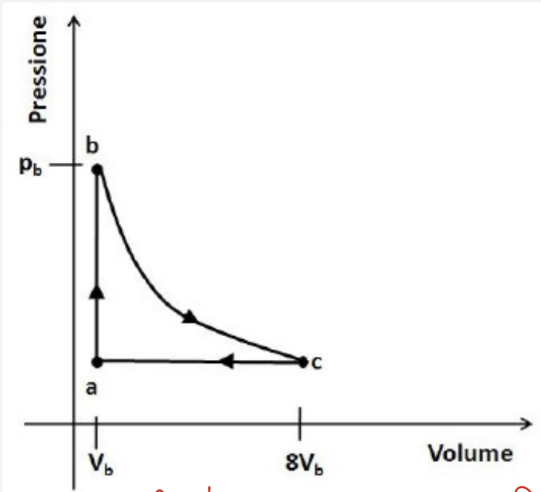




Example

One mole of monatomic gas undergoes the cycle shown in the figure. The BC process is an adiabatic expansion; $p_B = 1.03 \text{ bar}$, $V_B = 1.0 \times 10^{-3} \text{ m}^3$, $V_C = 8V_B$. Calculate for the entire cycle: a) the heat supplied to the gas; b) the heat released by the gas; c) the total work done by the gas; d) the efficiency of the cycle; e) the entropy changes.



$$p_B = 1.03 \text{ bar} = 103 \cdot 1000 \text{ Pa}$$

$$V_B = 1 \cdot 10^{-3} \text{ m}^3$$

$$V_C = 8V_B = 8 \cdot 10^{-3} \text{ m}^3$$

$$Q_{\text{ASS}}? \quad M?$$

$$Q_{\text{CED}}? \quad \Delta S_{AB, BC, CA}?$$

$$L_{\text{TOT}}?$$

$$p_C \rightarrow p_B V_B^\gamma = p_C V_C^\gamma \rightarrow V_C^\gamma = \frac{p_B V_B^\gamma}{p_C} = 3196 \text{ Pa}$$

$$\left[\gamma = \frac{c_p}{c_v} = \frac{5/2R}{3/2R} = \frac{5}{3} \right]$$

$$T_B = \frac{p_B V_B}{nR} = \frac{103 \cdot 1000 \text{ Pa} \cdot 10^{-3} \text{ m}^3}{1 \text{ mol} \cdot 8.31} = 12.4 \text{ K}$$

$$T_C = \frac{p_C V_C}{nR} = \frac{3196 \text{ Pa} \cdot 8 \cdot 10^{-3} \text{ m}^3}{1 \text{ mol} \cdot 8.31} = 3.08 \text{ K}$$

$$\textcircled{A} \quad p_A = p_C = 3196 \text{ Pa}$$

$$V_A = V_B = 1 \cdot 10^{-3} \text{ m}^3 \rightarrow T_A = \frac{p_A V_A}{nR} = \frac{3196 \text{ Pa} \cdot 1 \cdot 10^{-3} \text{ m}^3}{1 \cdot 8.31} = 0.38 \text{ K}$$

$$Q_{AB} = n c_v \Delta T = 1 \text{ mol} \cdot \frac{3}{2} \cdot 8.31 (12.4 \text{ K} - 0.38 \text{ K}) = +149.8 \text{ J} \longrightarrow Q_{\text{ASS}}$$

$$Q_{BC} = 0$$

$$Q_{CA} = n c_p \Delta T = 1 \cdot \frac{5}{2} \cdot 8.31 (0.38 - 3.08) = -56.1 \text{ J} \longrightarrow Q_{\text{CED}}$$

$$L_{AB} = 0$$

$$L_{BC} = -n c_v \Delta T = -1 \text{ mol} \cdot \frac{3}{2} \cdot 8.31 (3.08 - 12.4) = +116.17 \text{ J}$$

$$L_{CA} = p \Delta V = 3196 \text{ Pa} (10^{-3} - 8 \cdot 10^{-3}) = -22.37 \text{ J}$$

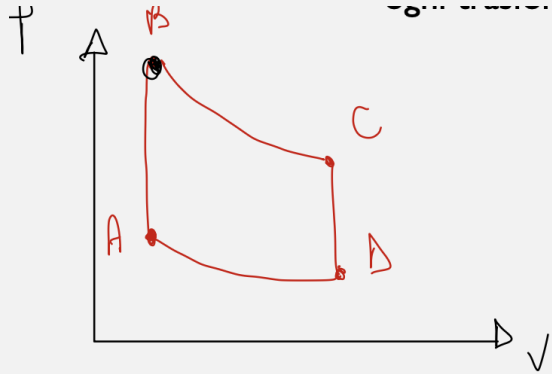
$$\left. \begin{array}{l} +116.17 \text{ J} \\ -22.37 \text{ J} \end{array} \right\} L_{\text{TOT}} = 93.8 \text{ J}$$

$$\eta = \frac{L_{\text{CICLO}}}{Q_{\text{ASS}}} = \frac{+93.8 \text{ J}}{+149.8 \text{ J}} = 0.63$$



Example

3 moles of diatomic gas undergo a reversible thermodynamic cycle consisting of an isochoric heating AB, an isothermal expansion BC, an isochoric cooling CD, and finally an isothermal compression DA. Given that the work of the cycle is 5000 J, $p_B/p_C=2$ and that $T_A=250$ K, calculate the temperature T_B and the amounts of heat exchanged for each transformation, and the efficiency of the cycle.



$$n = 3 \text{ mol}$$

$$L = 5000 \text{ J}$$

$$p_B/p_C = 2$$

$$T_A = 250 \text{ K} = T_D$$

$$T_B ? (> T_A)$$

$$Q_{AB}, Q_{BC}, Q_{CD}, Q_{DA} ?$$

$$\eta ?$$

$$L_{\text{ciclo}} = 5000 \text{ J} = L_{AB} + L_{BC} + L_{CD} + L_{DA} = nRT_B \ln\left(\frac{V_C}{V_B}\right) + nRT_A \ln\left(\frac{V_A}{V_D}\right)$$

ISOTERMA:

$$p_B V_B = p_C V_C \rightarrow \frac{p_B}{p_C} = \frac{V_C}{V_B} = 2$$

$$\frac{V_B}{V_C} = \frac{V_A}{V_D} = \frac{1}{2}$$

$$\frac{V_C}{V_B} = 2 \rightarrow \frac{V_B}{V_C} = \frac{1}{2}$$

$$5000 \text{ J} = nRT_B \ln(2) + nRT_A \ln\left(\frac{1}{2}\right)$$

$$\hookrightarrow T_B = 540 \text{ K}$$

$$Q_{AB} = nC_v \Delta T = 3 \text{ mol} \cdot \frac{5}{2} R \cdot (540 \text{ K} - 250 \text{ K}) = +18.1 \text{ KJ} \rightarrow \underline{\text{ASSORB.}}$$

↓
isocore

$$Q_{BC} = L_{BC} = nRT \ln\left(\frac{V_C}{V_B}\right) = 3 \text{ mol} \cdot R \cdot 540 \text{ K} \cdot \ln(2) = +9.33 \text{ KJ} \rightarrow \underline{\text{ASSORB.}}$$

↓
isoterme

$$Q_{CD} = 3 \text{ mol} \cdot \frac{5}{2} R \cdot (250 - 540) = -18.1 \text{ KJ} \rightarrow \text{CEJUTU}$$

↓
isocore

$$Q_{DA} = 3 \text{ mol} \cdot \frac{5}{2} R \cdot 250 \text{ K} \cdot \ln\left(\frac{1}{2}\right) = -4.32 \text{ KJ} \rightarrow \text{CEJUTU}$$

↓
isot.

$$M = \frac{L_{\text{iclo}}}{Q_{\text{ASS}}} = \frac{5000 \text{ J}}{Q_{AB} + Q_{BC}} = \frac{5000 \text{ J}}{18100 \text{ J} + 9330 \text{ J}} = 0.18$$