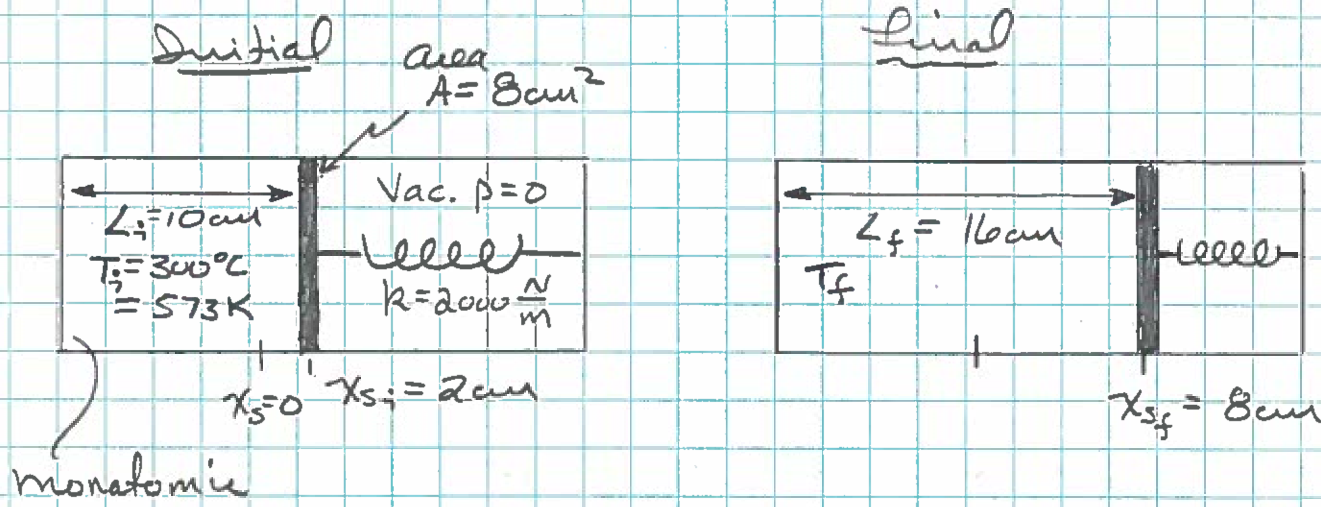
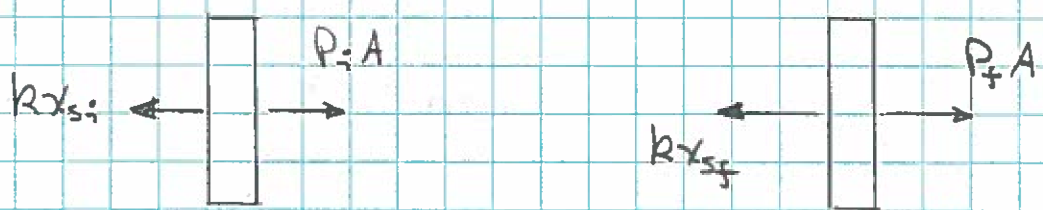


Start with the 1st Law, $\Delta E_{th} = Q + W$

If we can find ΔE_{th} and W, can get Q.

FBD's for initial and final:



So, for equilibrium:

$$kx_{s_i} = P_i A \qquad\qquad kx_{s_f} = P_f A$$

$$P_i = \frac{kx_{s_i}}{A} \qquad\qquad P_f = \frac{kx_{s_f}}{A}$$

also

$$V_i = L_i A \qquad\qquad V_f = L_f A$$

So $\Delta E_{th} = nc_v \Delta T = nc_v (T_f - T_i)$

$$= nc_v \left(\frac{P_f V_f}{nR} - \frac{P_i V_i}{nR} \right) \quad \text{from } PV = nRT$$

$$= \frac{c_v}{R} \left(\frac{kx_{s_f} L_f A}{A} - \frac{kx_{s_i} L_i A}{A} \right)$$

So:

$$\Delta E_{th} = \frac{C_v k}{R}\left(x_{s_f} L_f - x_{s_i} L_i\right)$$

use $C_v = 12.5 \frac{J}{mol K}$ and convert to m

$$\underline{\Delta E_{th} = 32.48 \text{ J}}$$

Now:

$$W = -\int_{V_i}^{V_f} p\,dV$$

where $p \neq$ const. From above, for any piston position.

$$p = \frac{kx}{A}$$

and the volume element is $dV = A\,dx$

So

$$W = -\int_{x_i}^{x_f} \frac{kx}{A} A\,dx = -k\int_{x_i}^{x_f} x\,dx$$

$$= -k \left.\frac{x^2}{2}\right|_{x_i}^{x_f} = -\frac{k}{2}\left(x_f^2 - x_i^2\right)$$

So: $W = -6.0$ J.

$\therefore$ $\underline{Q = \Delta E_{th} - W = 38.48 \text{ J}}$