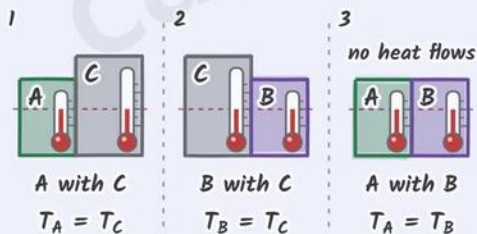


heat flows on its own only one way, from hot to cold, until the two agree

Heat and temperature

- temperature: how hot or cold a body is, read off a scale
- heat: energy in transit between bodies at different temperatures
- heat flows on its own **only hot to cold**, until the two agree
- that state is thermal equilibrium: no net flow
- zeroth law: A and B each in equilibrium with C, so A and B are in equilibrium
- that is why a thermometer works: it settles with the body



A settles with C, then B with C; A against B: no heat flows

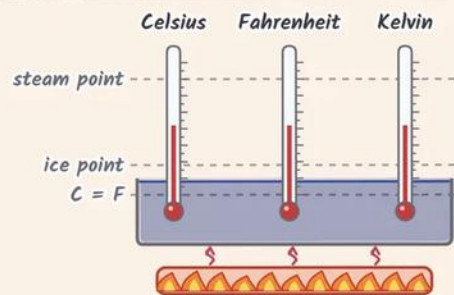
Temperature scales

all three scales read one hotness

$$\frac{C}{5} = \frac{F-32}{9} = \frac{K-273.15}{5}$$

kelvin is fixed by the triple point of water

$$T_{tr} = 273.16 \text{ K}$$



one bath, three thermometers, one level: three numbers; the steam point, the ice point and the line where $C = F$ ruled across

celsius and fahrenheit use **two fixed points**, ice and steam; kelvin needs only one. **-40** reads the same on C and F

Temperature or heat?

Temperature

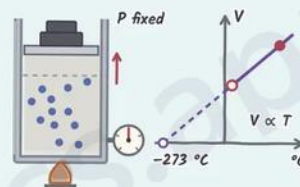
- a state: how hot
- read with a thermometer
- unit: K, C or F

Heat

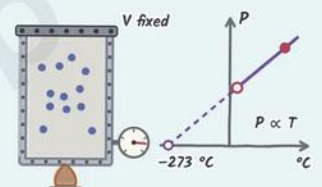
- energy in transit
- flows only hot to cold
- unit: joule

Gas laws and absolute zero

- Boyle: **PV constant** at fixed T; Charles: **V/T constant** at fixed P
- Gay-Lussac: **P/T constant** at fixed V, T always in kelvin
- any gas's P-T line, run back to zero pressure, ends at **-273.15°C**
- that is absolute zero, 0 K: the lowest temperature possible



Charles, P fixed by a loaded piston: heated, the piston rises; V proportional to T



Gay-Lussac, V fixed in a sealed vessel: heated, the gauge rises; P proportional to T