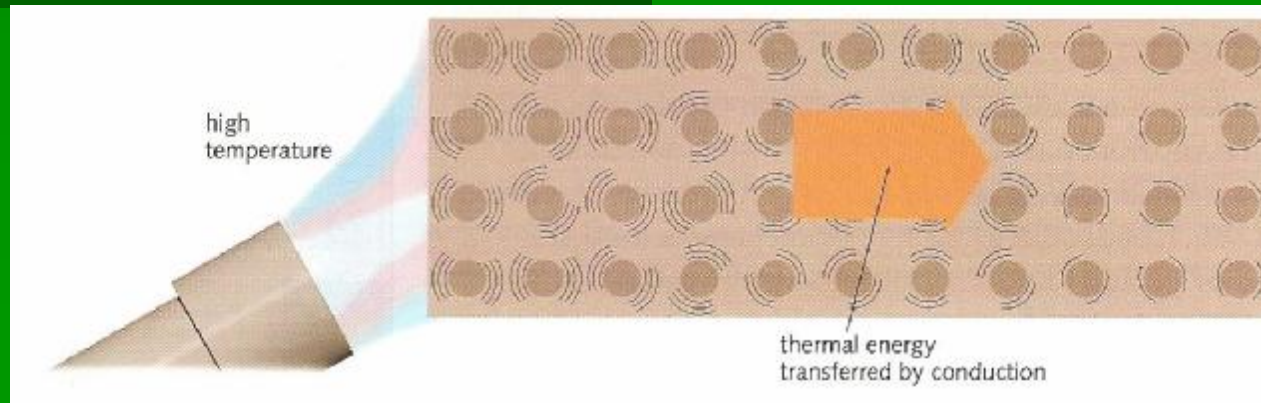
k – constant of thermal conductivity of given material

(J.s⁻¹m⁻¹K⁻¹)

T₂, T₁ – temperature (°C, K)

l – length of the object (m)

S - cross-sectional area of the bar (m²)



Thermal conductors and insulators

Some materials are much better **conductors** of thermal energy than the others. Poor conductors are called **insulators**.

Metals are the best thermal conductors. Non-metal solids tend to be poor conductors, so do most liquids. Gases are the worst of all. Many materials are insulators because they contain tiny pockets of trapped air. (lots layers of clothes)

You can sometimes tell how well something conducts just by touching it. A metal door handle feels cold because it quickly conducts thermal energy away from your hand, which is warmer. A polystyrene tile feels warm because it insulates your hand and stops it losing thermal energy.

Good conductors

metals e.g. copper
aluminium
iron

silicon

graphite

Poor conductors (insulators)

glass

water

plastics

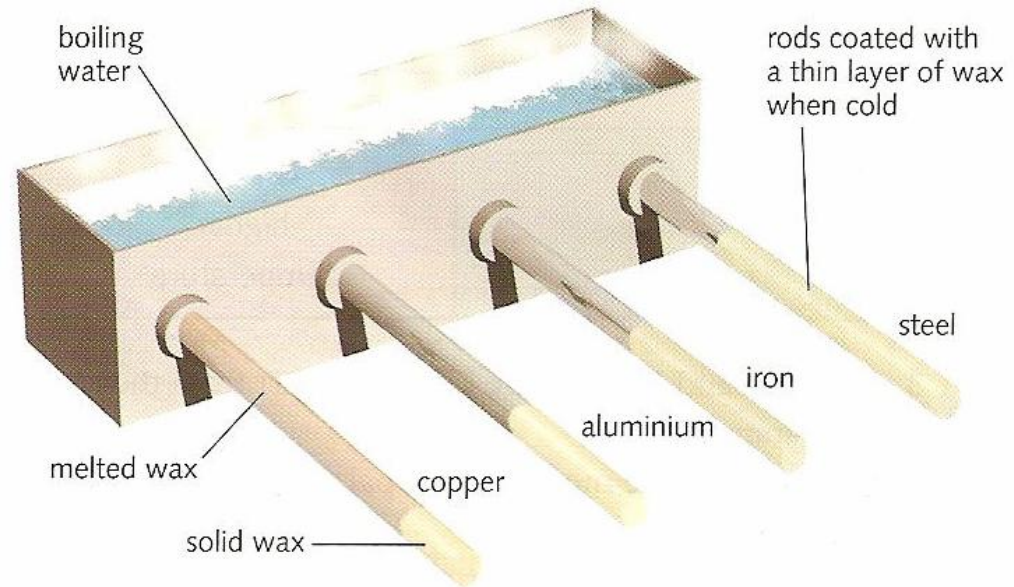
rubber

wood

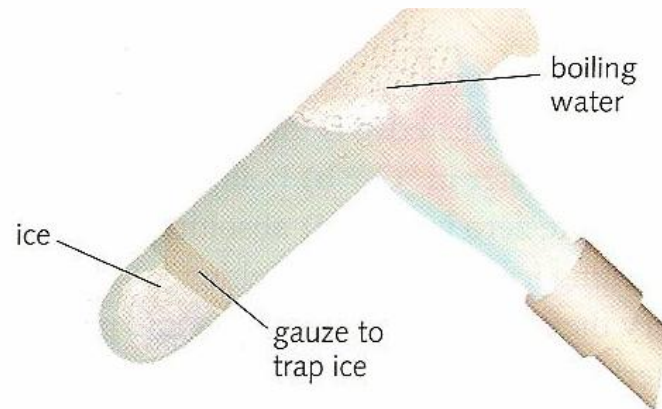
materials containing trapped air

[wool
	glass wool (fibreglass)
	plastic foam
	expanded polystyrene

The materials above are arranged in order of conducting ability starting with the best.

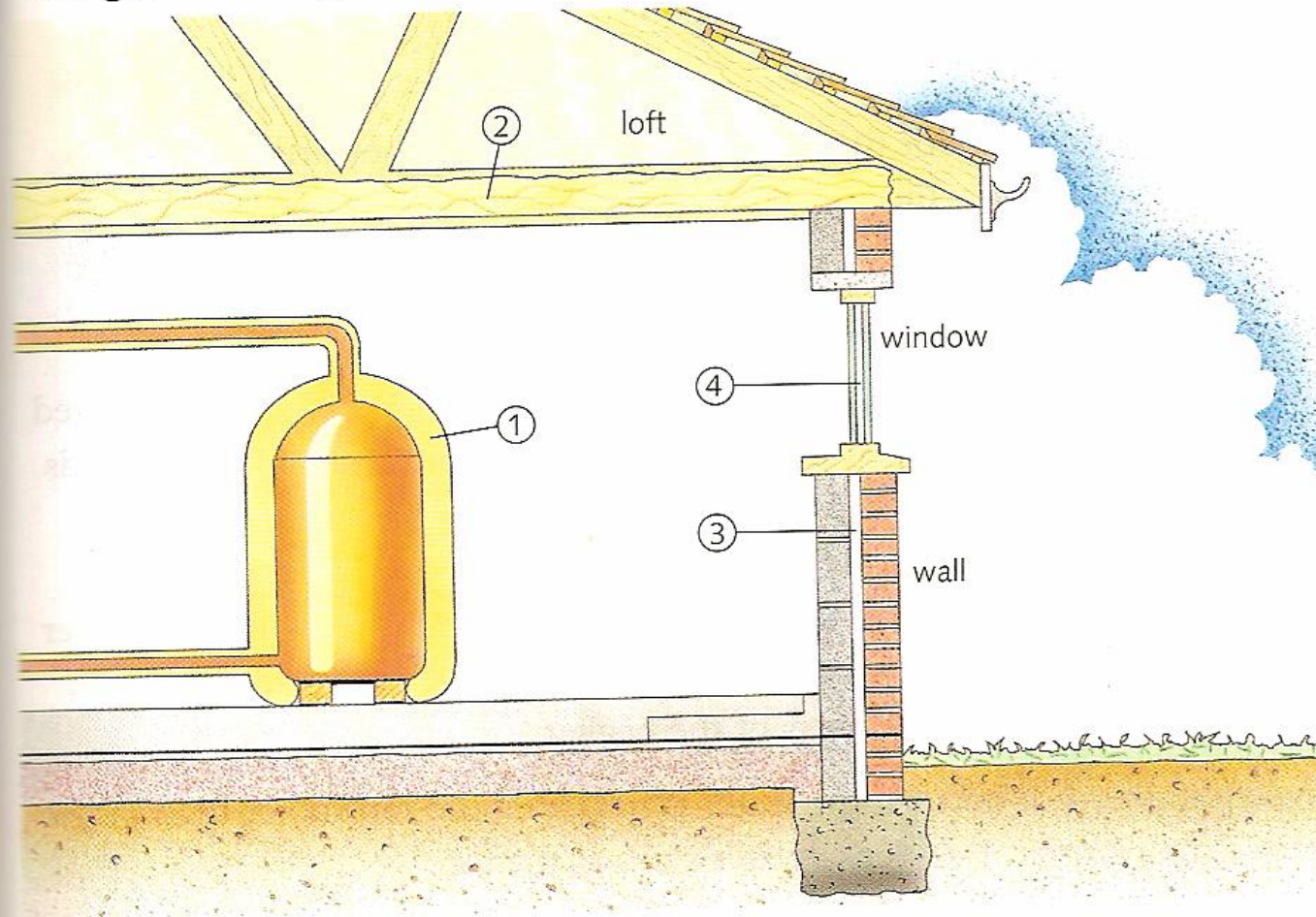


▲ Comparing four good thermal conductors. Ten minutes or so after the boiling water has been tipped into the tank, the length of melted wax shows which material is the best conductor.



▲ This experiment shows that water is a poor thermal conductor. The water at the top of the tube can be boiled without the ice melting.

Using insulating materials



In a house, good insulation means lower fuel bills. Above are some of the ways in which insulating materials are used to reduce heat losses:

- 1 Plastic foam lagging round the hot water storage tank.
- 2 Glass or mineral wool insulation in the loft.
- 3 Wall cavity filled with plastic foam, beads, or mineral wool.
- 4 Double-glazed windows: two sheets of glass with air between them.

How materials conduct

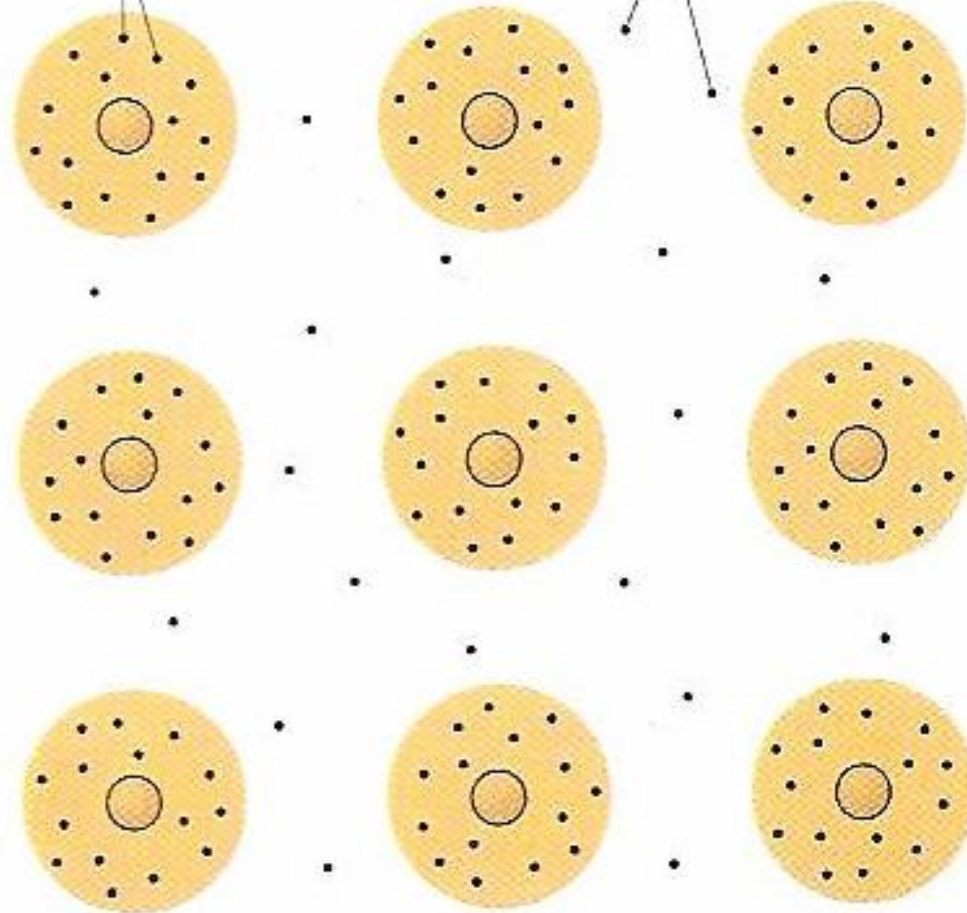
When a material is heated, the particles move faster, push on neighbouring particles, and speed those up too. All materials conduct thermal energy like this, but the process is slow. In metals, energy is also transferred by another much quicker method.

Most of electrons are firmly attached, but in metals, some are free to drift between the atoms. When a metal is heated, these free electrons speed up. As they move randomly between material, they collide with atoms and make them vibrate faster.

An electrical current is a flow of electrons – so metals are good electrical conductors as well as good thermal conductors.

electrons in
atom

free
electrons



Atoms in a metal

A shop window has thickness of 5 mm and area of 3m². Calculate amount of heat passed per 1 second through the window, if the internal temperature is 20°C and temperature outside is -10°C. K of the glass is 0.84 J.s⁻¹m⁻¹K⁻¹.

Solution:

$$\Delta Q / \Delta t = k S (T_2 - T_1) / l$$

$$\Delta Q / \Delta t = 0.84 \times 3 \times 35 / 0.005 = 18 \text{ kJ.}$$

<http://www.youtube.com/watch?v=pDuJFJB190k>

