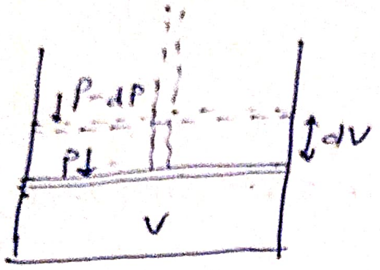
Work done in reversible isothermal Expansion →



$dw = -(P - dP)dV = -PdV$

$dPdV$ → infinitesimal small → can be ignored.

$$w = -\int_{V_1}^{V_2} PdV$$

$$w = -RT\int_{V_1}^{V_2} \frac{dV}{V} = -RT \ln\frac{V_2}{V_1} \qquad \left[\because P = RT/V\right]$$

At const. temperature $P_1V_1 = P_2V_2$.

$$w = -RT \ln(P_1/P_2)$$

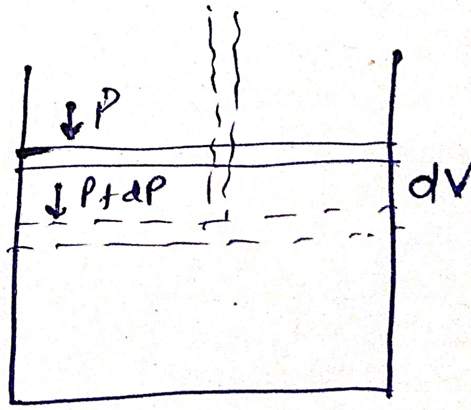
$$\boxed{w = -nRT \ln(V_2/V_1) = -nRT \ln(P_1/P_2)}$$

$V_2 > V_1$ (for expansion) $w = -ve$

Work done in isothermal Compression

$$dw = -(P + dP)dV$$

$$w' = -\int_{V_2}^{V_1} PdV.$$



$$w' = -RT\int_{V_1}^{V_2}\frac{dV}{V} = RT\ln(V_1/V_2)$$
$$= -RT\ln(P_2/P_1)$$

for n moles.

$$\boxed{w' = -nRT\ln(V_1/V_2) = -nRT\ln(P_2/P_1)}$$

Maximum Work →

If $P_{ext} << P$ → expansion irreversible. & rapidly
↓
Work done will be much smaller.

If P_{ext} is infinitesimally smaller than gas pressure.
→ expansion reversibly & slowly

If $P_{ext} = 0$ (i.e. gas expands in vacuum)
$W = 0$.

⟹ Closer is the opposing force (Pressure) to the pressure of gaseous system in the cylinder, the greater is the work performed by the system on expansion.