

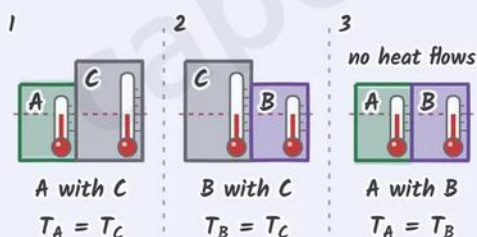


heat and work both move energy, but only one of them is ever a state function



Zeroth law of thermodynamics

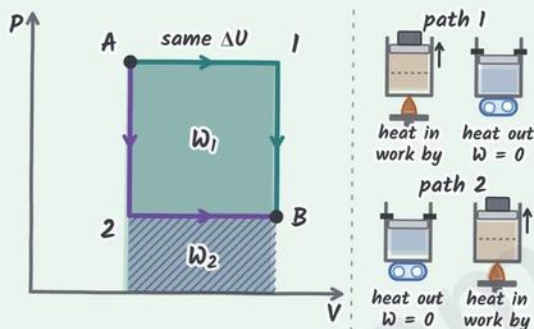
- bodies in contact exchange heat until their temperatures are equal
- then no net heat flows: they are in **thermal equilibrium**
- A with C, and B with C: then **A and B are in equilibrium too**
- the shared property is **temperature**: why a thermometer works at all



A settles with C, then B with C; put A against B and no heat flows, since $T_A = T_B$

Heat, work and internal energy *

- U is a **state function**, fixed by the state alone (ideal gas: by T alone)
- heat Q and work W are **not state functions**: they change with the path
- sign convention: Q positive when absorbed, W positive when done **by the gas**
- work is the area under the path on a P-V diagram
- a cycle ends where it began: $\Delta U = 0$, net W = the enclosed area



A to B by two paths, each leg done by the piston beside it: different areas, so different W and Q; the same two ends, so the same ΔU

The first law of thermodynamics

general statement

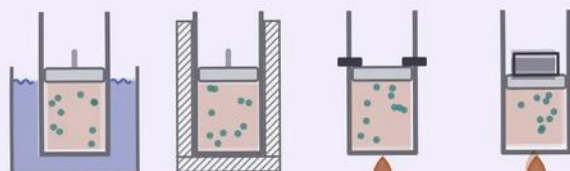
$$\Delta U = Q - W$$

a complete cycle, back to the start

$$\Delta U = 0, Q = W$$

no heat crosses the boundary (adiabatic)

$$Q = 0, \Delta U = -W$$



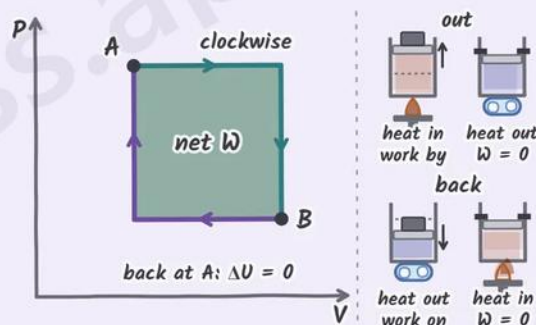
isothermal
 T fixed

adiabatic
 $Q = 0$

isochoric
 V fixed

isobaric
 P fixed

what holds each process: a water bath holds T , an insulating jacket keeps $Q = 0$, a latch holds V , a weight on a free piston holds P



a clockwise cycle, leg by leg in the cylinder: net work by the gas is the enclosed area; back at A, $\Delta U = 0$ and $Q = W$

just energy conservation: **nothing created or destroyed**, only moved as heat or work

