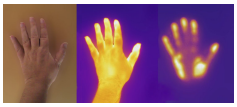
Thermal Physics

IGCSE Physics ▪ Topic 2

IGCSE Physics

What we will cover



1 States and the particle model

States of matter

solid 固体	liquid 液体	gas 气体
regular; vibrate about fixed positions	close; can slide – take the container's shape	far apart, fast; fill the container

Temperature and the particle model

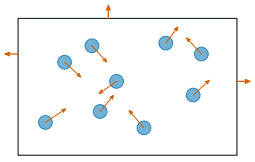
All matter is moving **particles** 粒子.

> **Temperature** 温度 measures the average kinetic energy of the particles.

Lowest possible: **absolute zero** 绝对零度, $-273°\mathrm{C}$.

$$T\,(\mathrm{K}) = \theta\,(°\mathrm{C}) + 273.$$

Gas pressure and Boyle's law



gas particles hit the walls — each hit is a tiny force.
Pressure = force per unit area

particle hits make the pressure

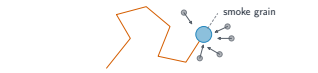
Fixed mass, constant temperature:

$$pV = \text{constant}.$$

$200\,\mathrm{cm}^3$ at $100\,\mathrm{kPa} \to 50\,\mathrm{cm}^3$

$$p_2 = \frac{100 \times 200}{50} = 400\,\mathrm{kPa}$$

Brownian motion



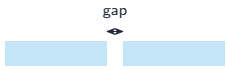
fast, invisible air particles hit the smoke grain from random directions, so it moves in a jerky, random path

Smoke specks move in a jerky, random path – pushed by fast, invisible air particles.

> **Brownian motion** 布朗运动 is strong evidence for the particle model.

2 Heating

Thermal expansion and heat capacity



cool: a gap is left for expansion

hot: the rails expand and the gap closes

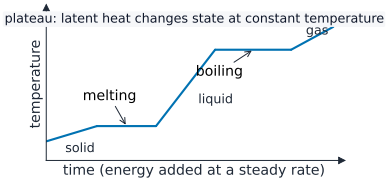
Heated matter expands (gases most).
Specific heat capacity 比热容:

$$c = \frac{\Delta E}{m\,\Delta\theta}.$$

$2.0\,\mathrm{kg}$ **water,** $20 \to 70^{\circ}\mathrm{C}$, $c = 4200$

$\Delta E = mc\,\Delta\theta = 420\,\mathrm{kJ}$

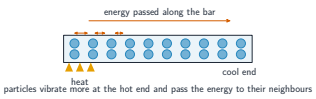
Changes of state



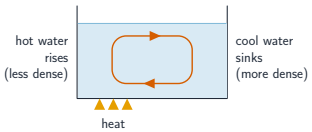
- **melting** 熔化/**boiling** 沸腾 – temperature stays flat while the state changes
- **evaporation** 蒸发 – fastest particles leave the surface, so the liquid cools

3 Thermal transfer

Conduction and convection



conduction 热传导*: particles pass energy*



convection 对流*: hot fluid rises*

Metals conduct well (free **electrons** 自由电子); convection needs a moving fluid, so not in solids.

Radiation

Thermal radiation 热辐射 is **infrared** 红外线 – it needs no material and crosses space.

> Dull black surfaces are good emitters and absorbers; shiny white ones reflect.

4 Recap

Topic 2 – key takeaways

1. **Particles**
   temperature = average kinetic energy
2. **Gas law**
   pV = constant at constant temperature
3. **Heating**
   $\Delta E = mc\Delta\theta$; state changes stay flat
4. **Transfer**
   conduction, convection, radiation

Check yourself

1. Convert $25^{\circ}\mathrm{C}$ to kelvin.
2. Halve a gas's volume – what happens to its pressure?
3. Why does evaporation cool a liquid?
4. Which surface is the best emitter of infrared?

> **Answers** **1.** $298\,\mathrm{K}$ **2.** it doubles **3.** the fastest particles leave **4.** dull black