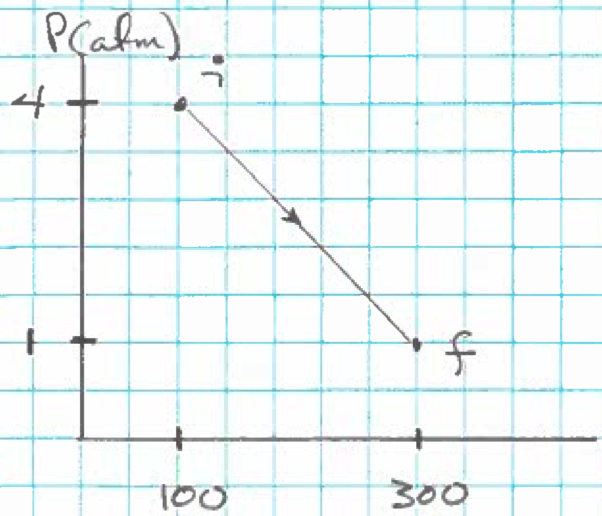

$n = 0.015$ mol of H_2

$P_i = 4\text{ atm} = 4.052\times10^5\text{ Pa}$

$P_f = 1\text{ atm} = 1.013\times10^5\text{ Pa}$

$V_i = 100\text{ cm}^3 = 100\times10^{-6}\text{ m}^3$

$V_f = 300\text{ cm}^3 = 300\times10^{-6}\text{ m}^3$

<u>Must use first Law</u>

$$W_{i\to f} = -\int_{V_i}^{V_f} P\,dV = -(\text{area under path})$$

$$= -\left\{\frac{1}{2}(V_f - V_i)(P_i - P_f) + (V_f - V_i)P_f\right\}$$

$$\boxed{W_{i\to f} = -50.56\text{ J.}}$$

For any process: $\Delta E_{th} = nC_V\Delta T$

So, $\Delta E_{th} = nC_V(T_f - T_i)$

Now, $PV = nRT \Rightarrow T = \dfrac{PV}{nR}$

So,

$$\Delta E_{th} = nC_V\left(\frac{P_fV_f - P_iV_i}{nR}\right) = \frac{C_V}{R}(P_fV_f - P_iV_i)$$

$$\boxed{\Delta E_{th} = -24.8\text{ J} \quad \text{for}}\quad C_V = 20.4\ \frac{\text{J}}{\text{mol K}}$$

for H_2

Now, <u>use the first Law</u>:

$$\Delta E_{th} = Q + W$$

So, $\boxed{Q = \Delta E_{th} - W = 25.78\text{ J}}$