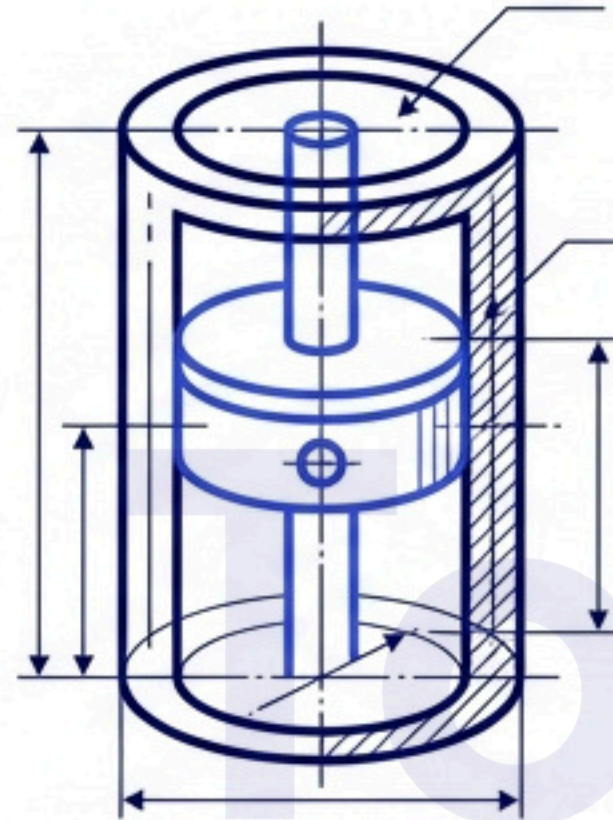




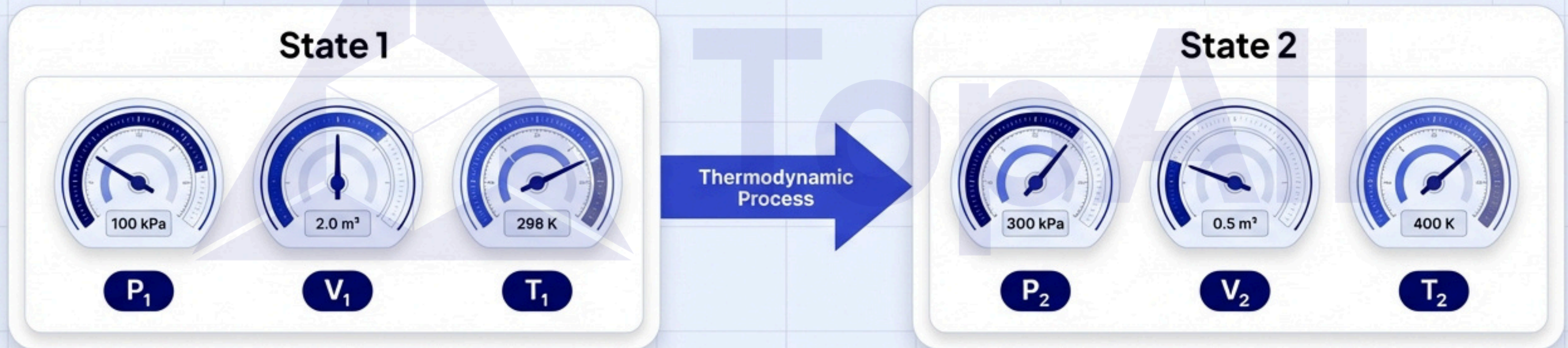
11.8 Thermodynamic Processes

Understanding State Changes and the First Law

THE BASICS

Changing the State of a System

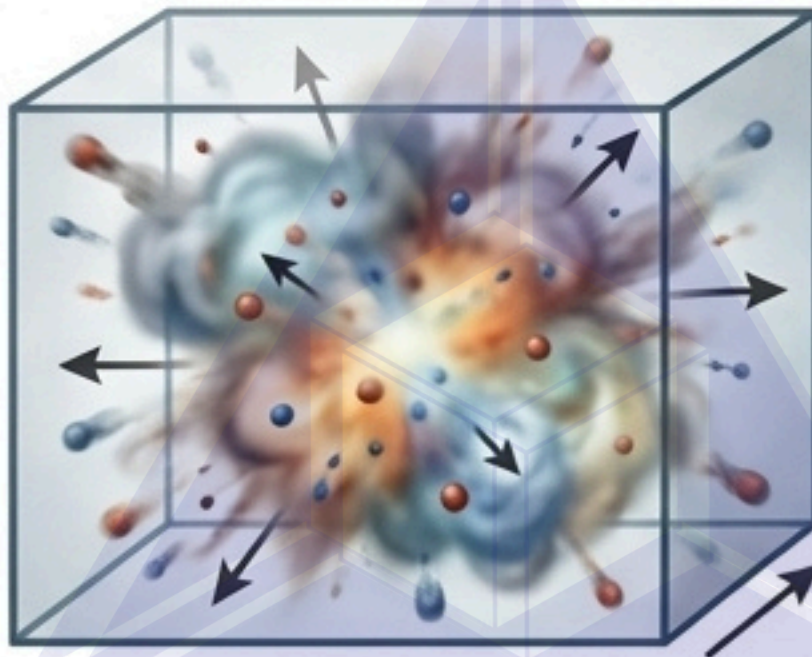
- A thermodynamic system is in an equilibrium state when its macroscopic (Temperature, Mass) do not change over time.
- A thermodynamic process occurs when a system transitions from one equilibrium state to another, shifting these variables.



$$(P_1, V_1, T_1) \rightarrow (P_2, V_2, T_2)$$

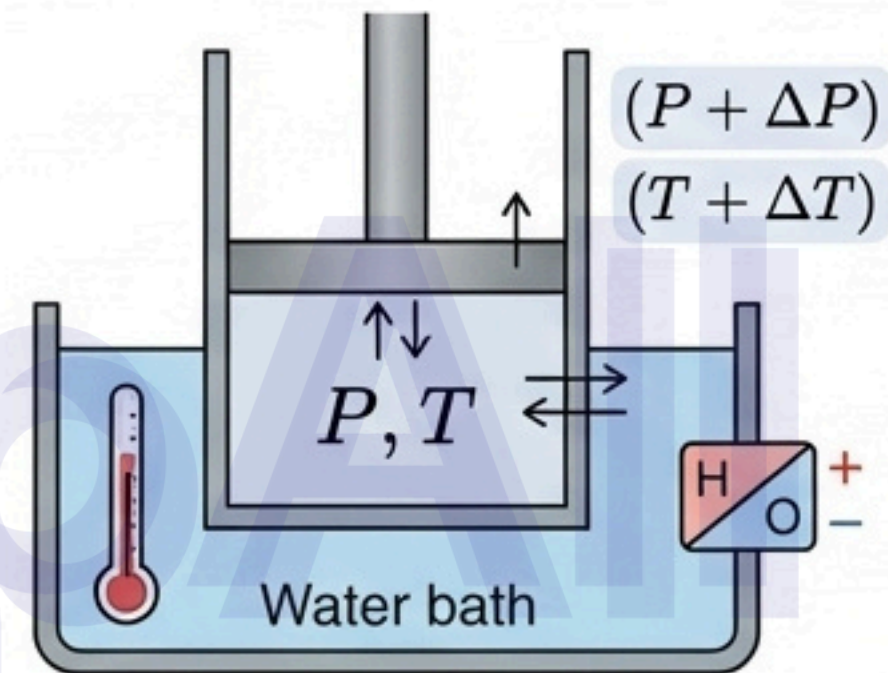
The Quasi-Static Ideal

Non-Equilibrium State



- Sudden, rapid changes.
- Pressure and temperature are not uniform.

Quasi-Static (Ideal) State



- Process is infinitely slow.
- System remains in continuous equilibrium.
- ΔP and ΔT are infinitesimally small.

EXAM TIP: "Quasi-static" means "nearly static." It allows us to calculate changing variables accurately!



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Table 11.2: Special Thermodynamic Processes

Process Type	Feature
Isothermal	Temperature constant
Isobaric	Pressure constant
Isochoric	Volume constant
Adiabatic	No heat flow between system and surroundings

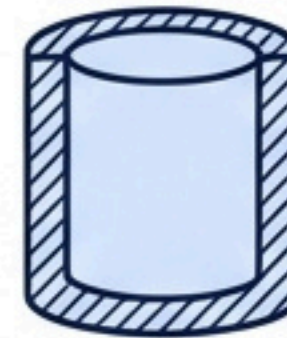
Locking the Variables



Isothermal

$$T = \text{Constant}$$

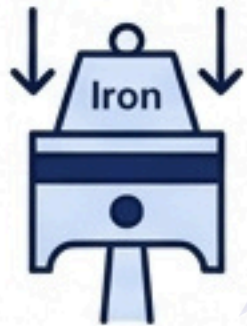
Temperature is fixed; gas expands/compresses in a heat reservoir.



Adiabatic

$$\Delta Q = 0$$

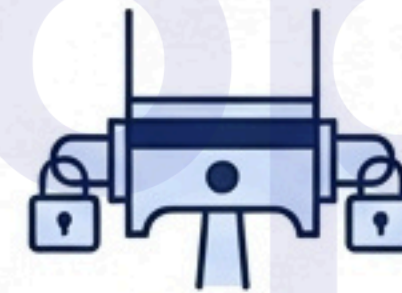
System is completely insulated; no heat enters or leaves.



Isobaric

$$P = \text{Constant}$$

Pressure is fixed; volume changes as heat is added.



Isochoric

$$V = \text{Constant}$$

Volume is fixed; gas cannot do physical work.



Cyclic Process

$$\text{Final State} = \text{Initial State}$$

The system completes a journey and returns exactly to its starting state ($\Delta U = 0$).

Simplifying the First Law

$$\Delta Q = \Delta U + \Delta W$$

Isothermal

Since $\Delta T = 0$, Internal Energy doesn't change ($\Delta U = 0$).

$$\Delta Q = \cancel{\Delta U} + \Delta W$$

Result: $\Delta Q = \Delta W$

(Heat supplied equals work done)

Adiabatic

No heat flow allowed ($\Delta Q = 0$).

$$\cancel{\Delta Q} = \Delta U + \Delta W$$

Result: $\Delta W = -\Delta U$

(Work done by gas decreases its temp)

Isochoric

Volume is fixed ($\Delta V = 0$), so
Work = 0.

$$\Delta Q = \Delta U + \cancel{\Delta W}$$

Result: $\Delta Q = \Delta U$

(All heat goes directly into internal energy)

Key Takeaways



A Thermodynamic Process is a transition from one equilibrium state to another, analyzed ideally as an infinitely slow quasi-static process.



Each special process “locks” a variable: Isothermal (Temp), Isobaric (Pressure), Isochoric (Volume), Adiabatic (No heat flow).



Identifying the process type immediately simplifies the First Law of Thermodynamics $\cancel{\Delta Q} = \cancel{\Delta U} + \cancel{\Delta W}$ by turning specific terms to zero.

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