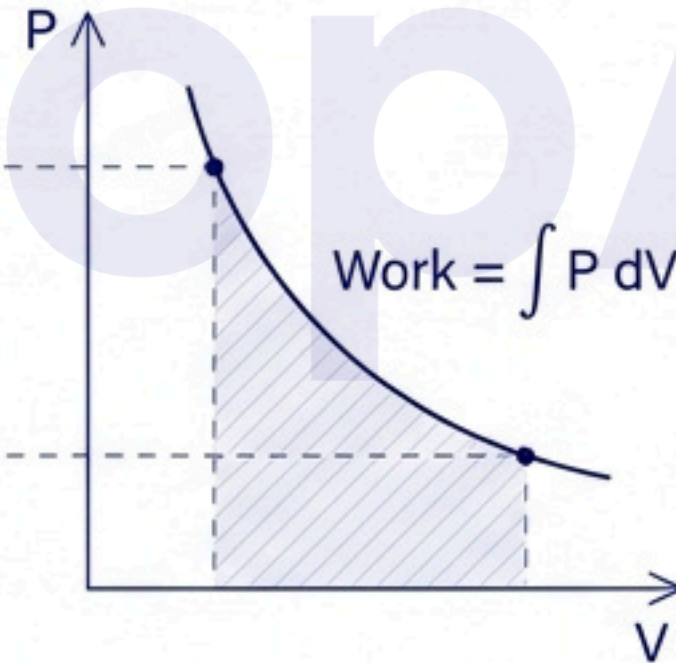
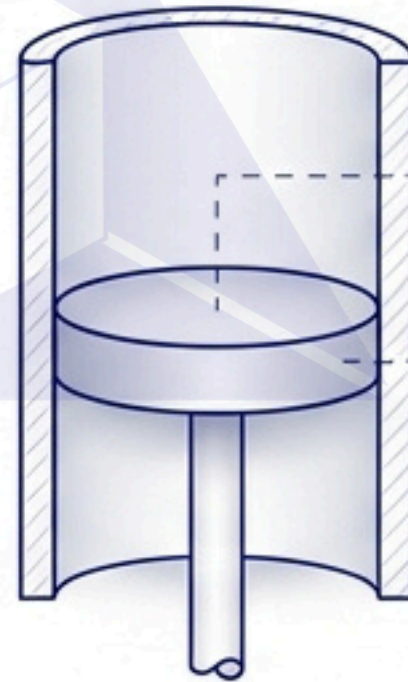


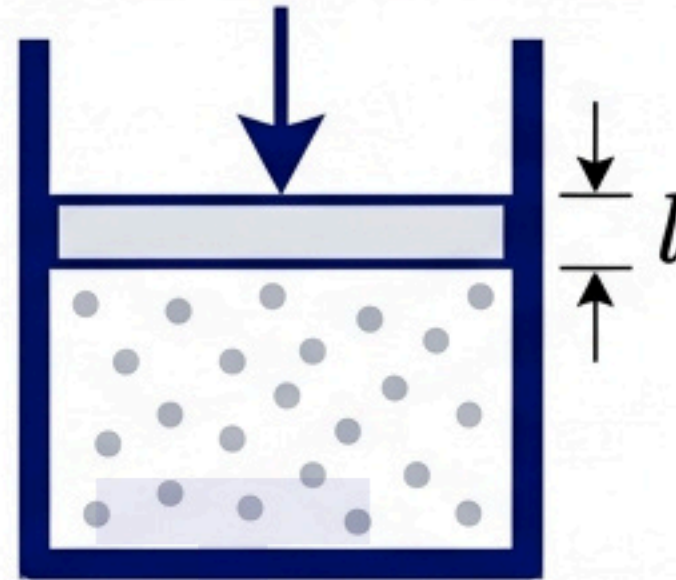
Thermodynamics | Chapter 5

5.2.1 Work



THE PHYSICAL MODEL

THE GAS IN A CYLINDER SETUP



THE SYSTEM

Initial Volume: V_i

Internal Pressure: p_{in}

Cross-sectional Area: A

THE SURROUNDINGS

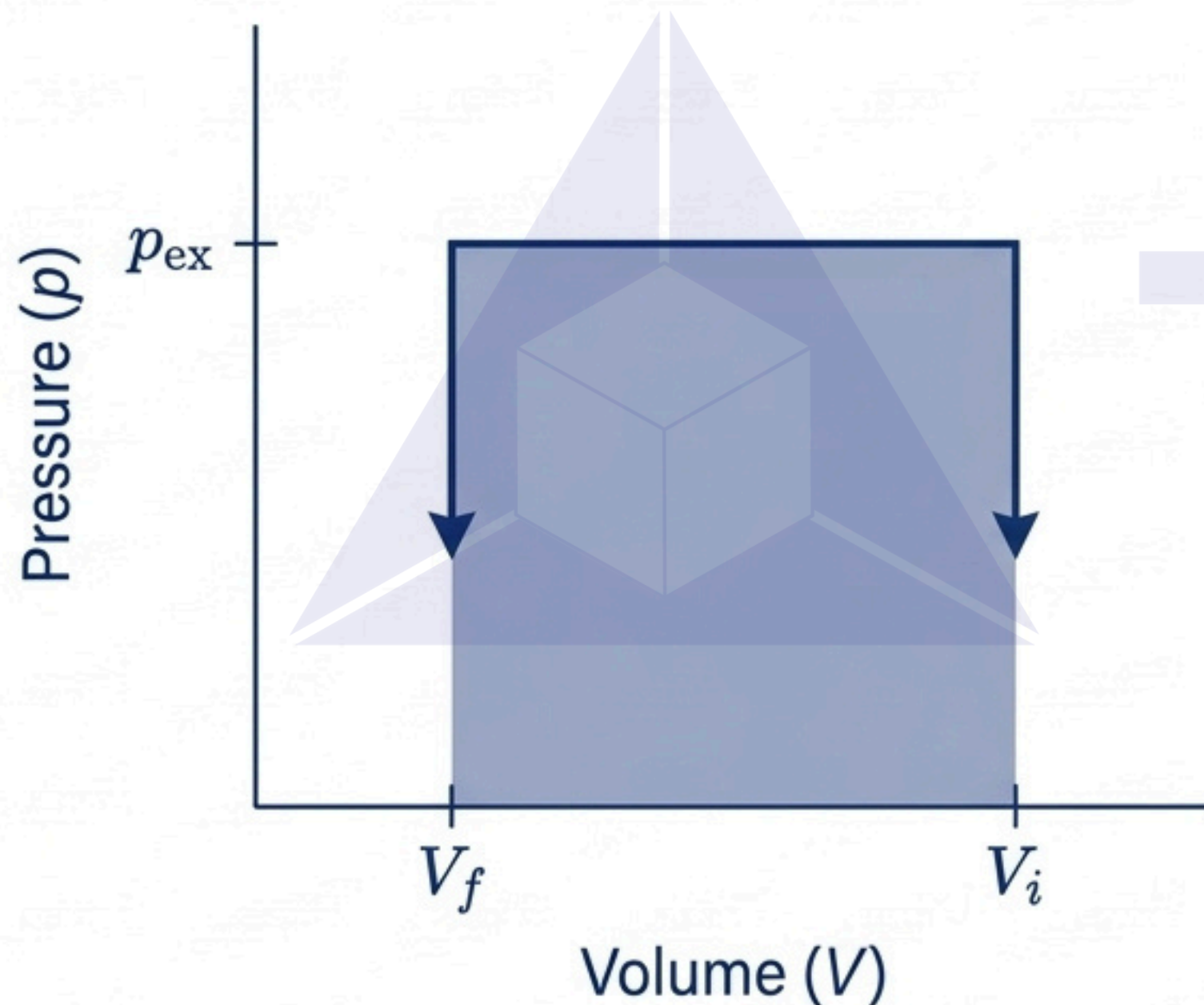
External Pressure: p_{ex}

Distance Moved: l

Geometric constraint: $\Delta V = l \times A$

Force on piston = $p_{ex} \times A$

Irreversible Work against Constant Pressure



CONCEPT CARD

The external pressure instantly crushes down until internal pressure matches it. Work is exactly equal to the shaded area.

$$w = -p_{\text{ex}}\Delta V = -p_{\text{ex}}(V_f - V_i)$$

RECAP BADGE

IUPAC Sign Convention:

+w indicates work is done on the system. Since ΔV is negative during compression, $-p_{\text{ex}}(-\Delta V)$ results in a positive w .



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

$$E=mc^2$$



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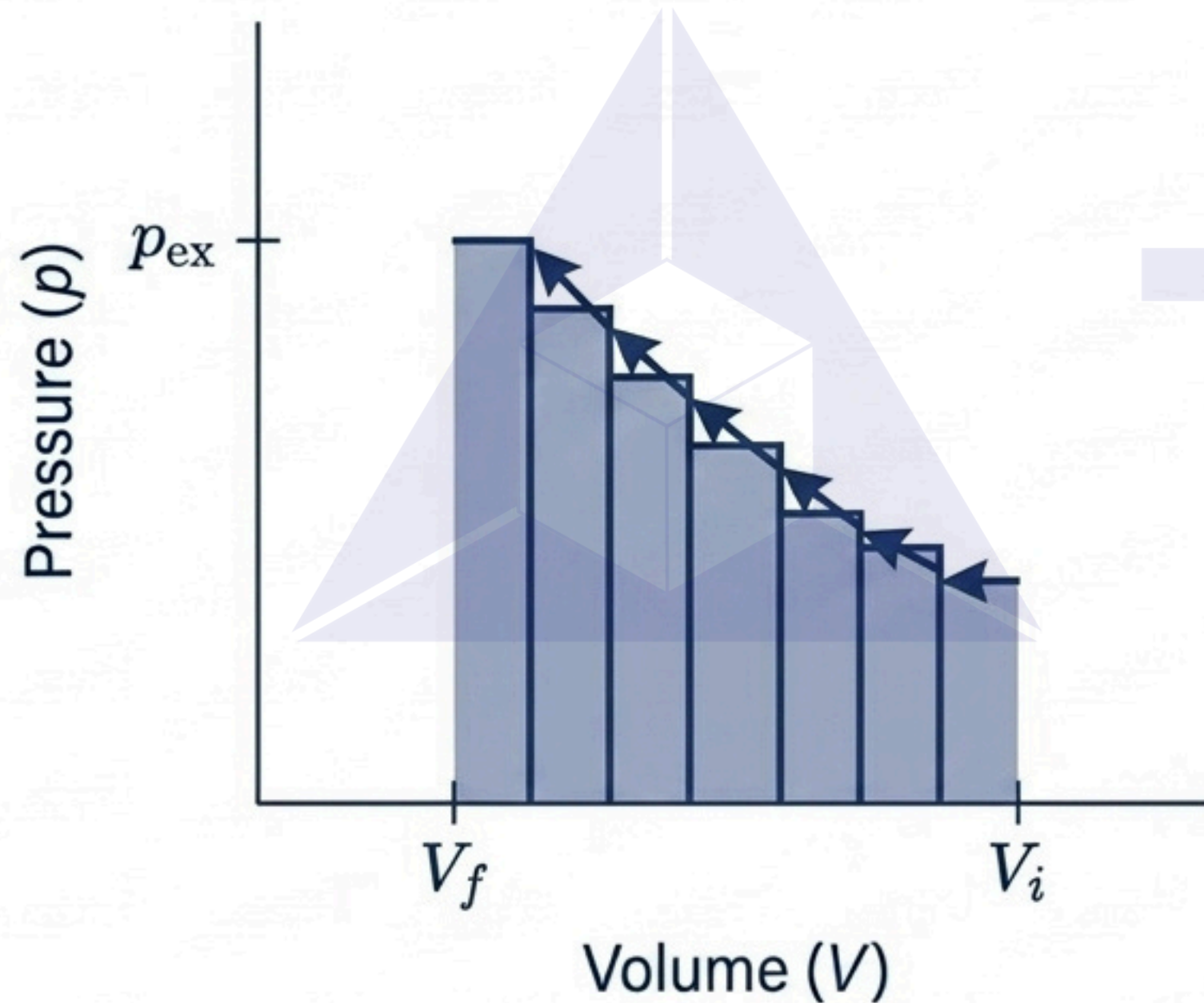
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Compression in Finite Steps



CONCEPT CARD

Pressure is no longer constant. Weights are added to the piston step-by-step. Total work is the sum of these individual rectangular chunks.

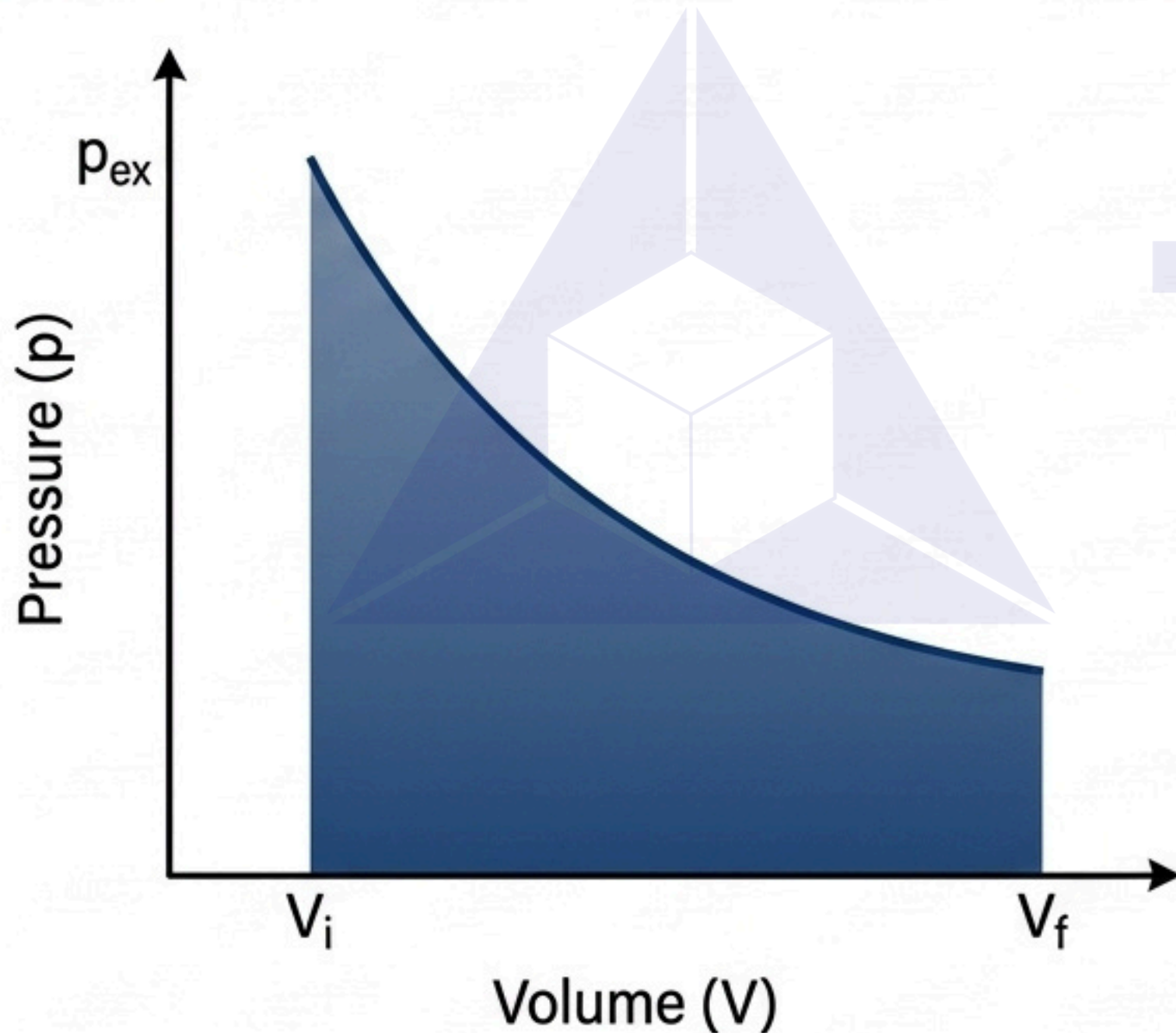
$$w = -\sum p \Delta V$$



As steps increase, we approach a smooth curve...

Infinite Steps

Reversible Compression (Thermodynamic Ideal)



CONCEPT CARD

The process proceeds infinitely slowly. The system and surroundings are always in near-equilibrium.

$$p_{ex} \approx p_{in} + dp$$

The volume decreases by an infinitesimal amount dV .

$$w = - \int_{V_i}^{V_f} p_{ex} dV$$

Isothermal Reversible Work (Ideal Gas)

Step 1 (Base Integral)

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

Step 2 (Ideal Gas Law)

$$p = \frac{nRT}{V}$$

Step 3 (Integration Constraint)

Isothermal means T is constant. Pull constants n , R , T out of the integral:

$$-nRT \int \frac{1}{V} \, dV$$

Natural Log

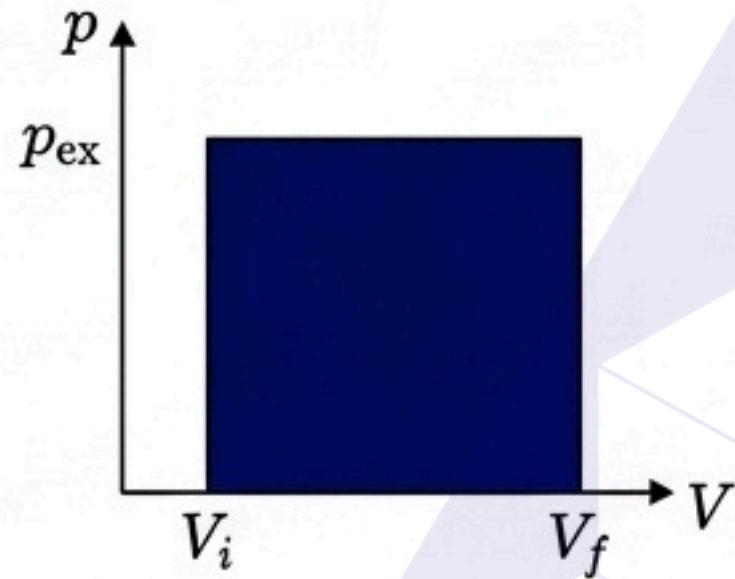
$$w_{rev} = -nRT \ln \left(\frac{V_f}{V_i} \right)$$

Base 10 Log

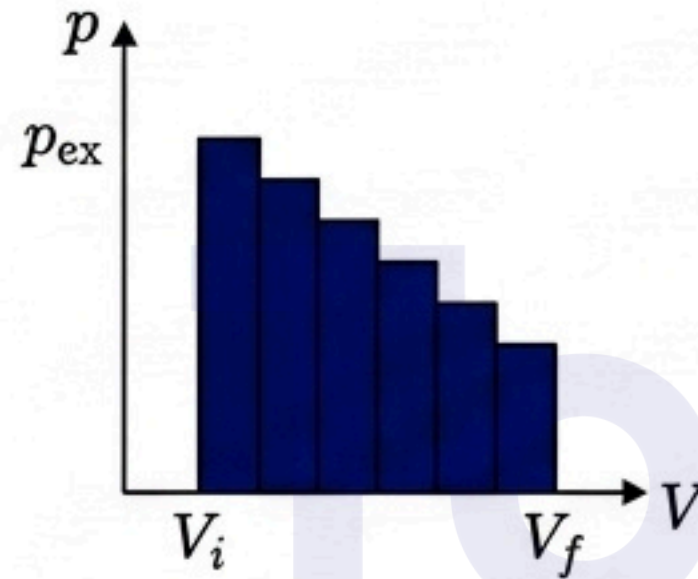
$$w_{rev} = -2.303 \, nRT \log \left(\frac{V_f}{V_i} \right)$$

Why Path Matters for Work

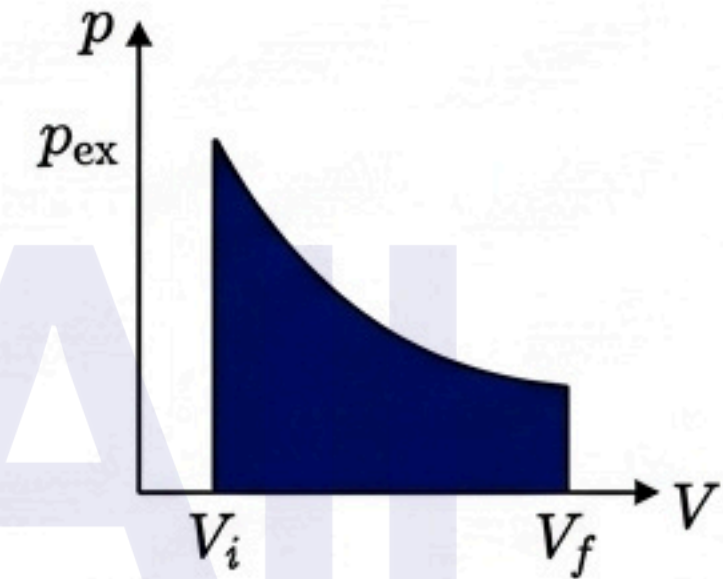
Irreversible (Single-step)



Finite-step



Reversible



Notice the shaded areas: Even though the starting volume (V_i) and ending volume (V_f) are identical in all three scenarios, the total area (Work) is drastically different.

Work (w) is a Path Function.

Unlike internal energy or enthalpy, work is not a state function. The specific route taken from state A to state B entirely defines the energy transferred.



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