

11.8.3 Adiabatic Process

Mastering the physics of perfectly insulated systems.

Definition & Conditions

An adiabatic process is a thermodynamic process in which there is no heat transfer into or out of the system ($Q = 0$). This typically occurs when the system is perfectly insulated or when the process happens so rapidly that there is insufficient time for heat exchange.

$Q = 0$ (No Heat Exchange)

Rapid Process or Perfect Insulation

Key Characteristics & Formulas

In an adiabatic process, changes in internal energy are solely due to work done. The P-V curve for an adiabatic process is steeper than an isothermal one for the same gas.

$$P_1 V_1^\gamma = P_2 V_2^\gamma = \text{constant} \quad (\text{Poisson's Law})$$

$$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1} = \text{constant}$$

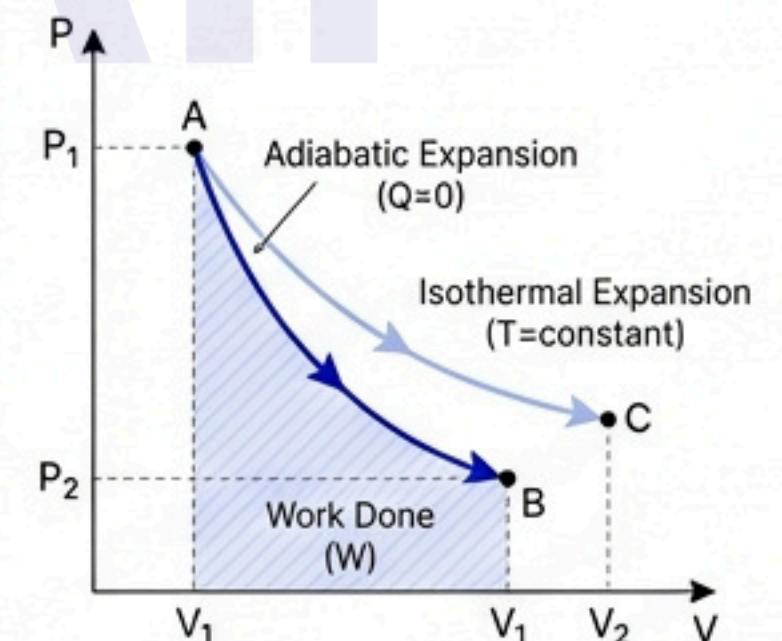
$$W = \frac{P_1 V_1 - P_2 V_2}{\gamma - 1} = \frac{nR(T_1 - T_2)}{\gamma - 1}$$

$$\gamma = \frac{C_p}{C_v}$$

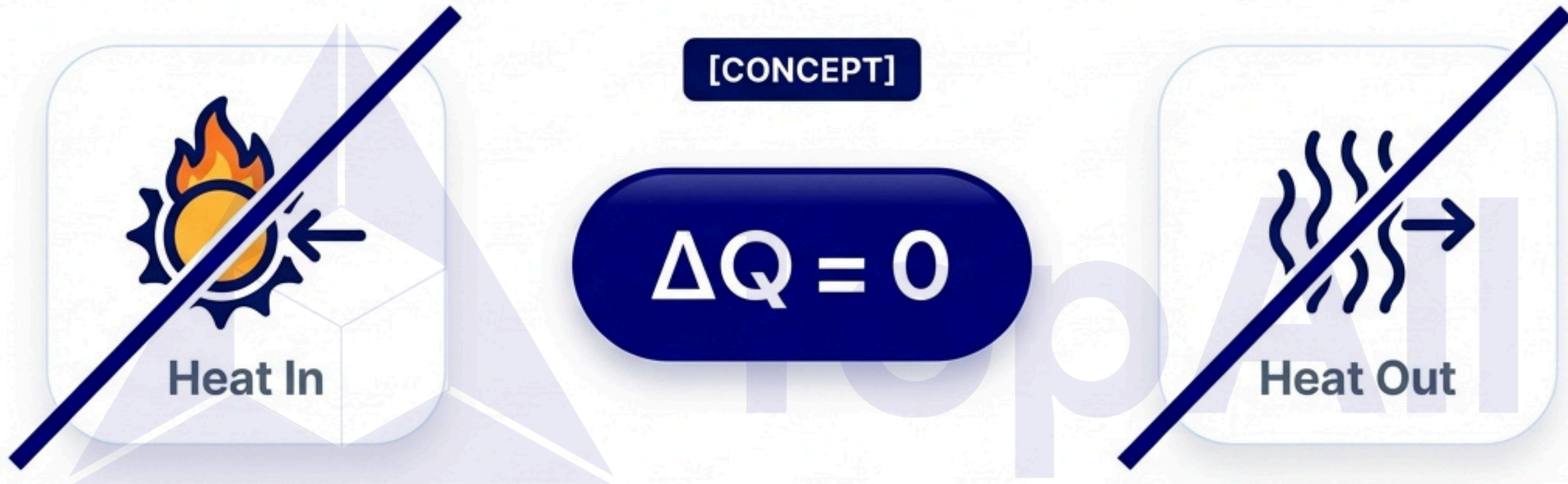
EXAM TIP

Remember that the slope of an adiabatic process is γ times steeper than the slope of an isothermal process on a P-V diagram. Always check for keywords like 'rapid', 'sudden', or 'insulated' to identify adiabatic processes in problems.

P-V Diagram Visualization

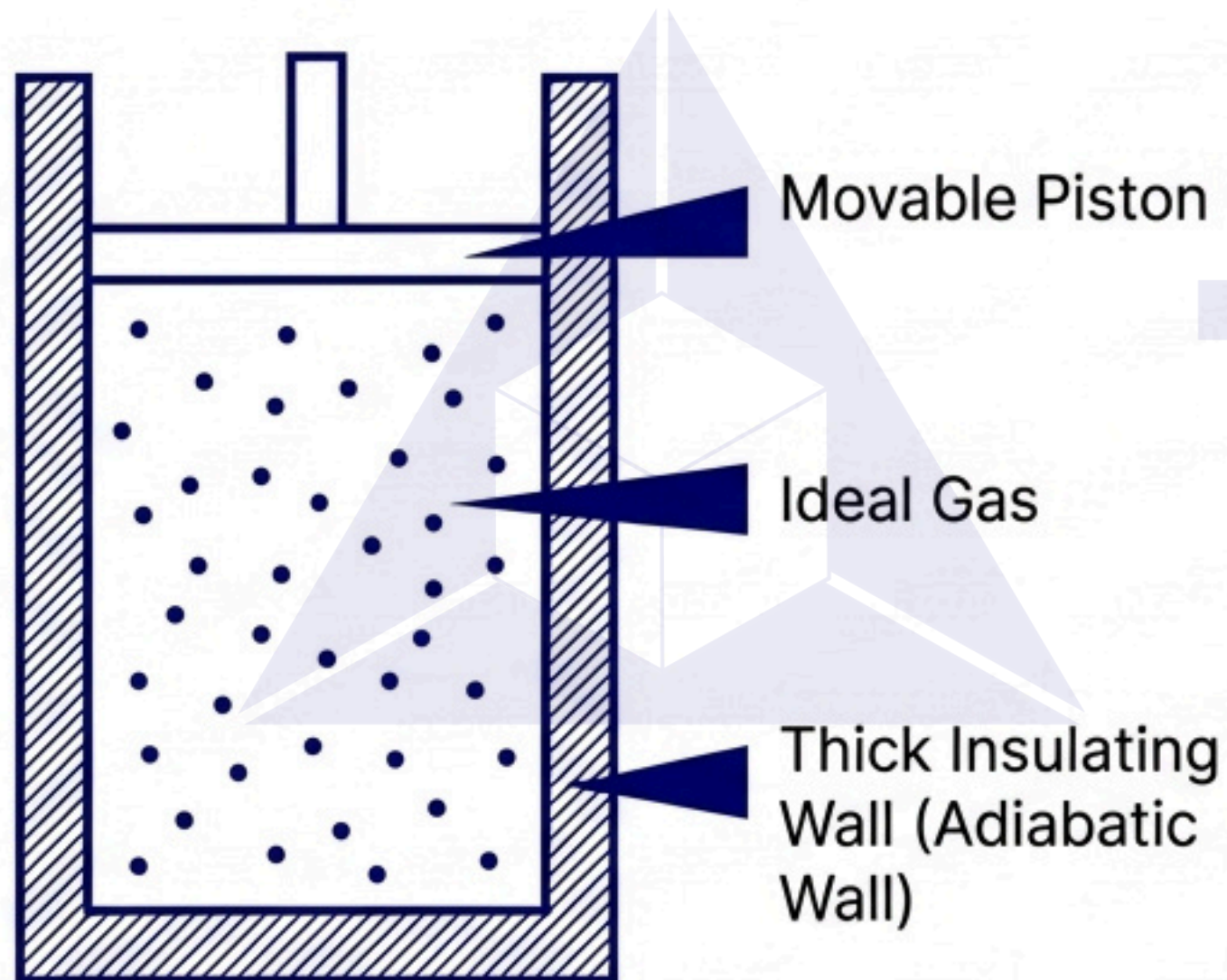


Zero Heat Transfer



- The system is completely insulated from its surroundings.
- No heat is absorbed by the gas.
- No heat is released by the gas.

The Adiabatic Wall



- Achieved using an insulating wall that completely blocks heat flow.
- Process often happens rapidly, leaving no time for heat exchange.

[EXAM TIP] Rapid changes (like a bursting tyre) are often adiabatic!



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H2: The Adiabatic Relationship

[FORMULA]

$$PV^\gamma = \text{constant}$$

P = Pressure

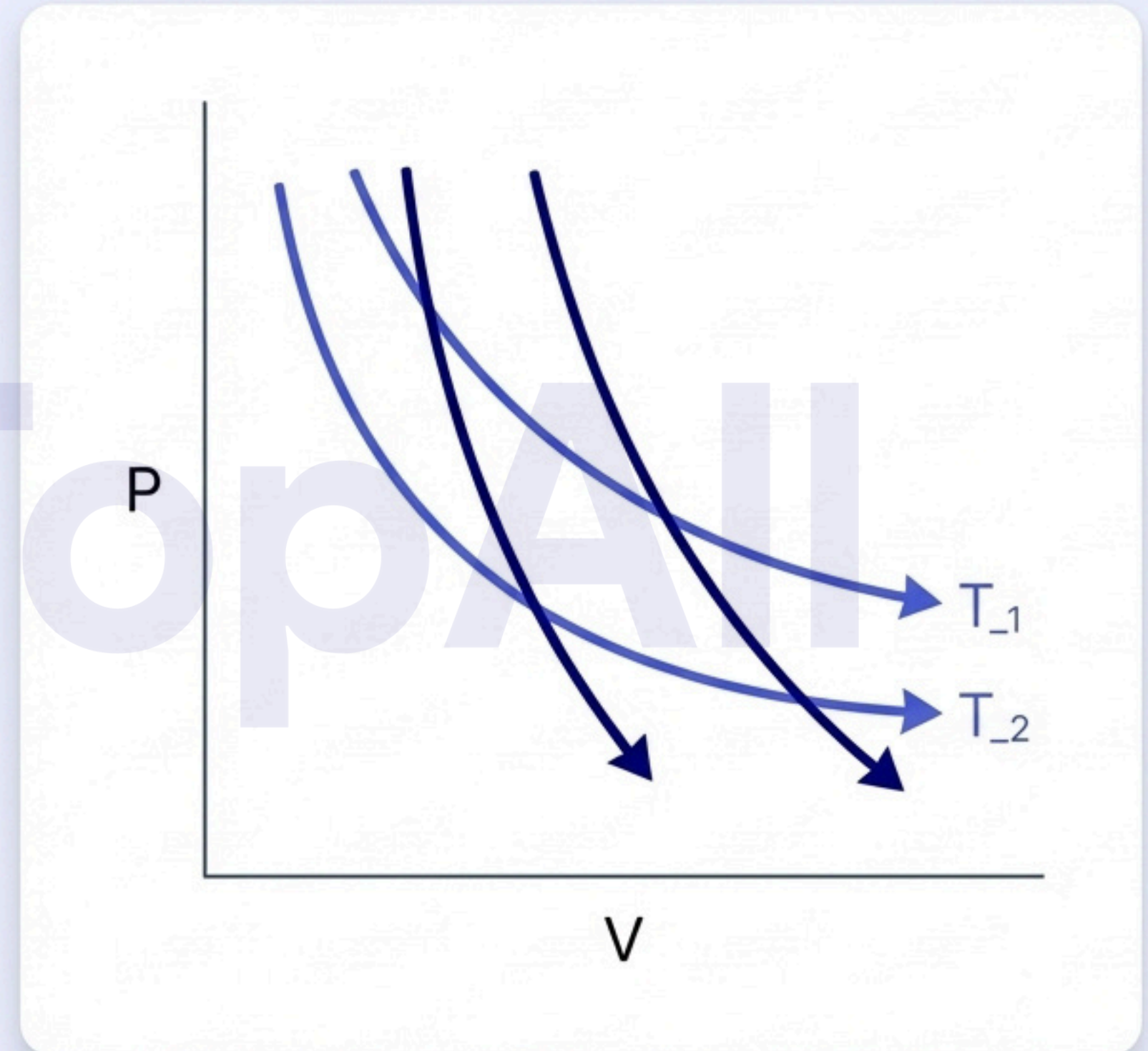
V = Volume

γ (Gamma) = Ratio of specific heats (C_p / C_v)

Therefore: $P_1 V_1^\gamma = P_2 V_2^\gamma$

H2: P-V Graph Analysis [FIGURE 11.8]

- Adiabatic curves connect different isotherms.
- The adiabatic curve is always steeper than the isothermal curve.



H2: Work & Temperature Change

[EQ. 11.16] Work Done

$$W = \frac{[\mu R(T_1 - T_2)]}{\gamma - 1}$$



Expansion: If gas does work ($W > 0$), internal energy drops → Temperature Falls.



Compression: If work is done on gas ($W < 0$), internal energy increases → Temperature Rises.

Core Takeaways for Exams

- ✓ **Zero Heat:** $\Delta Q = 0$ (perfectly insulated system).
- ✓ **State Law:** $PV^\gamma = \text{constant}$.
- ✓ **Steeper Graph:** Adiabatic P-V curves drop faster than isothermal curves.
- ✓ **Temp Shifts:** Gas cools during expansion; heats up during compression.

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