Thermodynamics

International Baccalaureate · IB Diploma · Physics · HL

Scope and prerequisites

This handout covers selected HL topics for the course first assessed in 2025; it is not the whole syllabus.

Prerequisites: read the stated quantities and units, and use arithmetic and the model conditions below.

The examples are original and fictional: they are not real measurements or real student investigations.

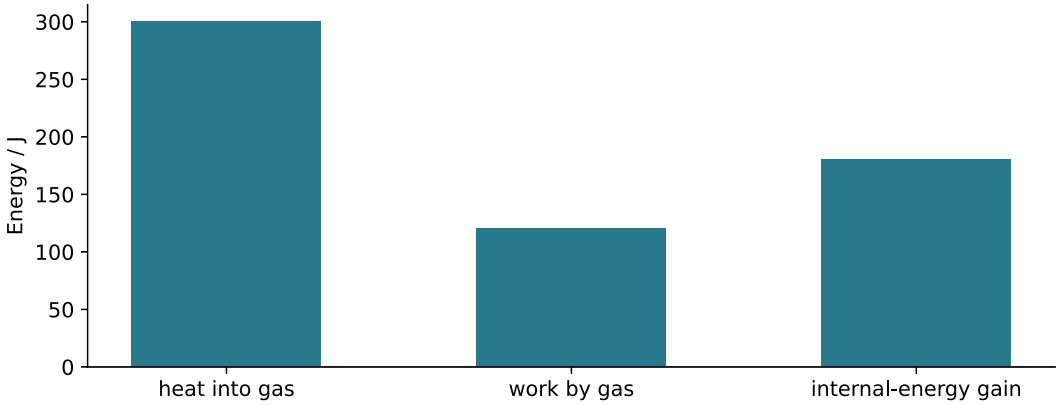
Thermodynamic systems and energy accounts

What would explain this observation?

- Compressing a gas can warm it even without a heater. Work is another path for energy transfer into the system.

Build the model

- **Internal energy** is a property of the chosen system.
- Heat and work describe energy transfer across its boundary.
- For an ideal monatomic gas, internal energy depends on temperature and amount.
- **adiabatic** : A process with no heat transfer.
- internal energy: Total microscopic kinetic and potential energy of a system.



First law: $Q = \Delta U + W$, so 300 J = 180 J + 120 J

Choose evidence that can test it

- State a sign convention before using the first law.
- Here change in internal energy equals heat into the system minus work done by the system.
- Expansion work can reduce internal energy when no heat enters.

In the lab: Identify whether a process is isothermal, adiabatic or at constant volume. On a pressure-volume graph, area under the process curve gives work done by the gas. The path matters for work even when endpoints match.

Work from known quantities

- Known: gas gains 300 J by heating and does 120 J of work.
- With $\Delta U = Q - W$, $\Delta U = 300 - 120 = 180$ J.
- For adiabatic compression, $Q = 0$ and work done by the gas is negative, so ΔU is positive.

Your turn: A gas gains 500 J of heat and does 200 J work. Find internal-energy change.

Check the conclusion and its limits

- Adiabatic does not mean constant temperature.
- Use the stated sign convention; some courses write work done on the gas with the opposite sign.

Not true: Every adiabatic process has constant temperature. Adiabatic fixes heat transfer ($Q = 0$), not temperature. An adiabatic compression raises temperature - bicycle pumps warm up - and an adiabatic expansion lowers it. Isothermal, not adiabatic, is the constant-temperature process.

Key:

- Internal energy is a property of the chosen system.
- State a sign convention before using the first law.
- Watch for: adiabatic does not mean constant temperature.

Write from an internal-energy change of 450 J

- A gas gains 800 J of heat and does 350 J of work.
- Find the change in internal energy. Adiabatic means no heat transfer, not constant temperature.

■ **Write from an isothermal account**

- A gas expands slowly at constant temperature, doing 200 J of work.
- $\Delta U = 0$, so $Q = W = 200$ J: heat enters exactly as fast as work leaves – an isotherm is a balance, not an absence of energy.

■ **Write from a cycle's net**

- Over one full cycle a gas absorbs 500 J and rejects 300 J.
- Net work $= 500 - 300 = 200$ J and $\Delta U = 0$ over the cycle – internal energy is a state function; it returns to its starting value.