

How water melts, boils and freezes

Grade 6 science (Year 7 · Class 6) · Lesson

Quick answer: Water changes state when heat is added or removed. It melts and freezes at 0 °C, and it boils and condenses at 100 °C. During each change the temperature stays constant, because the heat is used to rearrange the particles rather than to make them move faster.

Level: Grade 6 science (Year 7 · Class 6) · **Curriculum:** MS-PS1-4

What are the changes of state?

When heat is added to or removed from a substance, it can change from one state to another. Water is the best example because we see all three states every day: ice, liquid water and water vapour. A change of state is a physical change. The substance is still water afterwards, and its mass has not changed.

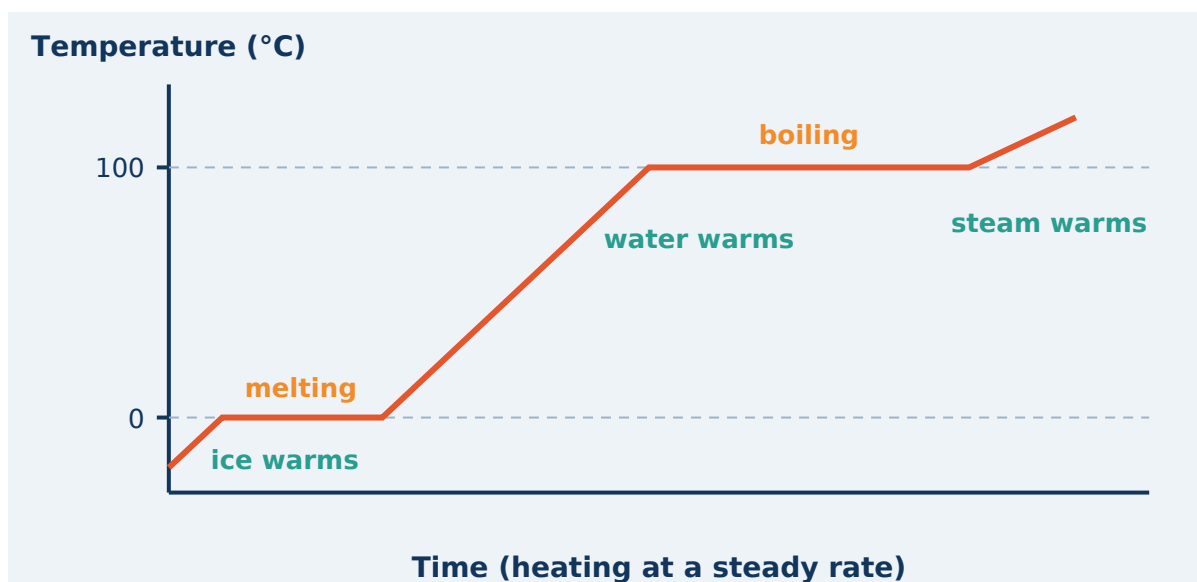
Definition

A **change of state** happens when a substance turns from solid, liquid or gas into a different one of these states because heat has been added or removed.

Change	From → to	Heat	Everyday example
Melting	solid → liquid	taken in	an ice lolly dripping
Freezing	liquid → solid	given out	water turning to ice in a tray
Evaporation	liquid → gas	taken in	a puddle drying after rain
Boiling	liquid → gas	taken in	water bubbling in a kettle
Condensation	gas → liquid	given out	droplets on a cold bottle

At which temperatures does water change state?

Pure water melts and freezes at 0 °C. It boils, and steam condenses, at 100 °C when the air pressure is normal at sea level. Below 0 °C water is ice, between 0 °C and 100 °C it is liquid, and above 100 °C it is a gas. The graph shows a sample of ice heated at a steady rate.



Heating curve of water: the temperature stays constant while the state is changing.

Why does the temperature stay the same while ice melts?

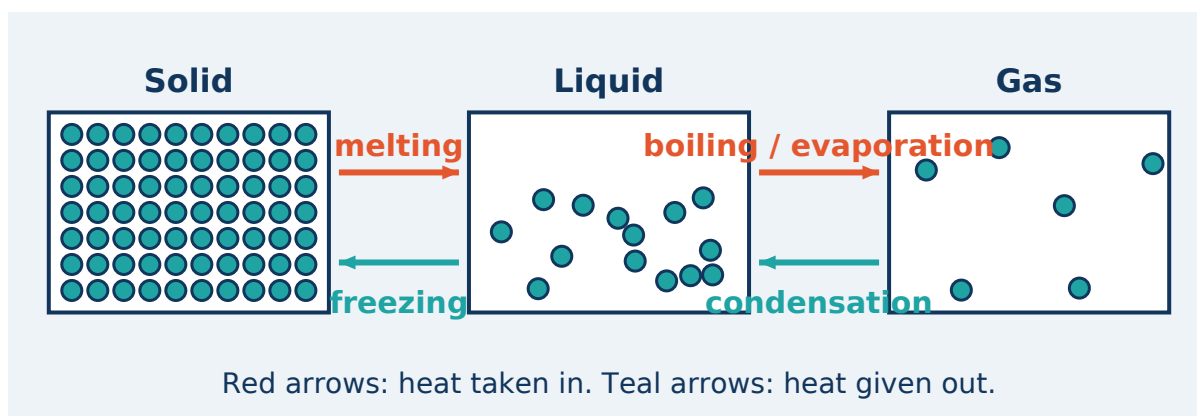
The flat sections of the graph are called plateaus. During melting, the heat you add is used to pull particles out of their fixed places in the ice. It is not used to make them move faster, so the thermometer does not move. The same happens at 100 °C: the heat separates the particles from each other, and the temperature stays at 100 °C until all the liquid has gone.

Key law

While a pure substance is melting, freezing, boiling or condensing, its temperature stays constant.

What do the particles do in each change?

In melting, vibrating particles gain energy and break free from their fixed positions. In boiling, they gain enough energy to leave the liquid entirely and spread far apart. In freezing and condensation the process runs in reverse: particles lose energy and are pulled into closer, more orderly arrangements.



The four main changes, shown with particles.

Worked example

Kwame in Accra heats water at 20 °C. The temperature rises by 4 °C every minute. How long does it take to reach 100 °C?

Rise needed = $100 - 20 = 80$ °C.

Time = $80 \div 4 = 20$ min.

The water reaches 100 °C after 20 min.

Worked example

A block of ice starts to melt after 3 min and is all melted at 11 min. Then the water warms from 0 °C to 100 °C in 25 min.

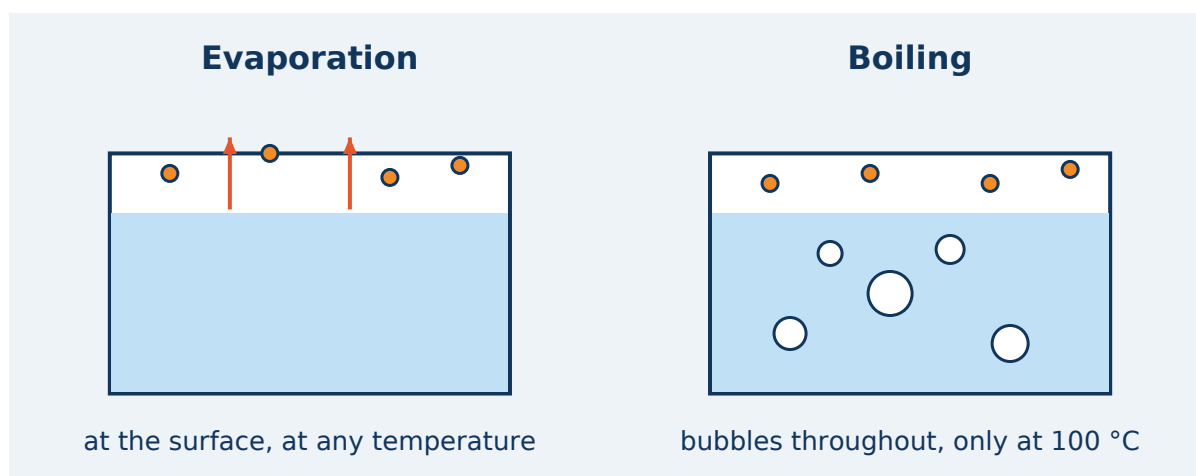
Melting time = $11 - 3 = 8$ min, at 0 °C.

From the start of melting to the start of boiling = $8 + 25 = 33$ min.

Melting lasts 8 min at a steady 0 °C, and boiling begins 33 min after melting began.

How is evaporation different from boiling?

Evaporation happens only at the surface of a liquid and can occur at any temperature. The fastest particles at the surface escape. Boiling happens throughout the liquid, forms bubbles of vapour, and occurs only at the boiling point. That is why a puddle disappears on a warm day while it stays far below 100 °C.



Evaporation takes place at the surface; boiling takes place throughout the liquid.

Common mistake

Steam is invisible. The white cloud above a kettle is not steam; it is tiny droplets of liquid water that formed when the hot vapour met cooler air and condensed.

Lina's tip

Heat goes IN for melting, evaporation and boiling. Heat comes OUT for freezing and condensation. If the substance gets more spread out, heat went in.

Why do wet clothes dry on a warm, windy day?

Warmer water has more fast particles able to escape, and wind carries escaped vapour away before it can return. A bigger exposed surface also helps. All three factors raise the rate of evaporation.

Key points to remember

- Melting and freezing point of pure water: 0 °C.
- Boiling and condensation point of pure water: 100 °C at sea level.
- Melting, evaporation and boiling take in heat; freezing and condensation give out heat.
- The temperature stays constant (a plateau) during a change of state.
- Evaporation happens at the surface at any temperature; boiling happens throughout at 100 °C.

How water melts, boils and freezes: frequently asked questions

At what temperature does water freeze and boil?

Pure water freezes at 0 °C and boils at 100 °C at normal air pressure. The same temperatures apply to melting and condensation.

Why does the temperature stay constant while water boils?

The heat is used to separate the particles from one another and turn liquid into gas. It does not raise the average speed of the particles, so the temperature stays at 100 °C.

What is the difference between evaporation and boiling?

Evaporation occurs only at the surface and at any temperature below the boiling point. Boiling occurs throughout the liquid, with bubbles, at the boiling point.

Is the white cloud above a kettle steam?

No. Steam is an invisible gas. The cloud you see is made of tiny droplets of liquid water that condensed when the vapour cooled.

What is condensation?

Condensation is the change from gas to liquid. Particles of water vapour lose energy when they meet a cold surface and come together as droplets.