

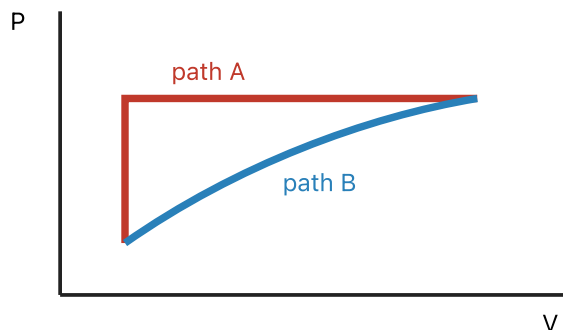
THERMO DAY 11: P–V DIAGRAMS II: PATHS & ADIABATIC PROCESSES

CED 9.4 · Skill 1.C · FRQ: TBR · target: treating heat and work as state functions

SAME ENDPOINTS, DIFFERENT PATHS

WARMUP Which path transfers more work?

Two processes take a gas from the same initial state to the same final state. Path A first raises pressure, then expands. Path B follows the lower curved route. Predict which has the greater W_{by} .



Internal energy change is fixed by the endpoints. Work is fixed by the area under the chosen path, so heat must adjust to satisfy the First Law.

QUICK If both paths have $\Delta U = +40$ kJ, Path A has $W_{by} = 90$ kJ, and Path B has $W_{by} = 55$ kJ, find Q for each.

ADIABATIC PROCESSES

Adiabatic: $Q = 0 \Rightarrow \Delta U = W_{on}$

Rapid compression raises internal energy and temperature. Rapid expansion lowers them. On a P–V graph, an adiabatic curve is steeper than an isothermal curve through the same state.

WE DO An insulated gas is compressed; $W_{on} = +65$ kJ. Find Q and ΔU . State the temperature change.

YOU DO An insulated gas expands and does 42 kJ of work. Find all three First-Law terms and state the temperature change.

Free expansion: an ideal gas expanding into vacuum has $Q = 0$ and $W = 0$, so $\Delta U = 0$ even though the volume increases.

MULTI-STEP ENERGY LEDGER

Leg	Q (kJ)	W_{on} (kJ)	ΔU (kJ)
A→B	+80	0	
B→C	+30	-50	
C→D	0	+25	

COMPLETE Fill the ΔU column and find totals for Q, W_{on} , and ΔU .

REPRESENT Sketch a plausible P–V path for: isochoric heating, isobaric expansion, then adiabatic compression. Label the sign of work on every leg.

PRACTICE

1. Path X has $W_{by} = 70 \text{ kJ}$ and $\Delta U = +20 \text{ kJ}$. Find Q.

2. An adiabatic compression does 110 kJ of work on a gas. Find ΔU .

3. An adiabatic expansion transfers 85 kJ as work to the surroundings. Find ΔU .

4. A gas freely expands into vacuum in an insulated container. Find Q, W, and ΔU .

5. Explain why two paths between the same states can have different Q even though they have the same ΔU .