56. (a) Processes 1 and 2 both require the input of heat, which is denoted $Q_{\rm H}$. Noting that rotational degrees of freedom are not involved, then, from the discussion in Chapter 20, $C_V = \frac{3}{2}R$, $C_p = \frac{5}{2}R$, and $\gamma = \frac{5}{3}$. We further note that since the working substance is an ideal gas, process 2 (being isothermal) implies $Q_2 = W_2$. Finally, we note that the volume ratio in process 2 is simply 8/3. Therefore,

$$Q_{\rm H} = Q_1 + Q_2 = nC_V\,(T' - T) + nRT'\,\ln\frac{8}{3}$$

which yields (for $T = 300$ K and $T' = 800$ K) the result $Q_{\rm H} = 25.5 \times 10^3$ J.

(b) The net work is the net heat ($Q_1 + Q_2 + Q_3$). We find Q_3 from $nC_p\,(T - T') = -20.8 \times 10^3$ J. Thus, $W = 4.73 \times 10^3$ J.

(c) Using Eq. 21-9, we find that the efficiency is

$$\varepsilon = \frac{|W|}{|Q_{\rm H}|} = \frac{4.73 \times 10^3}{25.5 \times 10^3} = 0.185\ .$$