

How heat moves and how to measure temperature

Grade 7 science (Year 8 · Class 7) · Lesson

Quick answer: Temperature measures how hot or cold an object is in degrees Celsius, while heat is thermal energy moving from a hotter object to a colder one. Heat travels by conduction through solids, by convection in liquids and gases, and by radiation through space. Insulators such as wool and trapped air slow this transfer.

Level: Grade 7 science (Year 8 · Class 7) · **Curriculum:** MS-PS3-3, MS-PS3-4

What is the difference between heat and temperature?

People often use the words heat and temperature as if they mean the same thing. In science they do not. Temperature tells you how hot or cold something is. Heat is about energy moving from one place to another.

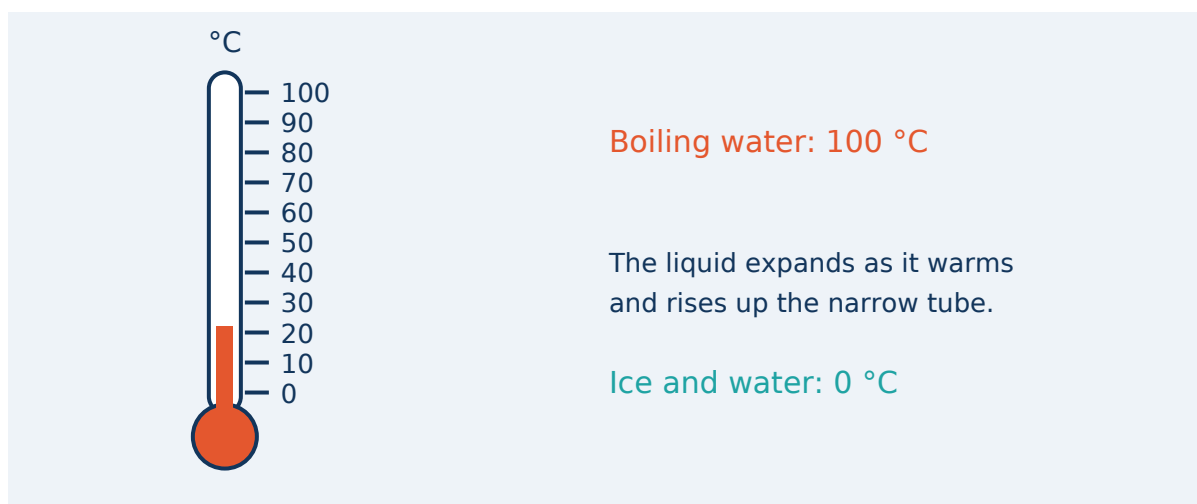
Definition

Temperature is a measure of how hot or cold an object is. It depends on how fast its particles move. **Heat** is the transfer of thermal energy from a hotter object to a colder one.

A bucket of water and a small cup of water can both be at 60 °C, so they have the same temperature. The bucket has many more particles, so it holds much more thermal energy and would melt much more ice. Thermal energy always flows from the hotter object to the colder one, until both are at the same temperature.

How do thermometers measure temperature?

A common thermometer has a thin glass tube holding a liquid, often dyed alcohol. When the bulb is warmed, the liquid expands and climbs up the tube. The Celsius scale is built on two fixed points: **0 °C** is where ice and water are together, and **100 °C** is where pure water boils at sea level. The space between is divided into 100 equal steps.



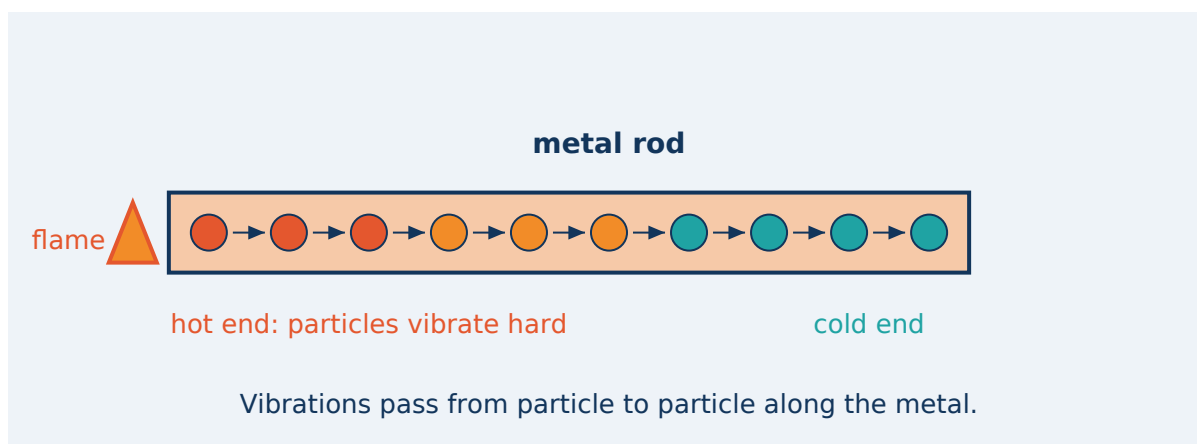
A thermometer scale and its two fixed points.

Key rule

Heat always flows from the hotter object to the colder object. It never flows the other way by itself. A cold drink does not give coldness to your hand: your hand gives heat to the drink.

How does heat travel by conduction?

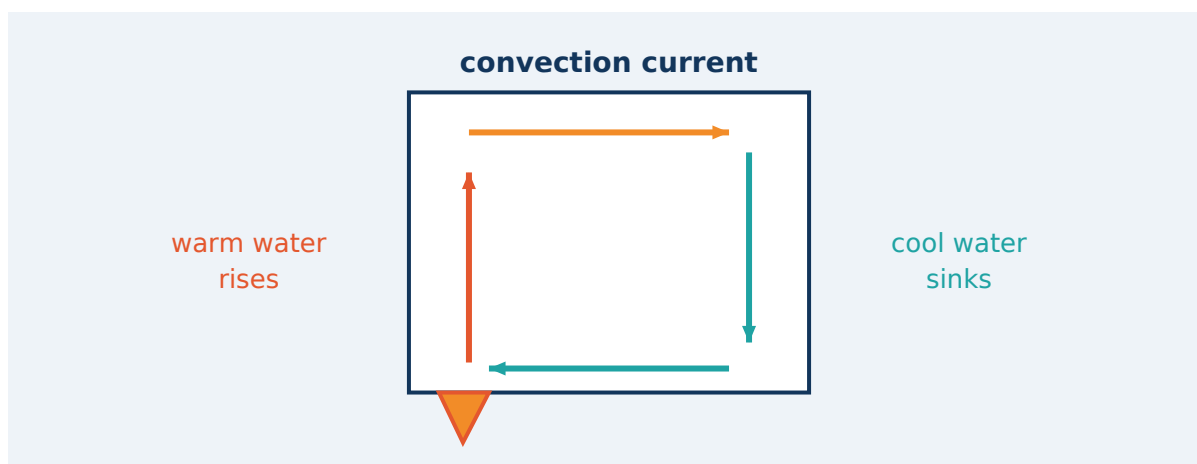
When you leave a metal spoon in a hot soup, the handle soon becomes warm. The particles in the soup bump the particles in the spoon, which vibrate harder and pass the energy along, one particle to the next. This is **conduction**. It happens in solids, and it is fastest in metals. Materials that conduct poorly, such as wood, plastic, wool and air, are called **insulators**.



Conduction: energy moves along a solid without the material moving.

How does heat travel by convection?

In liquids and gases the particles can move from place to place. When a fluid is heated, it expands and becomes less dense, so the warm fluid rises. Cooler, denser fluid sinks to take its place. This circular flow is a convection current. It explains sea breezes, the way a room warms above a radiator and how a pot of soup heats evenly.



Convection: a current carries energy through a liquid or gas.

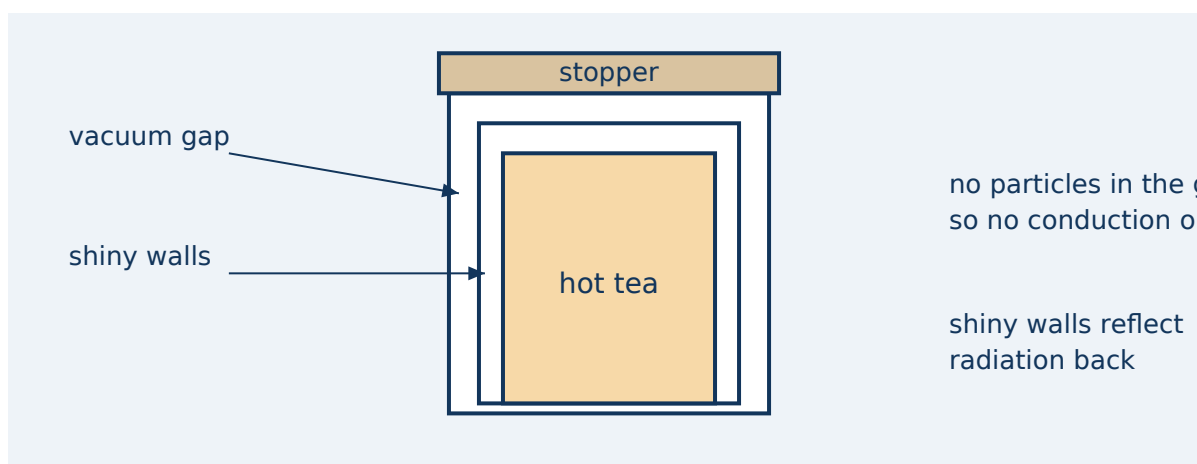
How does heat travel by radiation?

The Sun warms the Earth across empty space, where there are no particles to carry the energy. The energy travels as infrared radiation, a kind of wave. Every object gives out some radiation, and hotter objects give out more. Dark, matt surfaces absorb and give out radiation well, while shiny and white surfaces reflect it.

Method	Needs particles?	Where it happens	Example
Conduction	Yes, touching	Solids, mostly	Pan handle getting hot
Convection	Yes, moving	Liquids and gases	Sea breeze
Radiation	No	Anywhere, even a vacuum	Warmth from a campfire

How does insulation reduce heat loss?

An insulator slows down heat transfer. Wool, foam and fibreglass trap pockets of air, and air is a poor conductor which cannot circulate in small pockets. A vacuum flask stops conduction and convection with a vacuum gap, and shiny walls reflect radiation.



A vacuum flask reduces all three kinds of heat transfer.

Worked example 1

Kiran in Pune lets a cup of tea cool from 85 °C to 61 °C in 12 minutes. **Find the average**

cooling rate. Temperature fall = $85\text{ }^{\circ}\text{C} - 61\text{ }^{\circ}\text{C} = 24\text{ }^{\circ}\text{C}$. Rate = $24\text{ }^{\circ}\text{C} \div 12\text{ min} = 2.0\text{ }^{\circ}\text{C}$ per minute. **Answer: $2.0\text{ }^{\circ}\text{C/min}$.**

Worked example 2

Two cups of water start at $90\text{ }^{\circ}\text{C}$. After 15 minutes the cup wrapped in wool is at $72\text{ }^{\circ}\text{C}$ and the bare cup is at $54\text{ }^{\circ}\text{C}$. **Compare the heat lost.** Wool cup: $90 - 72 = 18\text{ }^{\circ}\text{C}$. Bare cup: $90 - 54 = 36\text{ }^{\circ}\text{C}$. Ratio: $36 \div 18 = 2$. **Answer: the bare cup cools twice as much, so wool is a good insulator.**

Common mistake

A woolly jumper does not make heat. It keeps your own heat from escaping by trapping air. Likewise, ice does not give out "cold": heat flows from the warmer surroundings into the ice.

Lina's tip

To name a heat transfer, ask two questions: is there a solid or a moving fluid, or neither? Solid touching: conduction. Moving fluid: convection. Neither (empty space): radiation.

Key points to remember

- Temperature is measured with a thermometer in $^{\circ}\text{C}$: $0\text{ }^{\circ}\text{C}$ is melting ice and $100\text{ }^{\circ}\text{C}$ is boiling water.
- Heat flows from hot to cold until the temperatures are equal.
- Conduction moves energy through solids, convection through liquids and gases, radiation through space.
- Metals are good conductors; wool, plastic and trapped air are insulators.
- Cooling rate = temperature fall $\div$ time, in $^{\circ}\text{C/min}$.

How heat moves and how to measure temperature: frequently asked questions

What is the difference between heat and temperature?

Temperature measures how hot something is, using a thermometer in $^{\circ}\text{C}$. Heat is the energy that flows from a hotter object to a colder object. Two objects at the same temperature can hold different amounts of thermal energy.

Why do metals feel colder than wood at the same temperature?

Metals are good conductors, so they carry heat away from your hand quickly and feel cold. Wood is an insulator, so it takes heat from your hand slowly and feels less cold.

Why does hot air rise?

When air is heated its particles move faster and spread out, so the air becomes less dense than the cooler air around it. The cooler, denser air sinks and pushes the warm air upwards.

Can heat travel through empty space?

Yes, by radiation. The Sun's energy reaches the Earth through space as infrared and visible radiation, with no particles needed to carry it.

How does a vacuum flask keep drinks hot?

A vacuum between its two walls stops conduction and convection, shiny surfaces reflect radiation back inside, and the stopper traps heat at the top.