64. (a) The most obvious input-heat step is the constant-volume process. Since the gas is monatomic, we know from Chapter 20 that $C_V = \frac{3}{2}R$. Therefore,

$$\begin{aligned} Q_V &= nC_V\Delta T \\ &= (1\,\text{mol})\left(\frac{3}{2}\right)\left(8.31\,\frac{\text{J}}{\text{mol}\cdot\text{K}}\right)(600\,\text{K} - 300\,\text{K}) \\ &= 3740\ \text{J}\ . \end{aligned}$$

Since the heat transfer during the isothermal step is positive, we may consider it also to be an input-heat step. The isothermal Q is equal to the isothermal work (calculated in the next part) because $\Delta E_{\text{int}} = 0$ for an ideal gas isothermal process (see Eq. 20-45). Borrowing from the part (b) computation, we have

$$Q_{\text{isotherm}} = nRT_{\text{H}}\ln 2 = (1\,\text{mol})\left(8.31\,\frac{\text{J}}{\text{mol}\cdot\text{K}}\right)(600\,\text{K})\ln 2 = 3456\ \text{J}\ .$$

Therefore, $Q_{\text{H}} = Q_V + Q_{\text{isotherm}} = 7.2\times10^3$ J.

(b) We consider the sum of works done during the processes (noting that no work is done during the constant-volume step). Using Eq. 20-14 and Eq. 20-16, we have

$$W = nRT_{\text{H}}\ln\left(\frac{V_{\max}}{V_{\min}}\right) + p_{\min}\left(V_{\min} - V_{\max}\right)$$

where (by the gas law in ratio form, as illustrated in Sample Problem 20-1) the volume ratio is

$$\frac{V_{\max}}{V_{\min}} = \frac{T_{\text{H}}}{T_{\text{L}}} = \frac{600\,\text{K}}{300\,\text{K}} = 2\ .$$

Thus, the net work is

$$\begin{aligned} W &= nRT_{\text{H}}\ln 2 + p_{\min}V_{\min}\left(1 - \frac{V_{\max}}{V_{\min}}\right) \\ &= nRT_{\text{H}}\ln 2 + nRT_{\text{L}}(1-2) \\ &= nR\left(T_{\text{H}}\ln 2 - T_{\text{L}}\right) \\ &= (1\,\text{mol})\left(8.31\,\frac{\text{J}}{\text{mol}\cdot\text{K}}\right)((600\,\text{K})\ln 2 - (300\,\text{K})) \\ &= 9.6\times10^2\ \text{J}\ . \end{aligned}$$

(c) Eq. 21-9 gives

$$\varepsilon = \frac{W}{Q_{\text{H}}} = 0.134 \quad \approx\ 13\%\ .$$