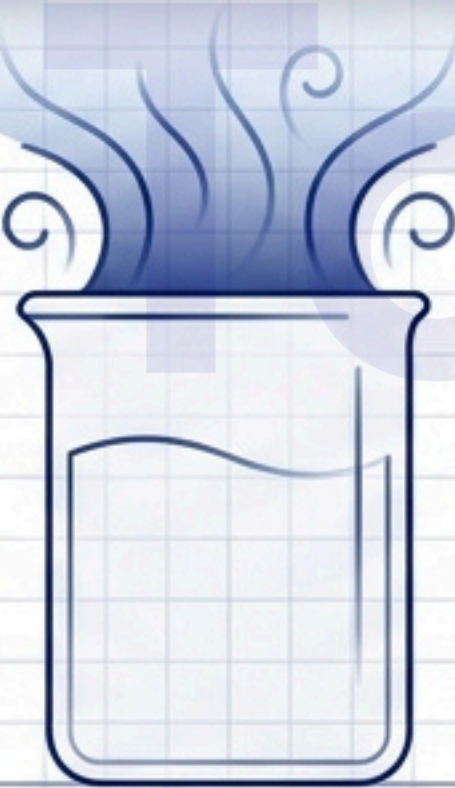


Enthalpy, H

Understanding heat changes
at constant pressure.

$$H = U + pV$$



Why Internal Energy (U) Alone Is Not Enough

The Sealed Flask (Constant Volume)

$$\Delta V = 0$$



In a rigid container, the system cannot expand. No physical work is done. All heat transferred directly changes the Internal Energy (U).

$$q_v = \Delta U$$

The Open Beaker (Constant Pressure)

$$\Delta p = 0$$



Most chemistry happens in open vessels! Expanding gases must push against the atmosphere, doing physical work ($p\Delta V$). Some energy is "lost" to this work.

We need a new metric.



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Defining Enthalpy: The Total Heat Content

$$H = U + pV$$

H

Enthalpy

The total heat content of the system at constant pressure. Because **U**, **p**, and **V** are state functions, **H** is also a state function (path-independent).

U

Internal Energy

The sum of all chemical, electrical, and mechanical energy stored inside the system's molecules.

pV

Pressure-Volume Energy

The environmental work energy required to "make room" for the system to exist against atmospheric pressure.

Heat at Constant Pressure (q_p)

Step 1

$$\Delta U = q_p - p\Delta V$$

First Law of Thermodynamics
(expansion work is negative).

Step 2

$$q_p = \Delta U + p\Delta V$$

Rearranging to solve for
heat absorbed.

Step 3, Final Resolution

$$q_p = \Delta H$$

Substituting the
definition of Enthalpy.

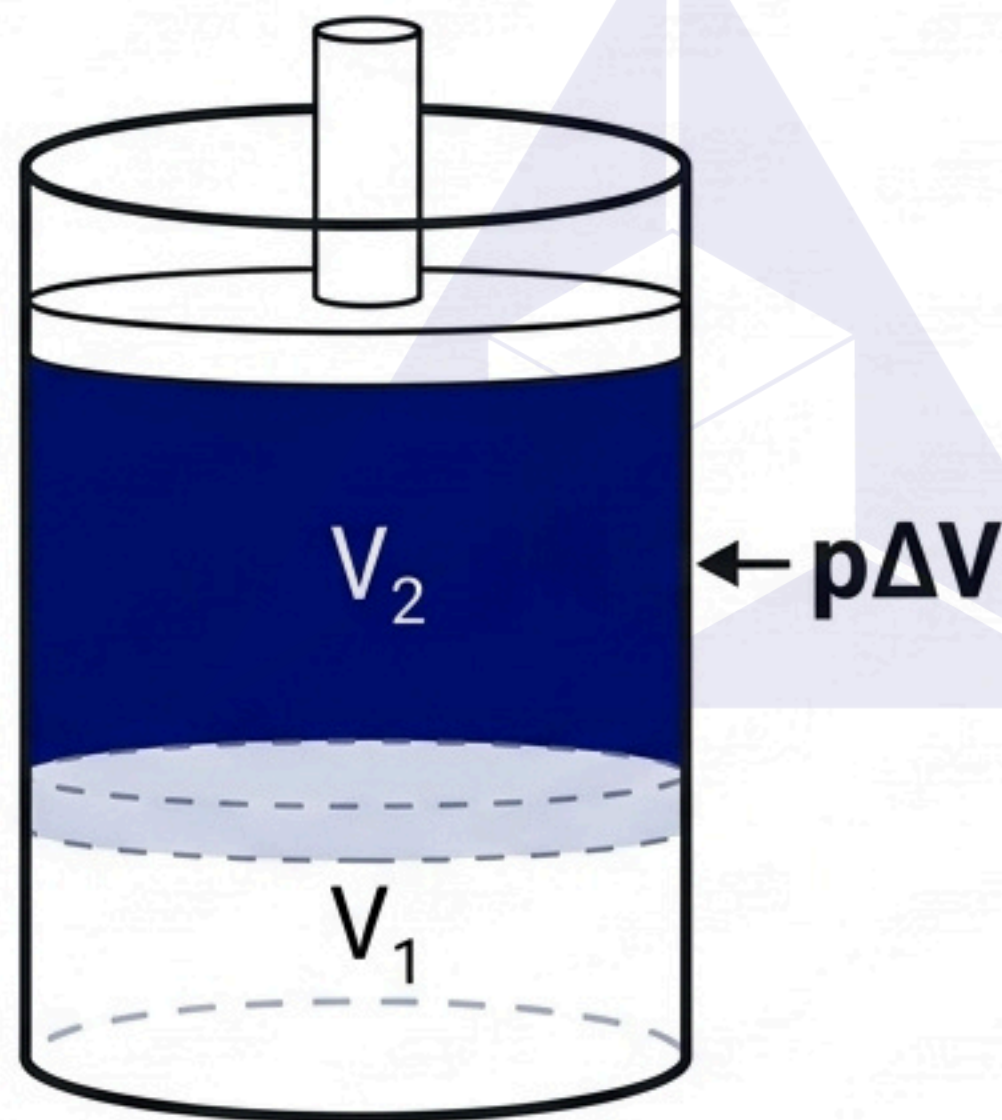


For solids and liquids, volume changes are negligible ($\Delta V \approx 0$). Therefore, the $p\Delta V$ term vanishes, making $\Delta H \approx \Delta U$.

The Master Relationship:

ΔH vs ΔU

$$\Delta H = \Delta U + p\Delta V$$



ΔH is always the sum of two distinct energy requirements:

1. The energy required to change the internal temperature and chemical bonds (ΔU).
2. The physical work required to push back the atmosphere and expand the system's volume ($p\Delta V$).

If a system expands ($\Delta V > 0$), it must do work. Therefore, ΔH will be greater than ΔU .

The Gas-Phase Correction



Using the ideal gas law ($pV = nRT$), we substitute $p\Delta V$ to handle gaseous reactions.

$$\Delta H = \Delta U + \Delta n_g RT$$

Calculation Rules

Calculating Δn_g

$\Delta n_g = (\text{moles of gas products}) - (\text{moles of gas reactants})$

Ignore all solids and liquids. Only count species with the (g) state symbol!

Warning Panel

⚠ Exam Pitfall Alert

Units are the most common cause of errors here.

- T must be in Kelvin.
- $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$.
- Ensure ΔH and ΔU are converted to Joules (or R to kilojoules) before adding!



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