Specific Heat Capacity Notes

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Internal energy: the total energy stored by the particles that make up a system. It is the sum of **two** things:

1. The kinetic energy of the particles (due to their random motion/vibration).
2. The potential energy of the particles (due to the bonds and forces between them).

A system: in physics, a system is the object or group of objects that you are working with. 😊

Internal energy is often used to describe the kinetic energy that is in a system. This energy is typically gained as thermal energy by the system in the first place. The hotter that an object becomes, the more kinetic energy each of the particles, in the system, has.

Exam note: most exam questions on internal energy deal with a system being heated. So, the system is gaining thermal energy which becomes internal energy as soon as it's within the system.

Specific Heat Capacity

Specific heat capacity: the energy that is needed to raise the temperature of 1 kg of a substance by 1°C.

The units of specific heat capacity are **J/kg °C**

The equation:

change in thermal energy = mass × specific heat capacity × temperature change

$$\Delta E = m \times c \times \Delta\theta$$

Δ (delta) is a Greek letter is stands for "change in". So, we say "delta E" (ΔE), meaning the change in energy.

ΔE = change in thermal energy (J)	**m** = mass (kg)	**c** = specific heat capacity J/kg °C	**Δθ** = temperature change

Exam note: almost all exam questions involving specific heat capacity have calculations within them. Also, the majority of those questions have asked students to rearrange the equation to find the mass involved.
With that in mind let's look at a few example calculations 😊

Example 1: The energy transferred to a sample of water in 100 seconds was 155 000 J. The temperature of the water increases by 78 degrees Celsius. Specific heat capacity of water = 4200 J/kg °C

Determine the mass of water in the kettle.

$$155\,000 = m \times 4200 \times 78$$

$$m = 155\,000 \div (4200 \times 78)$$

$$m = 0.4731 \text{ (kg)}$$

$$\mathbf{m = 0.47 \text{ (kg)}}$$

Example 2: A coffee machine heats some water from 20 °C to 90 °C. The power output of the coffee machine is 2.53 kW. The specific heat capacity of water is 4200 J/kg °C.

Calculate the mass of water that the coffee machine can heat in 14 seconds.
Step 1: We haven't been given the change in energy so we must calculate this using the energy equation E = p × t

$$E = 2530 \times 14$$

$$E = 35\,420 \text{ (J)}$$

Step 2: Now we put the energy value into the equation and calculate the mass.

$$35\,420 = m \times 4200 \times 70$$

$$m = 35\,420 \div (4200 \times 70)$$

$$\mathbf{m = 0.12 \text{ (kg)}}$$

Specific Latent Heat

Specific Latent Heat (L): the general term for the energy needed to change the state of 1 kg of a substance without changing its temperature.

There are **two** types of specific latent heat:

Specific latent heat of fusion: the energy needed to change 1 kg of a substance from a solid to a liquid (melting) or from a liquid to a solid (freezing).

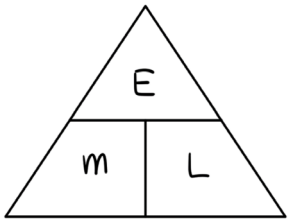
Specific latent heat of vaporisation: The energy needed to change 1 kg of a substance from a liquid to a gas (boiling/evaporating) or from a gas to a liquid (condensing).

The units of specific latent heat are **J/kg**

The equation:

Energy = mass × specific latent heat

E = m × L



E = energy (J)	**m** = mass (kg)	**L** = latent heat (J/kg)

Exam note: all AQA exam questions (to date) involving specific latent heat are calculation based.
Let's have a look at a few examples 😊

Example 3: A student takes some measurements to determine the latent heat of vaporisation of ethanol.

The student discovered that it takes 8460 J to evaporate 10 g from boiling point.
Calculate the latent heat of vaporisation of ethanol.

Step 1: We need to convert the grams into kilograms we do this by dividing by 1000.

$$\text{Mass} = 10 \div 1000 = 0.01 \text{ kg}$$

Step 2: Now we have the mass we put this into the equation.

$$E = m \times L$$

$$8460 = 0.01 \times L$$

$$L = 8460 \div 0.01$$

$$L = 846\,000 \text{ J/kg}$$

Example 4: When a sample of water was boiling, 0.050 kg of water turned into steam.

The energy transferred to the water was 80 kJ.

Calculate the specific latent heat of vaporisation of water. Give the unit.

Step 1: We must first convert the kJ in J. We do this by multiplying by 1000.

$$E = 80 \times 1000 = 80\,000 \text{ (J)}$$

Step 2: Now that we have the energy, we can put this into the equation.

$$E = m \times L$$

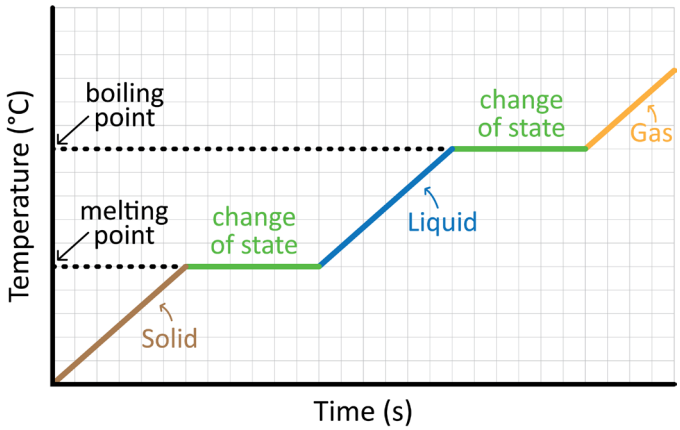
$$80\,000 = 0.050 \times L$$

$$L = 80\,000 \div 0.050$$

$$L = 1\,600\,000 \text{ J/kg} \quad \textbf{or} \quad L = 1.6 \times 10^6 \text{ J/kg}$$

Heating and Cooling Curves

A heating or cooling graph is a visual way of showing exactly what happens to the temperature of a substance as we steadily add heat to it, or take heat away from it, over time. The figure below shows a typical heating graph.



The Y-axis always shows the Temperature (usually in °C).

The X-axis shows the Time or sometimes the amount of thermal energy added.

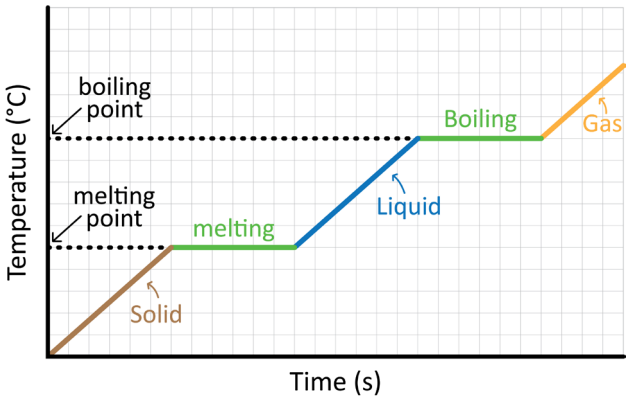
Why does it look a bit like a staircase? Let's explain this with an example, if we heat up a block of ice, we might expect the temperature to just go up in a straight line. **But**… because substances change state (melt and boil), the graph actually forms a "staircase" shape! Let's look at heating curves first 😊

Heating Curves

Heating curves are graphs that show a substance absorbing thermal energy.

As the overall temperature goes up, the substance changes from **solid to liquid to gas**.

What do we need to know? We need to know what the different lines on the graph mean and what is happening at the horizontal lines.



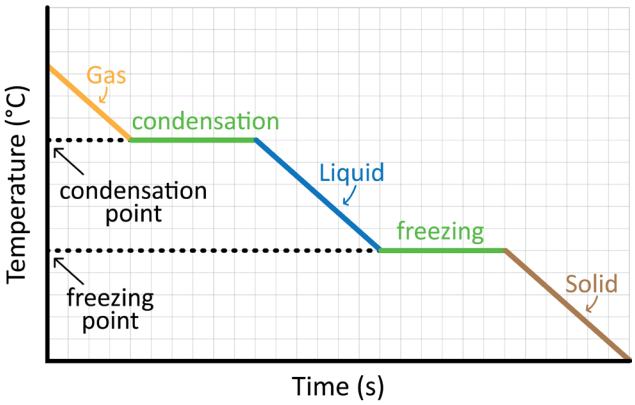
The sloped lines – Heating up: as we add heat, the particles gain kinetic energy and vibrate faster.

The first flat line – Melting: at the melting point, the temperature stops going up.

What happens here? The energy is now being used to break the bonds between particles instead, turning the solid into a liquid.

The second flat line – Boiling: the exact same thing happens here! The temperature stays perfectly steady while the heat energy completely breaks the bonds, turning the liquid into a gas. 😊

Cooling Curves



Cooling curves show a substance losing thermal energy to its surroundings.

As the overall temperature goes down, the substance changes from **gas to liquid to solid**.

The sloped lines – cooling down: as heat is transferred away, the particles lose kinetic energy and slow down.

The first flat line – condensing: The temperature stops dropping. The particles are coming close enough to form bonds, turning the gas into a liquid.

The second flat line – freezing: The temperature stops dropping The particles are coming close enough to form bonds, turning the liquid into a solid