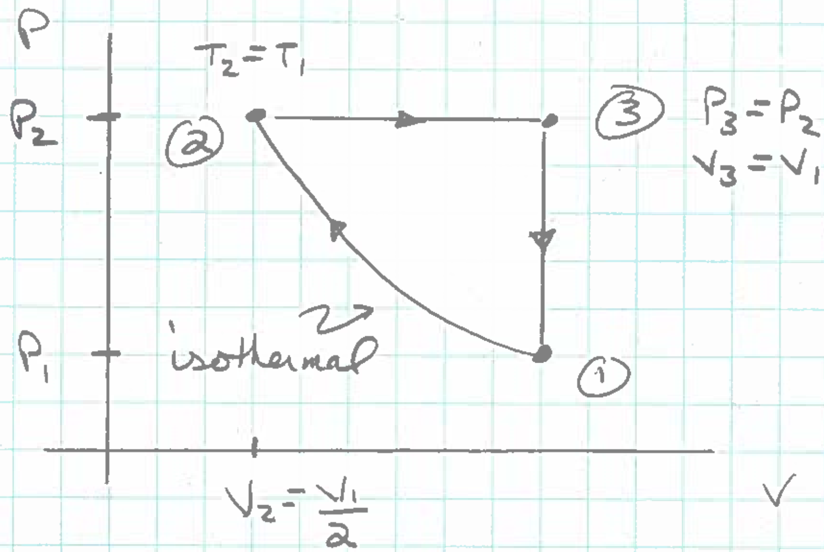
a.)



Diatomic:

$C_V = \frac{5}{2}R$

$C_P = \frac{7}{2}R$

b.)

find the efficiency, η, and compare it to the Carnot efficiency, η_c, between the highest and lowest temperatures.

This is a scary problem since we are asked to calculate a number for η, but only one number is given!

First: for ① and ②: $PV = nRT = \text{const} \Rightarrow P_1V_1 = P_2V_2$

So: $P_2 = P_1\left(\frac{V_1}{V_2}\right) = 2P_1$

And, for ② & ③: $PV = nRT \Rightarrow \frac{P}{nR} = \frac{T}{V} = \text{const.}$

So: $\frac{T_2}{V_2} = \frac{T_3}{V_3} \Rightarrow T_3 = T_2\frac{V_3}{V_2} = 2T_1$

Now, going around the cycle:

$$W_{s\,1\to2} = +\int P\,dV = nRT_1 \ln\left(\frac{V_2}{V_1}\right) = nRT_1 \ln(1/2) = -nRT_1 \ln(2)$$

$$\Delta E_{th} = Q - W_s = 0 \Rightarrow Q_{1\to2} = W_{s\,1\to2} = -nRT_1 \ln(2)$$

and,

$$W_{s\,2\to3} = +\int P\,dV = P_2(V_3 - V_2) = 2P_1\left(V_1 - \frac{V_1}{2}\right)$$

$$= P_1V_1 = nRT_1$$

$$Q_{2\to3} = nC_p\,\Delta T = \frac{7}{2}nR(T_3 - T_2) = \frac{7}{2}nR(2T_1 - T_1)$$

$$= \frac{7}{2}nRT_1$$

and,

$$W_{s\,3\to1} = 0$$

$$Q_{3\to1} = nC_v\,\Delta T = \frac{5}{2}nR(T_1 - T_3) = \frac{5}{2}nR(T_1 - 2T_1)$$

$$= -\frac{5}{2}nRT_1$$

<u>Now:</u>

$$Q_H = \sum(+Q\text{'s}) = Q_{2\text{-}3} = \frac{7}{2}nRT_1$$

$$Q_c = \sum|-Q\text{'s}| = |Q_{1\to2}| + |Q_{3\to1}|$$

$$= nRT_1\ln(2) + \frac{5}{2}nRT_1$$

So:

$$\eta = 1 - \frac{Q_c}{Q_H} = 1 - \frac{\left(nRT_1\ln(2) + \frac{5}{2}nRT_1\right)}{\frac{7}{2}nRT_1}$$

$$= 1 - \left\{\frac{2\ln(2) + 5}{7}\right\}$$

$\therefore$

$$\underline{\eta = 0.0876 = 8.76\,\%}$$

c.) the minimum temperature is T_1 and the maximum temperature is $T_3 = 2T_1$

$$\therefore \quad \eta_c = 1 - \frac{T_c}{T_H} = 1 - \frac{T_1}{2T_1} = \underline{0.5 = 50\%}$$

Note: $\eta < \eta_c$