Final Thermal worksheet

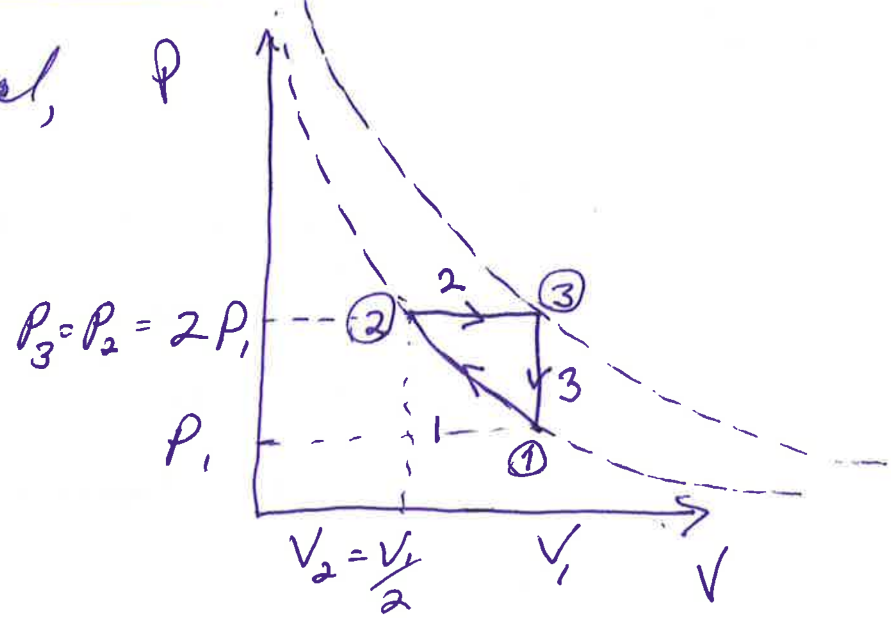
$PV = NkT$

#1 is isothermal,

so $PV = \text{const.}$

$V_2 = \frac{1}{2} V_1$, so

$P_2 = 2P_1$



Process 3 takes

Place at constant volume, so $PV = NkT$ $P \propto T$

$P_3 = 2P_1$, so $T_3 = 2T_1$

Make sure you understand this

	1	2	3
$\Delta U \equiv \Delta E$	0	+	−
Q	−	+	−
W_{in}	+	−	0

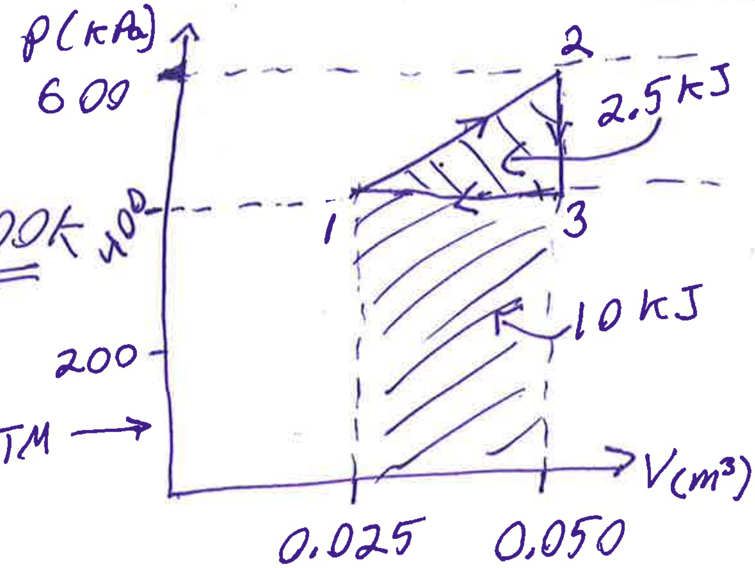
$$W_1 = \int_{(V_1)}^{(V_1/2)} P\,dV \quad \ldots \quad \text{isotherma} \quad P = \frac{nRT}{V}$$

$$= \int_{V_1}^{V_1/2} \frac{nRT}{V}\,dV = nRT \ln\left(\frac{V_1/2}{V_1}\right) = nRT \ln \frac{1}{2} = -nRT \ln 2$$

$$W_2 = \int P\,dV = \frac{P_2 V_1}{2} = \frac{2P_1 V_1}{2} = P_1 V_1 = nRT$$

$W_3 = 0 \quad \Delta V = 0$

n = 2 moles



a) $PV = nRT \quad T = \frac{PV}{nR}$

$T_1 = \frac{4\times10^5 \, N/m^2 \times 2.5\times10^{-2} \, m^3}{2 \text{ moles} \cdot 8.3 \, J/\text{mole } k} = \sim 600k$

because $T \propto P$ and $T \propto V$,

$T_2 = T_1\left(\frac{P_2}{P_1}\right)\left(\frac{V_2}{V_1}\right)$

$= 600k(1.5)(2) = 1800k$

$T_3 = T_1\left(\frac{V_3}{V_1}\right) = 600k(2) = 1200k$

b) $\Delta U \equiv \Delta E = C_v n \Delta T = \frac{f}{2} R n \Delta T = \underbrace{\frac{3}{2}(8.3 \, J/\text{mole}\cdot k) 2 \text{ moles}}_{= 24.9 \, J/k} \Delta T$

$\Delta E_{12} = 30 kJ$

$\Delta E_{23} = -15 kJ$

$\Delta E_{31} = -15 kJ$

$W_{(out)} = \int P dV$ = area under curve

$W_{12} = 12.5 kJ \quad W_{23} = 0 \quad W_{31} = -10 kJ$

$Q_{in} = \Delta U + W_{out}; \quad Q_{12} = 30kJ + 12.5kJ = 42.5kJ$

$Q_{23} = -15kJ + 0 = -15kJ$

$Q_{31} = -15kJ - 10kJ = -25kJ$

c) $\eta = \frac{\Sigma W_{out}}{Q_{HOT}}$

$= \frac{2.5kJ}{42.5kJ} \approx 5.9\%$ (not very efficient)

d) more work is put out by engine than put in. or because the cycle is clockwise

that is: $\Sigma W_{out} > 0$

on the ~~PV~~ $P \leftrightarrow V$ diagram