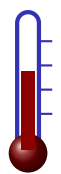
# Thermal Physics

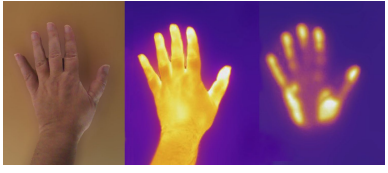
## IGCSE Physics ▪ Topic 2

IGCSE Physics

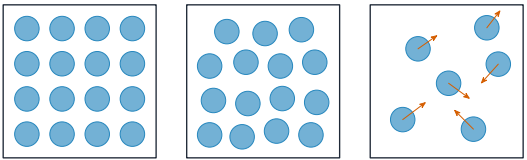


# What we will cover

1. States of matter
2. The kinetic particle model
3. Specific heat capacity
4. Changes of state
5. Conduction convection radiation
6. Recap



# States of matter



**solid**
fixed pattern,
vibrate in place

**liquid**
close, no pattern,
slide past

**gas**
far apart,
fast and random

- **solid** 固体 – fixed shape, ordered, vibrating
- **liquid** 液体 – takes the shape, slides past
- **gas** 气体 – fills the space, fast & random

# Temperature and the particle model

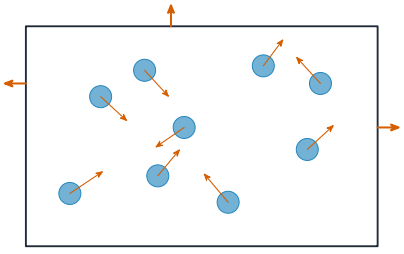
All matter is moving **particles** 粒子.

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

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

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

# 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*

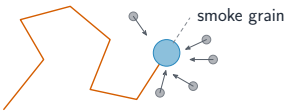
Fixed mass, constant temperature:

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

**$200\,\text{cm}^3$ at $100\,\text{kPa} \rightarrow 50\,\text{cm}^3$**

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

# 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.

# Thermal expansion and heat capacity


cool: a gap is left for expansion

hot: the rails expand and the gap closes

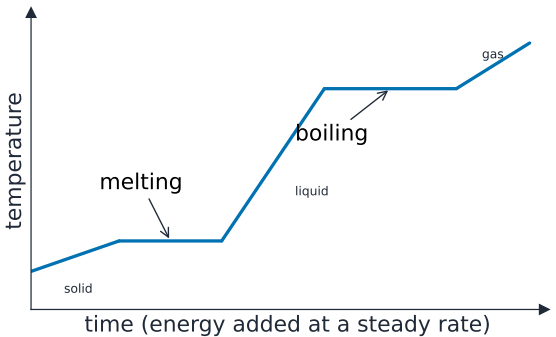
Heated matter expands (gases most).
**Specific heat capacity** 比热容:

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

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

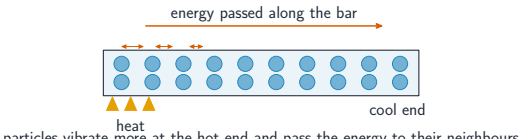
$\Delta E = mc\Delta\theta = 420\,\mathrm{kJ}$

# Changes of state

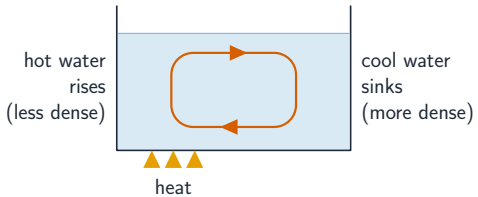



- **melting** 熔化/**boiling** 沸腾 – temperature stays flat while the state changes
- **evaporation** 蒸发 – fastest particles leave the surface, so the liquid cools

# 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.

# Topic 2 – key takeaways

**1 Particles**

temperature = average kinetic energy

**2 Gas law**

$pV$ = constant at constant temperature

**3 Heating**

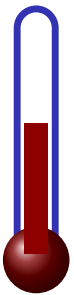
$\Delta E = mc\Delta\theta$; state changes stay flat

**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