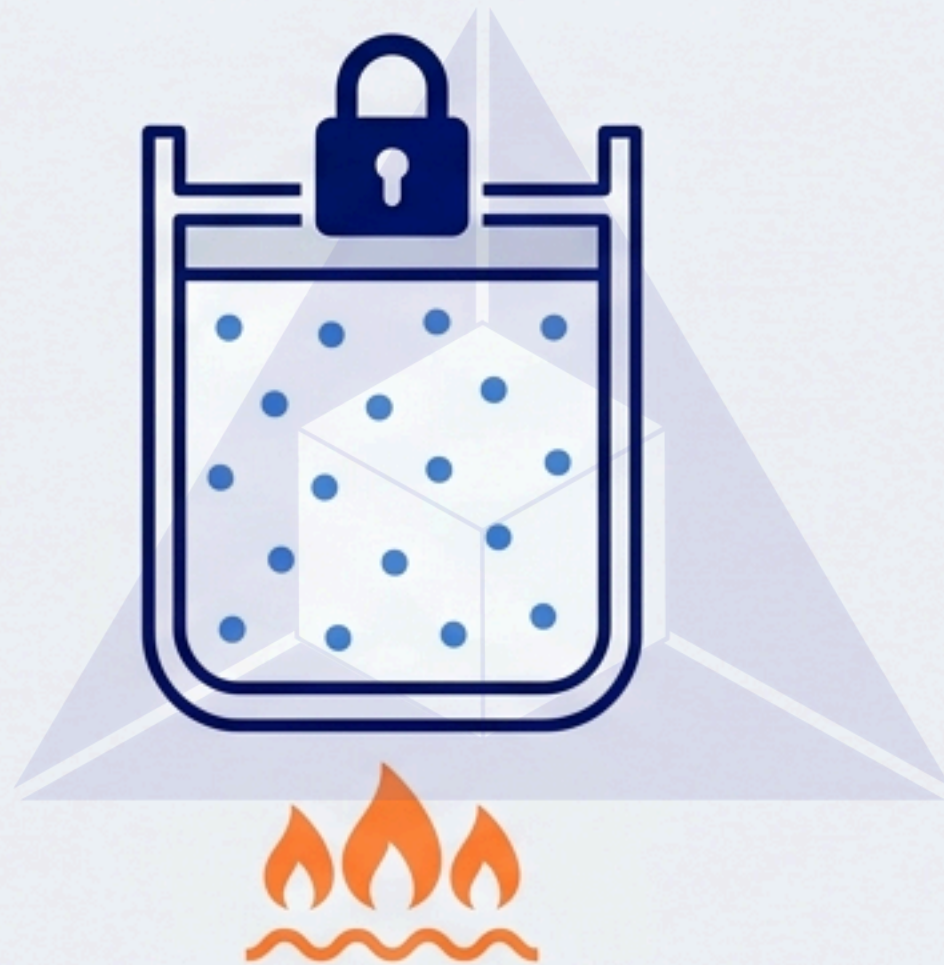


WHY IS $C_p > C_v$?

Exploring Mayer's Relation: $C_p - C_v = R$ | Ideal Gas Thermodynamics



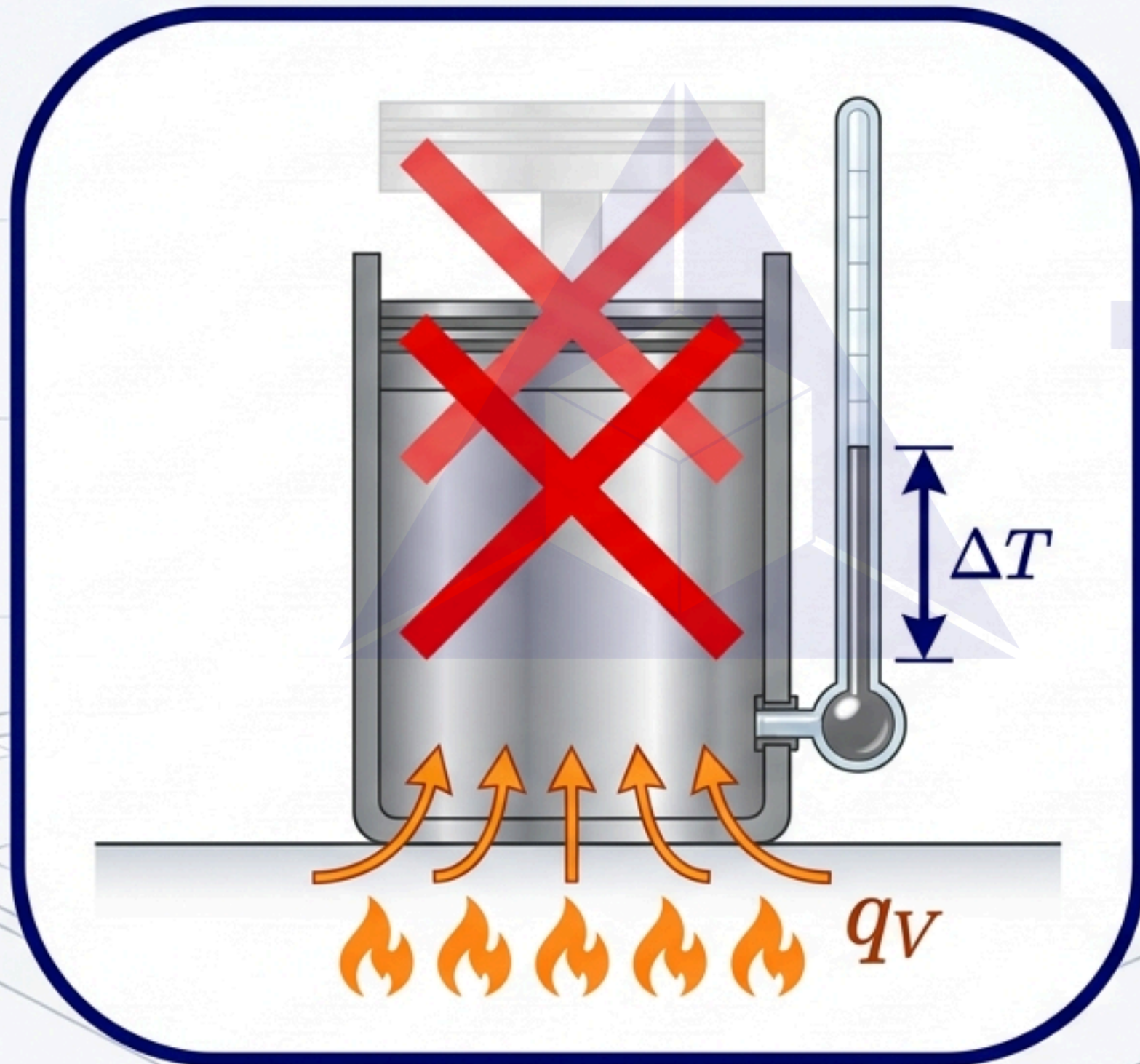
Heating at Constant Volume



Heating at Constant Pressure

Why does it take MORE heat to raise the temperature of a gas if the container can expand?

Heating at Constant Volume (Rigid Container)



$$q_V = C_V \Delta T = \Delta U$$

- Volume is locked ($\Delta V = 0$).
- No $P - V$ expansion work is done by the gas ($w = 0$).
- **All** supplied heat (q_V) goes directly into increasing the Internal Energy (ΔU).



You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



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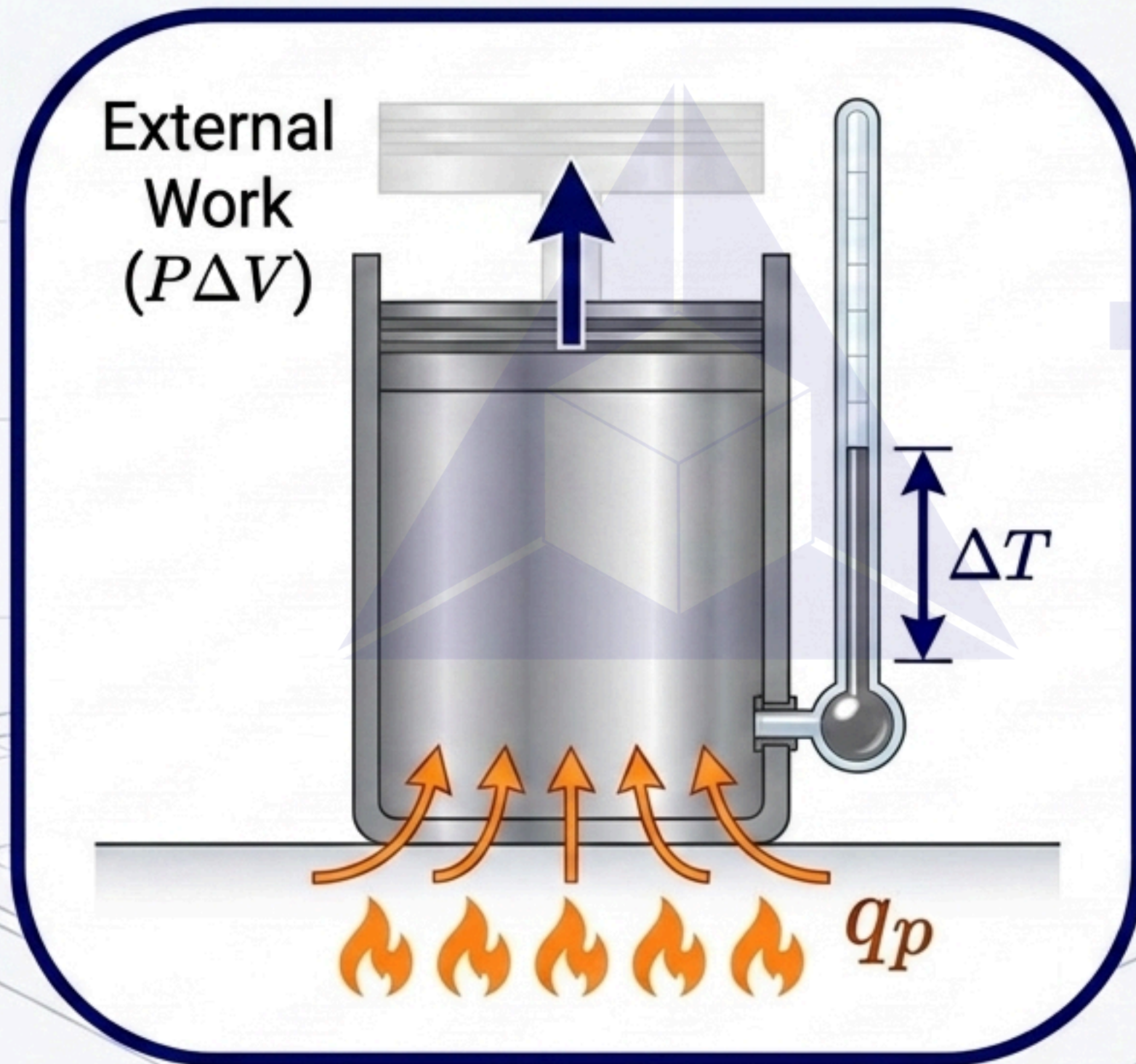
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Heating at Constant Pressure (Movable Piston)



$$q_p = C_p \Delta T = \Delta H$$

- Gas expands against external pressure.
- Part of the supplied heat (q_p) is “wasted” doing expansion work ($P\Delta V$).
- More total heat must be supplied to achieve the *same* temperature rise.

Deriving the Relationship

1. The Definition

$$\Delta H = \Delta U + \Delta(pV)$$



Substitute Ideal Gas Law ($pV = RT$)

2. For 1 Mole of Ideal Gas

$$\Delta H = \Delta U + \Delta(RT) \Rightarrow \Delta H = \Delta U + R\Delta T$$



Substitute definitions of q_p and q_v

3. Final Substitution

$$C_p\Delta T = C_v\Delta T + R\Delta T$$

Mayer's Relation

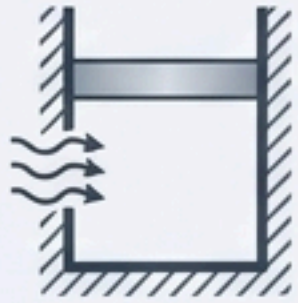
$$C_p - C_v = R$$



JEE TRAP ALERT: This specific relation ($C_p - C_v = R$) is **strictly for ONE MOLE of an IDEAL GAS**.

For n moles, the relation scales to $C_p - C_v = nR$. It does *not* apply to real gases, liquids, or solids.

Summary: Why $C_p > C_v$



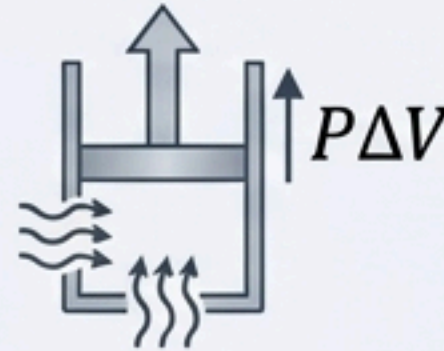
Constant V



No expansion possible



Heat *only* raises internal energy



Constant P



Expansion occurs ($P\Delta V$)



Heat must raise internal energy *and* do external work



Therefore, $C_p > C_v$ because extra energy is always **required to power the expansion work.**



You've Learned the Theory.

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