A-LEVEL PHYSICS • EXERCISE SHEET

14.3 Specific heat capacity and specific latent heat

Name: ______ Class: ______ Date: ______ **Total: 18 marks**

Objective

Build the skills to answer exam questions on **specific heat capacity** and **specific latent heat**.

You must be able to:

- use $Q = mc\Delta T$ and $Q = mL$ (fusion vs vaporisation)
- measure c **electrically** ($Q = VIt$) and by the **method of mixtures**
- read a **heating curve**; explain why $L_{\text{vap}} > L_{\text{fusion}}$

1 Worked examples

Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

Specific heat capacity

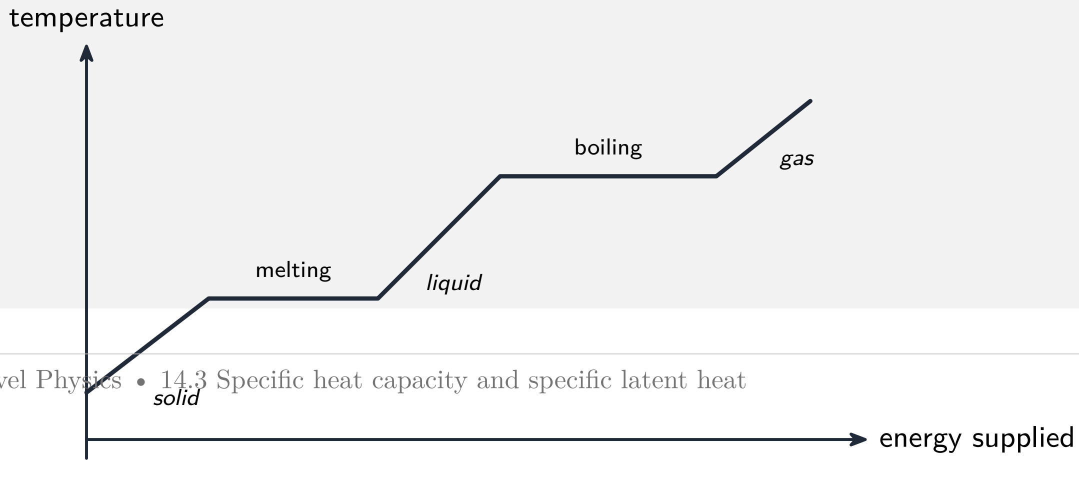
The energy to raise unit mass by one kelvin:

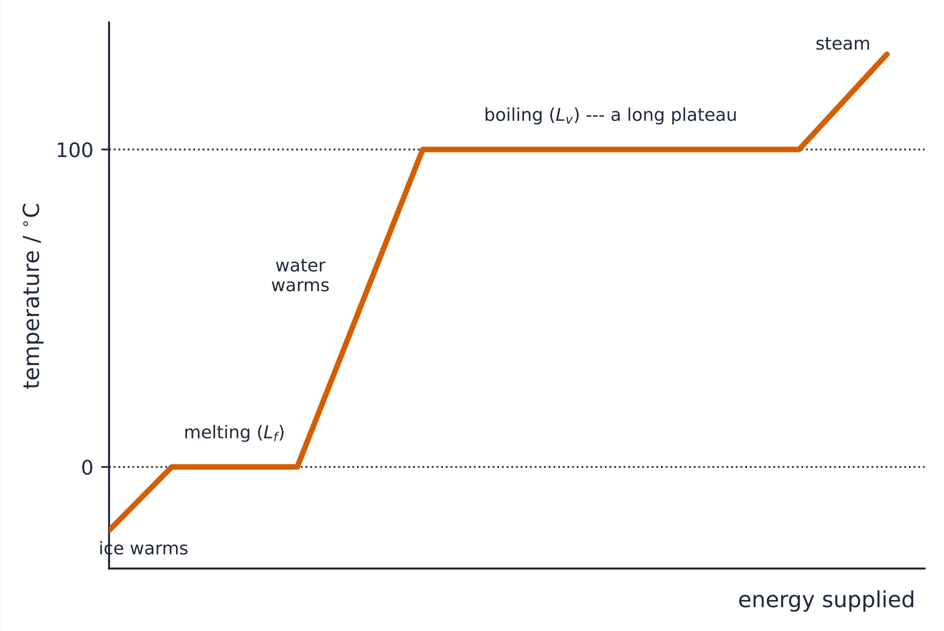
$$c = \frac{Q}{m\Delta T} \iff Q = mc\Delta T \quad (\text{J kg}^{-1}\,\text{K}^{-1}).$$

Worked example. Heat 0.50 kg of water from 20 to 100 °C ($c = 4200$): $\Delta T = 80$, so $Q = 0.50 \times 4200 \times 80 = 1.68 \times 10^5$ J.

Specific latent heat and the heating curve

Latent heat $Q = mL$ is the energy for a **change of state** at constant temperature —**fusion** (melting) or **vaporisation** (boiling). On a heating curve the **sloped** parts heat one phase ($Q = mc\Delta T$); the **flat plateaus** are changes of state ($Q = mL$):





A heating curve through changes of state

$L_{\text{vap}} > L_{\text{fusion}}$: vaporising must **fully separate** the molecules (and push back the atmosphere), whereas melting only **loosens** the lattice.

■ Measuring c —electrical method

An electrical heater supplies $Q = VIt = Pt$, which equals $mc\Delta T$.

Worked example. A 50 W heater warms 0.30 kg of a liquid by 8.0 K in 100 s (no losses): $Q = Pt = 50 \times 100 = 5000$ J, so $c = \dfrac{Q}{m\Delta T} = \dfrac{5000}{0.30 \times 8.0} = 2100$ J kg^{-1} K^{-1}.

■ Method of mixtures

In an **insulated** container, **energy lost by the hot body = energy gained by the cold body** (include any change of state).

Worked example. A 0.50 kg metal block at 90 °C is put into 0.40 kg of water at 15 °C; they settle at 22 °C. Then $m_{\text{m}}c_{\text{m}}\Delta T_{\text{m}} = m_{\text{w}}c_{\text{w}}\Delta T_{\text{w}}$: $0.50\,c_{\text{m}}(90 - 22) = 0.40 \times 4200 \times (22 - 15)$, so $c_{\text{m}} = \dfrac{11760}{0.50 \times 68} = 346$ J kg^{-1} K^{-1}.

2 Practice

Now apply the methods above.

2.1 Define **specific heat capacity**. [1]

2.2 Find the energy needed to heat 0.50 kg of water from 20 °C to 100 °C (c =

4200 J $kg^{-1} K^{-1}$). [2]

2.3 Define **specific latent heat**. [1]

2.4 State why the specific latent heat of **vaporisation** is greater than that of **fusion**. [1]

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3 Exam-style questions

3.1 On a heating curve, the **flat** sections represent: [1]

- **A** heating a solid
- **B** a change of state
- **C** cooling
- **D** heating a gas

3.2 A 60 W heater is used to find the specific heat capacity of a 0.25 kg metal block. In 120 s the temperature rises by 9.6 K. Calculate c (assume no heat loss). [3]

3.3 A 0.030 kg ice cube at 0 °C is added to 0.25 kg of water at 15 °C in an insulated cup. All the ice melts and the final temperature is 5.0 °C. (c_{water} = 4200 J $kg^{-1} K^{-1}$.)

Calculate the **specific latent heat of fusion** of ice. [4]

3.4 Explain, in terms of **particles**, why energy is needed to melt a solid even though the temperature does not rise. [2]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **14.3 Specific heat capacity and specific latent heat** past-paper sheet in the Library, or try these in **Practice mode**:

- 9702/41 J25 —Q3 (specific latent heat, mixtures)
- 9702/42 J25 —Q3 (latent heat, structured)
- 9702/43 N25 —Q2 (specific heat capacity)
- 9702/43 J25 —Q3 (specific heat capacity)
- 9702/44 J25 —Q2 (calorimetry)

Solutions

2.1 The energy needed to raise the temperature of **unit mass** (1 kg) by **one kelvin**.

2.2 $Q = mc\Delta T = 0.50 \times 4200 \times 80 = 1.68 \times 10^5$ J.

2.3 The energy needed to change the state of **unit mass** at **constant temperature**.

2.4 Vaporising must **completely separate** the molecules (and do work against the atmosphere), whereas melting only **loosens** the lattice.

3.1 **B** —a change of state.

3.2 $Q = Pt = 60 \times 120 = 7200$ J; $c = \dfrac{Q}{m\Delta T} = \dfrac{7200}{0.25 \times 9.6} = 3000$ J kg^{-1} K^{-1}.

3.3 Energy lost by the water $= m_{\mathrm{w}}c\Delta T = 0.25 \times 4200 \times (15 - 5) = 10\,500$ J; this melts the ice **and** warms the melted ice from 0 to 5 °C: $10\,500 = 0.030L + 0.030 \times 4200 \times 5$; $0.030L = 10\,500 - 630 = 9870$; $L = 3.3 \times 10^5$ J kg^{-1}.

3.4 The energy is used to **break the bonds** between particles (increase their potential energy / separate them), not to increase their kinetic energy, so the temperature stays constant.