Specific Heat Capacity and Latent Heat

Matthew Williams • Physics • May 20, 2026

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Heat Capacity and Specific Heat Capacity

Different materials need different amounts of heat to reach the same temperature rise. This is described by two related quantities.

Heat capacity (C) of an object is the energy required to raise its temperature by 1 K (or 1 °C):

$$C = \frac{E_H}{\Delta T}$$

Unit: J K^{-1}.

Specific heat capacity (c) of a substance is the energy required to raise the temperature of **1 kg** of that substance by **1 K** (or 1 °C):

$$c = \frac{E_H}{m\Delta T}$$

The working formula is:

$$E_H = mc\Delta T$$

where E_H is heat energy in joules (J), m is mass in kilograms (kg), and ΔT is the temperature change in kelvin or degrees Celsius.

Unit of c: J kg^{-1} K^{-1}.

The two quantities are related by: $C = mc$.

Selected Specific Heat Capacities

Substance	[Math: c] / J kg{ K{
Water	4 200
Aluminium	900
Copper	400
Iron	500
Air	1 000

Water has the highest specific heat capacity of common liquids. A large mass of water (ocean, lake) can absorb or release enormous amounts of thermal energy with a small temperature change, this moderates coastal climates.

Specific heat capacity from electrical heating (2023 Paper 02, Q1)

A 300 g liquid sample is heated by an electric heater rated at 105 W. Temperature readings are taken every 60 s. The temperature rises from 25.3 °C to 56.8 °C over 360 s.

Gradient of temperature-time graph:

$$G = \frac{\Delta\theta}{\Delta t} = \frac{56.8 - 25.3}{360 - 0} = \frac{31.5}{360} \approx 0.0875\,^{\circ}\mathrm{C\,s}^{-1}$$

Specific heat capacity(using $G = P/mc$):

$$c = \frac{P}{mG} = \frac{105}{0.300 \times 0.0875} = \frac{105}{0.02625} \approx 4\,000\mathrm{J\,kg}^{-1}\,^{\circ}\mathrm{C}^{-1}$$

Comparing with the table of liquids (cooking oil: 1700, paraffin: 2100, milk: 3900), the liquid is most likely **milk**.

Specific Latent Heat

When a substance changes state (melts, freezes, boils, or condenses), it absorbs or releases heat energy **without any change in temperature**. This hidden energy is the **latent heat** ("latent" means "hidden").

Specific latent heat(L

) is the energy absorbed or released when 1 kg of a substance changes state without a change in temperature:

$$E_H = mL$$

where E_H is in joules, m is mass in kilograms, and L is the specific latent heat in J kg{.

Two specific latent heats exist for each substance:

- **Specific latent heat of fusion** (L_f): energy to melt (or freeze) 1 kg of the substance at its melting point.
- **Specific latent heat of vaporisation** (L_v): energy to vaporise (or condense) 1 kg of the substance at its boiling point.

For water: $Lf = 3.4 \times 10^5$ J kg{, $Lv = 2.26 \times 10^6$ J kg{.

The latent heat of vaporisation of water is about 7 times its latent heat of fusion, it takes far more energy to convert water to steam than to melt ice.

Heating and Cooling Curves

When a pure substance is heated at a constant rate, a temperature-time graph shows flat regions during each phase change.

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caption="Heating curve for water: flat sections at 0 °C (melting) and 100 °C (boiling) represent latent heat being absorbed at constant temperature."

height={300}

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The **slope**of each rising section equals P/mc

(rate of temperature rise at constant heating power). The **flat sections**

have slope zero because the energy input goes into breaking intermolecular bonds rather than increasing kinetic energy.

Evaporation vs Boiling

Both processes convert liquid to vapour, but they differ in several ways:

Property	Evaporation	Boiling
Location	Surface of the liquid only	Throughout the bulk of the liquid
Temperature	Occurs at all temperatures	Occurs at the boiling point only
Rate	Slow; depends on surface area, air movement, humidity	Rapid; requires continuous heat input
Temperature of remaining liquid	Falls (faster molecules escape)	Stays at the boiling point
Bubbles	No bubbles form	Bubbles of vapour form inside the liquid

Evaporation cools the liquid because the fastest-moving molecules escape from the surface, lowering the average kinetic energy of those remaining. This is why sweating cools the body.

Latent heat of vaporisation (2017 Paper 02, Q5)

An immersion heater rated at 150 W boils water for 5 minutes. The mass of water decreases from 0.28 kg to 0.26 kg.

Energy supplied by heater:

$$E = P \times t = 150 \times (5 \times 60) = 150 \times 300 = 45\,000\text{J}$$

Mass of water vaporised:

$$m = 0.28 - 0.26 = 0.02\text{kg}$$

Specific latent heat of vaporisation:

$$L_v = \frac{E_H}{m} = \frac{45\,000}{0.02} = 2\,250\,000\text{J kg}^{-1} = 2.25 \times 10^6\text{J kg}^{-1}$$

This is close to the accepted value of 2.26×10^6 J kg{ for water.

📝 **Exam Tip**

In latent heat calculations, identify the mass that actually changes state, it is often the mass difference between the start and end of an experiment, not the total mass present.

On a heating curve, the flat region at 0 °C is melting (latent heat of fusion). The flat region at 100 °C is boiling (latent heat of vaporisation). Rising sections represent temperature change governed by specific heat capacity.