Particle model of matter

OxfordAQA International GCSE Physics 9203, topic 3.4: kinetic theory, heat capacity, (P) latent heat, transfers, expansion

Everything is particles

> Energy, separation and motion of particles explain the states of matter.

- OxfordAQA International GCSE Physics 9203, topic 3.4.
- (P) latent heat and the cooling curve.

Specific heat capacity

1. **Equation** $E = m \times c \times \Delta\theta$
2. **Data** $m = 1.5$ kg, $c = 4200$ J/(kg °C), $\Delta\theta = 40$ °C
3. **Energy** $E = 1.5 \times 4200 \times 40 = 252\,000$ J

Decision

252 000 J to warm 1.5 kg of water by 40 °C.

Measuring c

1. **Energy in** $E = Pt = 50 \times 600 = 30\,000$ J
2. **Rearrange** $c = E \div (m\Delta\theta) = 30\,000 \div (2.0 \times 15)$
3. **Result** $c = 1000$ J/(kg °C); accepted value about 900

Decision

Too high: some energy heated the air, not the block.

(P) Latent heat: the flat part

> While a substance changes state, its temperature does not change.

- E = m L_F to melt; E = m L_V to boil.
- Impurities change melting and boiling points.

(P) Worked: melting, then warming

33 400 + 8400 = 41 800 J: melting takes four times more.

- Melting: E = m L_F, no temperature change.
- Warming: E = m c $\Delta\theta$.

Conduction

> Vibrating particles pass energy along; free electrons speed it up in metals.

- Insulators lack free electrons: slower transfer.
- Metals feel cold because they conduct, not because they are colder.

Convection

> Warmer fluid expands, becomes less dense and rises.

- Heat does not rise: hot fluid rises.
- Only fluids (liquids and gases) convect.

Evaporation cools

> The fastest molecules escape, so the liquid left behind is cooler.

- It happens at any temperature, from the surface.
- Condensation reverses it.

Designing for heat transfer

Cooling fins

large surface area

energy leaves faster

Animals' ears

hot climates: large ears

cold climates: small ears

Thermal expansion

One metal expands more, so the strip bends.

- A hazard: bridges and roofs need gaps and rollers.
- A use: the bimetallic-strip thermostat.

Common mistakes

Mistake	**Fix**
final temperature in $E = mc\Delta\theta$	use the change
(P) $mc\Delta\theta$ while melting	use $E = mL$
(P) flat part = nothing happening	changing state, releasing energy
"heat rises"	hot fluid rises: less dense

Check yourself

Question	**Answer**
2 kg aluminium (c = 900) by 30 °C?	54 000 J
(P) melt 0.5 kg, $L_F = 330\,000$ J/kg?	165 000 J
Why does warm water rise?	less dense
Why do fins have a large area?	faster transfer