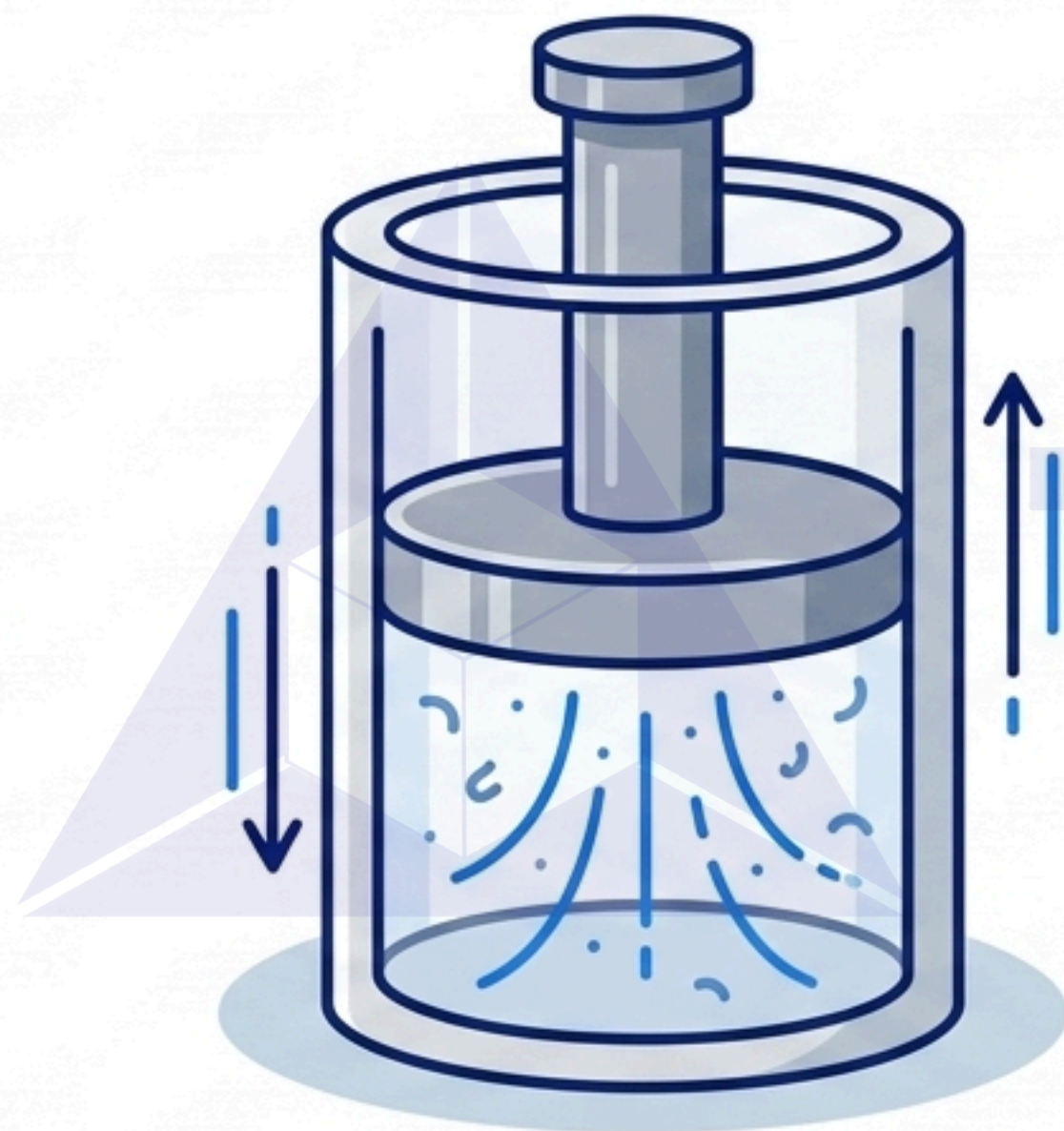


Pressure-Volume Work | JEE Thermodynamics

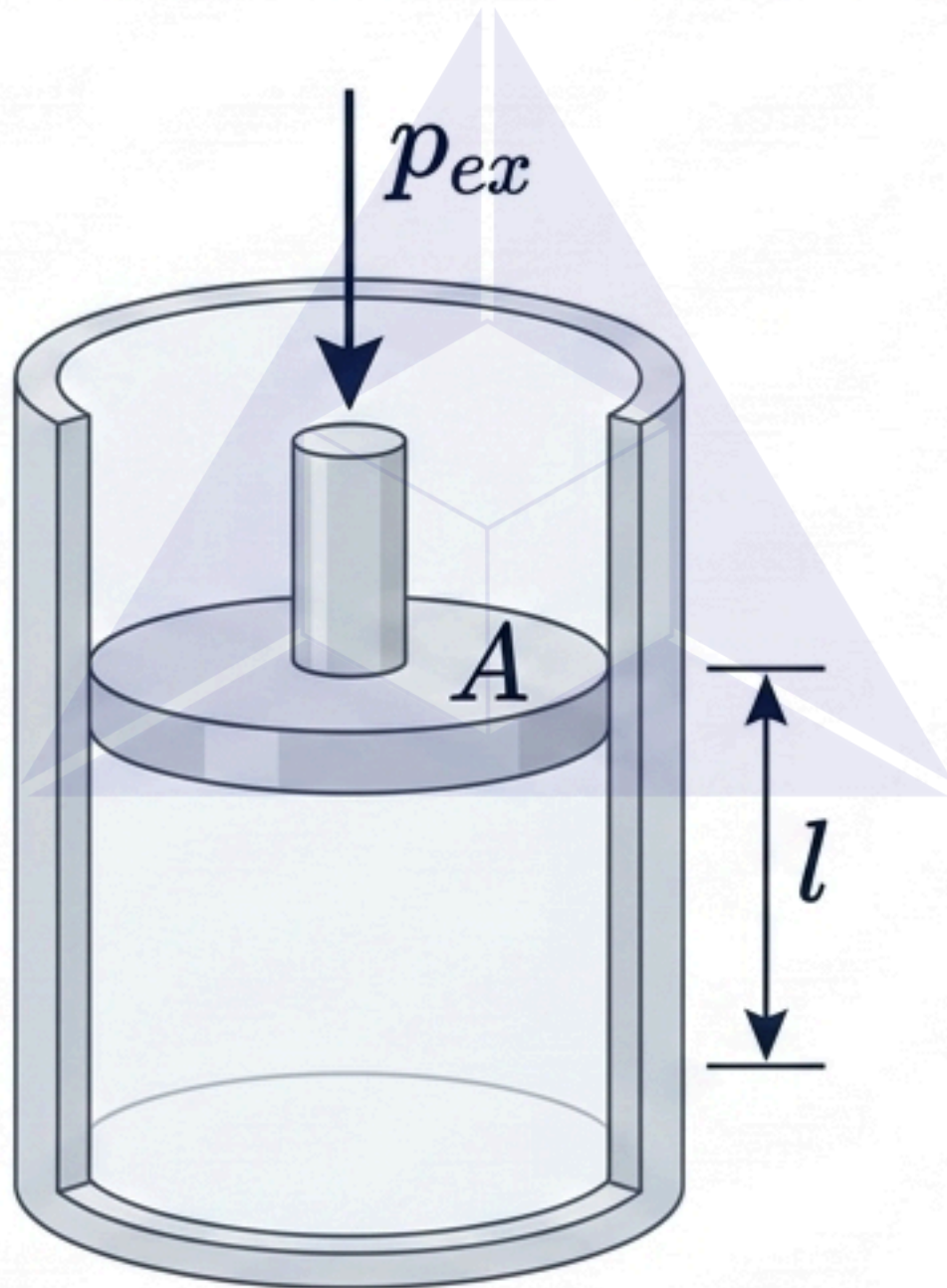


When this gas expands, is the work positive or negative?



(Hint: Chemistry IUPAC convention differs from Physics!)

Work Against Constant External Pressure



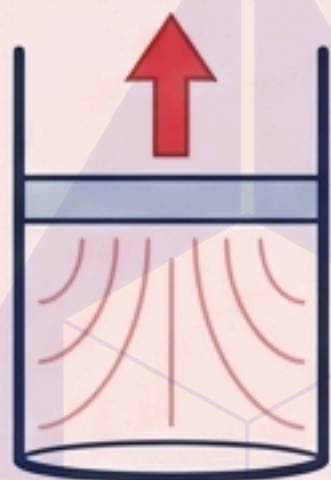
Irreversible P-V Work

$$w = -p_{ex}\Delta V$$

- $\Delta V = V_f - V_i$
- w = work done on the system
- p_{ex} = external pressure

Sign Convention: Expansion vs. Compression

EXPANSION

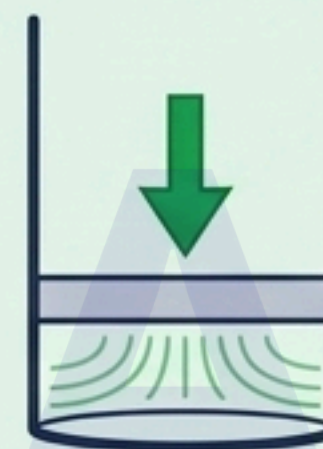


Final Volume > Initial Volume
 $\rightarrow \Delta V > 0$

$$w < 0$$

Work is done *by* the system.
Internal energy decreases.

COMPRESSION



Final Volume < Initial Volume
 $\rightarrow \Delta V < 0$

$$w > 0$$

Work is done *on* the system.
Internal energy increases.



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

$$E=mc^2$$



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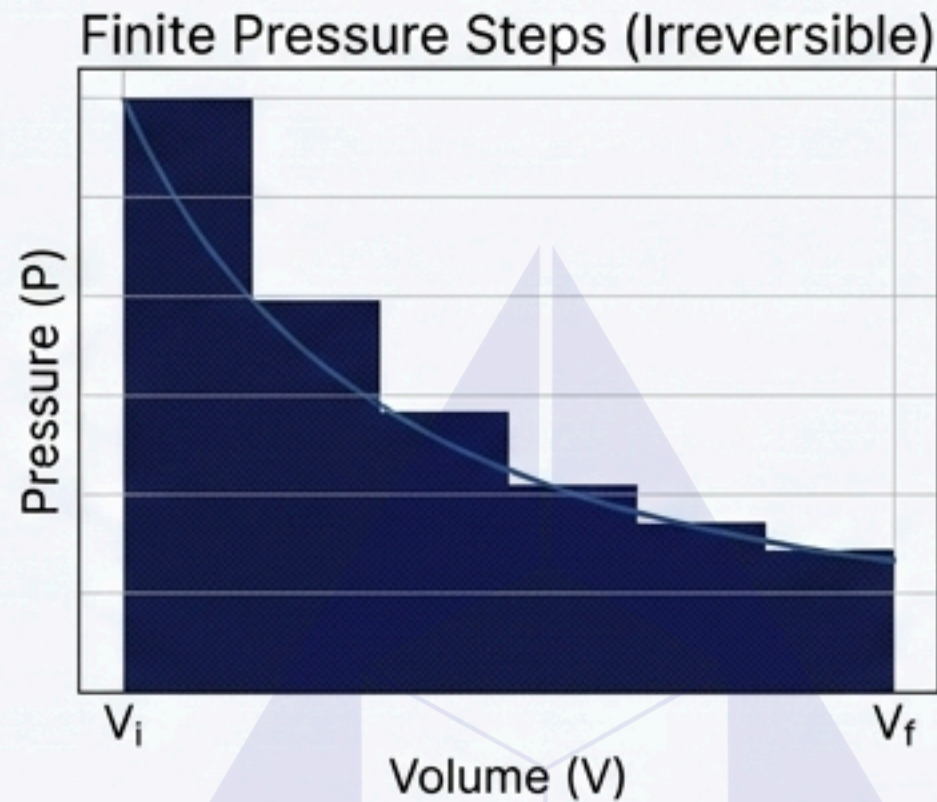
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Key Highlights

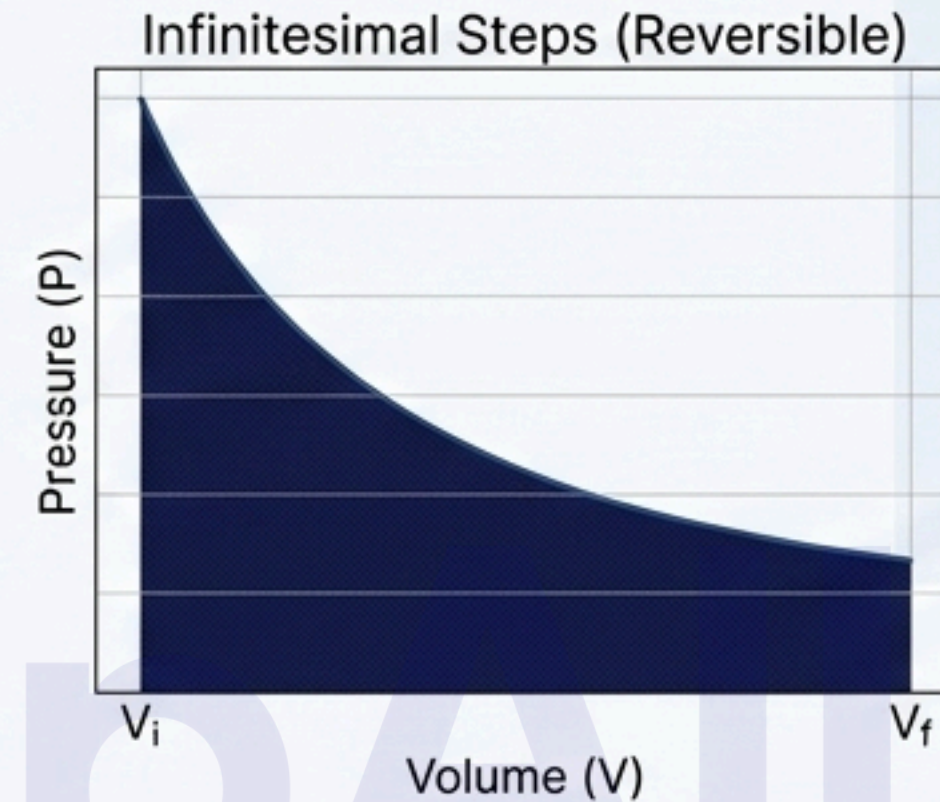
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Reversible Work & Changing Pressure



Mathematical Limit
($dp \rightarrow 0$)



Reversible Process Concept

Reversible process: proceeds infinitely slowly,
 $p_{\text{ex}} \approx p_{\text{in}} \pm dp$.

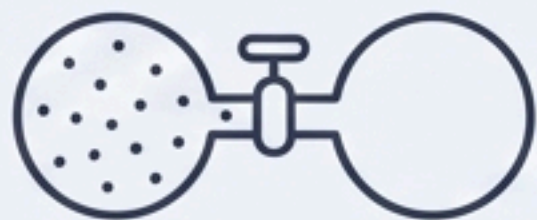
$$w_{\text{rev}} = - \int_{V_i}^{V_f} p dV$$

Isothermal Reversible Work (Ideal Gas)

Substitute $p = nRT/V$ to get:

$$w_{\text{rev}} = -nRT \ln \left(\frac{V_f}{V_i} \right) = -2.303nRT \log \left(\frac{V_f}{V_i} \right)$$

Free Expansion & The Vacuum Trap



Free Expansion

Expansion of a gas into a vacuum.

In a vacuum, $p_{ex} = 0$

$$w = 0$$

(For both reversible and irreversible processes).

JEE TRAP ALERT



When calculating irreversible work, never use the internal gas pressure (p_{gas}) in place of the external opposing pressure (p_{ex}). If $p_{ex} = 0$, no mechanical work is done, regardless of how high the internal gas pressure is!

Key Formula Cheat Sheet

Irreversible Work (Constant External Pressure)

$$w = -p_{\text{ex}} \Delta V$$

Reversible Work (Isothermal Ideal Gas)

$$w_{\text{rev}} = - \int p \, dV$$

$$w_{\text{rev}} = -nRT \ln(V_f/V_i)$$

$$w_{\text{rev}} = -2.303 \, nRT \log(V_f/V_i)$$

Edge Cases & Signs

Free Expansion (Vacuum)

$$p_{\text{ex}} = 0 \rightarrow \mathbf{w = 0}$$

Expansion

$$\Delta V > 0 \rightarrow \mathbf{w < 0}$$

Compression

$$\Delta V < 0 \rightarrow \mathbf{w > 0}$$



You've Learned the Theory.

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