

Changes of state and specific latent heat

6.3.2.3 · Physics · revision notes

Latent heat is the energy needed to change the state of a substance without changing its temperature. You need to define specific latent heat, use $E = m L$ (on the equation sheet), tell latent heat of fusion from latent heat of vaporisation, and interpret heating and cooling graphs. Harder questions combine $E = m L$ with $\Delta E = m c \Delta\theta$ or with power and time.

Key facts

- $E = m L$ (on the equation sheet); E in J, m in kg, L in J/kg
- Fusion: solid $\leftrightarrow$ liquid. Vaporisation: liquid $\leftrightarrow$ vapour (gas)
- Heating graph: sloping part = temperature changing; flat part = state changing
- Specific heat capacity $\rightarrow$ temperature change.
Specific latent heat $\rightarrow$ change of state
- Specific latent heat: energy to change the state of 1 kg with no change in temperature
- During a change of state: internal energy changes, temperature does not
- Freezing and condensing release energy; $E = m L$ gives how much

Notes

Latent heat

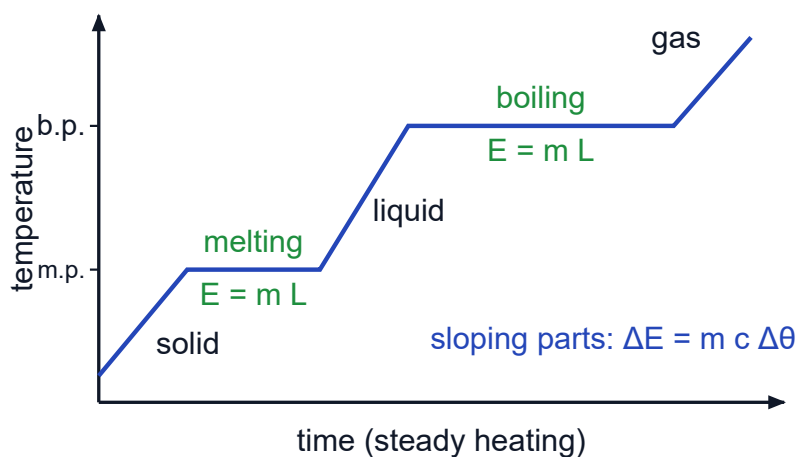
- The energy needed for a substance to change state is called **latent heat**.
- During a change of state, the energy supplied changes the internal energy (the potential energy of the particles) but **not the temperature**.
- When a substance freezes or condenses, the same amount of energy per kilogram as was needed to melt or boil it is transferred to the surroundings, again at constant temperature.

Specific latent heat

- The **specific latent heat** (L) of a substance is the amount of energy needed to change the state of **1 kg** of it with **no change in temperature**.
- thermal energy for a change of state = mass $\times$ specific latent heat: $E = m L$ (on the equation sheet). E in J, m in kg, L in J/kg.
- **Specific latent heat of fusion**: for a change between solid and liquid (melting, or freezing).
- **Specific latent heat of vaporisation**: for a change between liquid and vapour (boiling, or condensing).

Heating and cooling graphs

- A heating graph (temperature against time) for a solid heated at a steady rate has sloping parts and flat parts.
- Sloping parts:** the temperature of one state is rising (energy calculations use $\Delta E = m c \Delta\theta$).
- Flat parts:** a change of state at constant temperature, at the melting point (first flat part) or the boiling point (second flat part). Energy calculations use $E = m L$.



Flat parts: changes of state ($E = m L$). Sloping parts: temperature change ($\Delta E = m c \Delta\theta$).

- With steady heating, a longer flat part means more energy was needed. For water, the boiling section is much longer than the melting section.
- A cooling graph works the same way in reverse: its flat parts show condensing or freezing, where energy is released while the temperature stays constant.
- Keep the two ideas separate: specific heat capacity is for a temperature change without a change of state; specific latent heat is for a change of state without a temperature change.

How to answer each type of question

Calculate the energy for a change of state

2 marks

Grade 5

- Check the question is about a change of state with no temperature change, then choose $E = m L$.
- Choose the right L : fusion for melting or freezing, vaporisation for boiling or condensing.
- Make sure the mass is in kg, substitute and give the unit (J).

Example. Calculate the energy needed to melt 0.25 kg of ice at 0 °C.
specific latent heat of fusion of ice = 334 000 J/kg

Model answer. $E = 0.25 \times 334\,000$ (1)
 $E = 83\,500$ J (1)

Don't lose marks

- ✗ Using the wrong specific latent heat: fusion when the question is about boiling, or the reverse.

- ✗ Putting a temperature change into $E = m L$. The temperature does not change during a change of state.
- ✗ Saying the energy supplied during melting is 'lost' or 'does nothing'. It increases the internal energy (the potential energy of the particles).
- ✗ In multi-step questions, missing out a stage or leaving the mass in grams.
- ✗ Writing the unit of specific latent heat as $\text{J/kg } ^\circ\text{C}$. It is J/kg .

More tips

Memory tricks

- On a heating graph: Level line $\rightarrow$ Latent heat ($E = m L$); Climbing line $\rightarrow c$ ($\Delta E = m c \Delta\theta$).
- Fusion sounds like 'fuse' (melt together): solid $\leftrightarrow$ liquid. Vaporisation contains 'vapour': liquid $\leftrightarrow$ gas.
- There is no $\Delta\theta$ in $E = m L$. If the temperature doesn't change, you can't be using c .
- Sense check for water: boiling away 1 kg (about 2.26 million J) takes far more energy than heating 1 kg from 0°C to 100°C (420 000 J).

Exam technique

- Before calculating, decide: does the temperature change (use c) or does the state change (use L)? Some questions need both.
- Set out multi-step answers stage by stage with a label (melting, warming, boiling) so each stage can earn its marks.
- When explaining a flat section, use the words 'internal energy' and 'potential energy of the particles', and say the temperature does not change.
- Read graph values carefully from the axes; a melting or boiling point is the temperature of a flat section.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 4

Know temperature stays constant during state changes

While a substance melts, boils, freezes or condenses, its temperature does not change.

Grade 5

Define specific latent heat

The amount of energy needed to change the state of 1 kg of a substance with no change in temperature.

Grade 5

Use $E = m L$

Calculate the energy for a change of state with E in J, m in kg and L in J/kg .

Grade 5

Find changes of state on heating graphs

Flat sections show a change of state at the melting or boiling point; sloping sections show a temperature change.

Free notes, worksheets, practice papers and mock exams at chhetriacademy.com. Written for this site; not taken from past papers. Stuck? 1-to-1 tutoring with a free 30-minute trial lesson.