27. (a) Energy is added as heat during the portion of the process from a to b. This portion occurs at constant volume (V_b), so $Q_{\text{in}} = nC_V\,\Delta T$. The gas is a monatomic ideal gas, so $C_V = \frac{3}{2}R$ and the ideal gas law gives $\Delta T = (1/nR)(p_bV_b - p_aV_a) = (1/nR)(p_b - p_a)V_b$. Thus, $Q_{\text{in}} = \frac{3}{2}(p_b - p_a)V_b$. V_b and p_b are given. We need to find p_a. Now p_a is the same as p_c and points c and b are connected by an adiabatic process. Thus, $p_cV_c^\gamma = p_bV_b^\gamma$ and

$$p_a = p_c = \left(\frac{V_b}{V_c}\right)^\gamma p_b = \left(\frac{1}{8.00}\right)^{5/3}(1.013\times10^6\,\text{Pa}) = 3.167\times10^4\,\text{Pa}\,.$$

The energy added as heat is

$$Q_{\text{in}} = \frac{3}{2}(1.013\times10^6\,\text{Pa} - 3.167\times10^4\,\text{Pa})(1.00\times10^{-3}\,\text{m}^3) = 1.47\times10^3\ \text{J}\ .$$

(b) Energy leaves the gas as heat during the portion of the process from c to a. This is a constant pressure process, so

$$\begin{aligned} Q_{\text{out}} &= nC_p\,\Delta T = \frac{5}{2}(p_aV_a - p_cV_c) = \frac{5}{2}p_a(V_a - V_c) \\ &= \frac{5}{2}(3.167\times10^4\,\text{Pa})(-7.00)(1.00\times10^{-3}\,\text{m}^3) = -5.54\times10^2\ \text{J}\ . \end{aligned}$$

The substitutions $V_a - V_c = V_a - 8.00V_a = -7.00V_a$ and $C_p = \frac{5}{2}R$ were made.

(c) For a complete cycle, the change in the internal energy is zero and $W = Q = 1.47\times10^3\,\text{J} - 5.54\times10^2\,\text{J} = 9.18\times10^2\,\text{J}$.

(d) The efficiency is $\varepsilon = W/Q_{\text{in}} = (9.18\times10^2\,\text{J})/(1.47\times10^3\,\text{J}) = 0.624$.