# 4.2 Energy transfers by particles

Name: _____ Class: _____ Date: _____ **Total: 23 marks**

**KEY WORDS** convection • bimetallic strip

## Objective

Build the skills to answer exam questions on **heat transfer and expansion** : conduction, convection, evaporation and condensation, what changes the rate of energy transfer, and expansion with the bimetallic strip.

**You must be able to:**

- explain conduction in metals and non-metals, and convection in fluids
- explain evaporation and condensation with particles
- explain how temperature difference, surface area and materials change the rate of energy transfer
- explain expansion and the bimetallic strip

## 1 Key knowledge and worked examples

### ■ Heat transfer

| idea | equation or rule |
|---|---|
| conduction | vibrating particles pass energy to their neighbours; in metals, free electrons carry energy quickly; non-metals and gases are poor conductors (insulators) |
| convection | in liquids and gases: heated fluid expands, becomes less dense and rises; cooler, denser fluid sinks; this makes a convection current |
| evaporation | the fastest particles escape from the surface, so the liquid left behind cools; faster when warmer, with a larger surface area or with wind |
| condensation | a gas touching a cold surface cools and turns back into a liquid |
| rate of transfer | faster with a bigger temperature difference, a larger surface area (fins), and a thinner or better-conducting material |
| expansion | solids, liquids and gases expand when heated, because the particles move or vibrate more |
| bimetallic strip | two metals that expand by different amounts are joined; when heated, the strip bends with the metal that expands more on the outside |



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**Worked example 1: temperature difference.** A cup of tea at 80 °C cools by 3 °C a minute in a 20 °C room. Estimate how fast it cools at 50 °C.

1. Known: temperature difference 60 °C gives 3 °C per minute.
2. Rule: the rate of cooling is about proportional to the temperature difference.
3. Numbers: at 50 °C the difference is 30 °C, half as big.
4. Result: **about 1.5 °C per minute**.

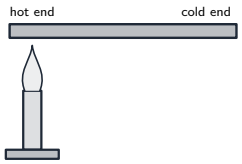
**Worked example 2: a bimetallic strip.** A strip of brass and steel is heated. Brass expands more than steel. Which way does it bend?

1. Known: brass expands more than steel.
2. Rule: the metal that expands more goes on the outside of the curve.
3. Apply: brass becomes longer than steel, so the strip curves away from the brass side.
4. Result: **it bends with brass on the outside**.

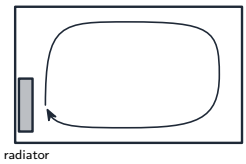
**Answer shapes:** in a particle explanation, say what the particles do and what that changes, e.g. "less dense, so it rises".

## 2 Practice

**2.1** Explain why metals are good thermal conductors. [2]




**2.2** A radiator is fixed to the wall of a cold room. Explain how it heats the air in the whole room. [2]




**2.3** An Arctic fox has small ears. A desert fox has very large ears. Explain how the size of the ears helps each fox. [2]






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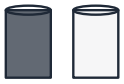
## 3 Exam-style questions

**3.1** Wet clothes dry faster on a warm, windy day. Explain why, using ideas about particles. [3]




**3.2** A student fills two cans with 0.30 kg of hot water each. One can is painted matt black and the other is shiny silver. She records the temperature of the water every 2 minutes.

(a) Calculate the average rate of cooling of each can over the 10 minutes. Which surface is the better emitter of infrared? [3]




| time / min | 0 | 2 | 4 | 6 | 8 | 10 |
|---|---|---|---|---|---|---|
| black / °C | 80 | 72 | 65 | 59 | 54 | 50 |
| silver / °C | 80 | 76 | 72 | 69 | 66 | 63 |

(b) Give two variables she must keep the same. [2]



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(c) Calculate the energy transferred from the water in the black can in the 10 minutes. Calculate the average power. ($c = 4200$ J/kg °C) [3]

(d) Explain why each can cools more slowly as time goes on. Then describe how a hot-water tank can be designed to keep the water hot. [6]



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