



the system, the four named processes and the two engines built out of them

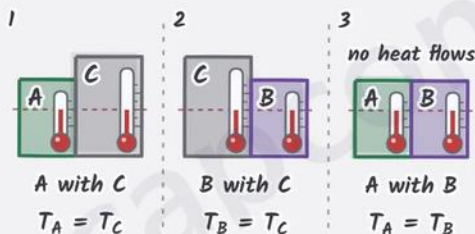


System, surroundings and equilibrium

- a system is what's under study, everything else the surroundings, split by a boundary
- intensive variables (P, T, density) don't change with size; extensive ones (mass, U) do
- equilibrium needs three at once: mechanical, thermal, chemical
- internal energy is a state function: set by the state, never the route taken

Zeroth law of thermodynamics *

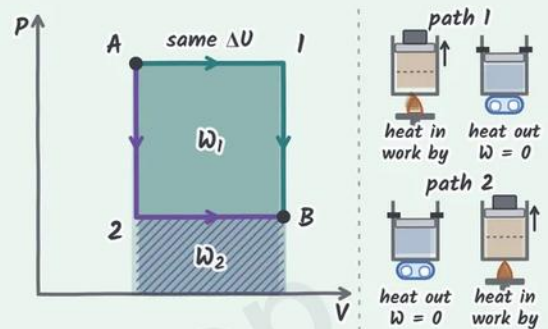
- bodies in contact exchange heat until their temperatures are equal
- A in thermal equilibrium with C, and B with C: then A with B too
- the shared quantity is temperature: every thermometer relies on this law
- named after the first and second laws, yet logically it comes first



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

Heat, work and the sign convention

- Q and W are not state functions: they change with the path taken
- sign convention: Q positive when absorbed, W positive when done by the system
- internal energy of an ideal gas is set by its temperature alone



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

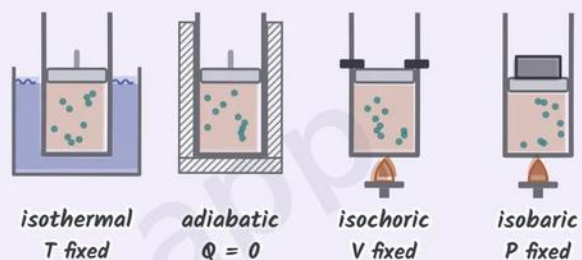
$$\Delta U = Q - W$$

a complete cycle, back to the start

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

no heat crosses the boundary (adiabatic)

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



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

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

