8. Thermodynamic Cycle

For a monatomic ideal gas, $C_V = \frac{3}{2}R$, $C_p = \frac{5}{2}R$, $\gamma = 5/3$.

- **State b:** $p_b = 1.013 \times 10^6$ Pa, $V_b = 1.00 \times 10^{-3}$ m^3, $T_b \approx 121.9$ K.
- **State c:** $V_c = 8V_b$. Adiabatic process gives $p_c = p_b(V_b/V_c)^\gamma \approx 3.166 \times 10^4$ Pa. $T_c \approx 30.48$ K.
- **State a:** $V_a = V_b$, $p_a = p_c$. $T_a \approx 3.81$ K.

(a) Energy Added as Heat (Q_H)

Heat is added during the isochoric process a $\rightarrow$ b.

$$Q_H = Q_{ab} = nC_V(T_b - T_a) = (1.00)\left(\frac{3}{2} \times 8.31\right)(121.9 - 3.81) \approx \mathbf{1472}\,\mathrm{J}$$

(b) Energy Leaving as Heat (Q_C)

Heat leaves during the isobaric process c $\rightarrow$ a.

$$Q_C = |Q_{ca}| = nC_p(T_c - T_a) = (1.00)\left(\frac{5}{2} \times 8.31\right)(30.48 - 3.81) \approx \mathbf{554}\,\mathrm{J}$$

(c) Net Work Done (W_{net})

$$W_{net} = Q_H - Q_C = 1472\,\mathrm{J} - 554\,\mathrm{J} = \mathbf{918}\,\mathrm{J}$$

(d) Efficiency (η)

$$\eta = \frac{W_{net}}{Q_H} = \frac{918}{1472} \approx 0.624 = \mathbf{62.4}\%$$
