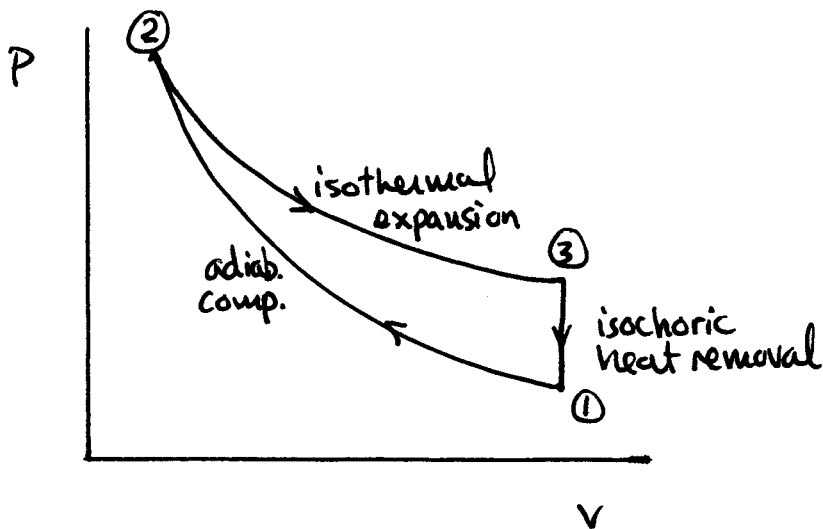


SOLUTIONS TO T5 BY WAITZ



a) LEG ①-②: ADIABATIC COMPRESSION  $Q=0$   $W \neq 0$  (-)

LEG ②-③: ISOTHERMAL EXPANSION

$$\Delta U = Q - W \quad \text{SO } Q = W \quad W \Rightarrow (+)$$

$$\therefore Q \Rightarrow (+)$$

LEG ③-①: CONSTANT VOLUME  
HEAT EXTRACTION

$$W=0, \quad Q \Rightarrow (-)$$

b) LEG ①-②

$$\Delta u = Q - W \quad C_v \Delta T = \Delta u = -W$$

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = (8)^{0.4} = 2.3$$

$$T_1 = 300\text{K} \quad \text{so } T_2 = 690\text{K}$$

$$\left[ \begin{array}{l} \Delta u = 716.5(690-300) = 280 \text{ kJ/kg} \\ W = -280 \text{ kJ/kg} \\ Q = 0 \\ \Delta h = C_p \Delta T = 391 \text{ kJ/kg} \end{array} \right.$$

LEG ②-③ ISOTHERMAL  $\Delta u = q - w$

$$q = w$$

$$w = RT \ln\left(\frac{v_2}{v_1}\right) = 287(690) \ln(8)$$

$$\left[ \begin{array}{l} w = 412 \text{ kJ/kg} \\ \Delta u = 0 \\ \Delta h = 0 \\ q = 412 \text{ kJ/kg} \end{array} \right.$$

LEG ③-① CONST. VOLUME

$$\left[ \begin{array}{l} w = 0 \quad \Delta u = q \quad C_v \Delta T = q \\ q = 716.5(300 - 690) = - \text{ kJ/kg} \\ \Delta h = C_p \Delta T = 1003.5(300 - 690) = -391 \text{ kJ/kg} \end{array} \right.$$

c) NET WORK

$$W_{\text{cycle}} = W_{1-2} + W_{2-3} + W_{3-1}$$

$$= -280 + 412 + 0 = 132 \text{ kJ/kg}$$

✓ [ NOTE FOR CYCLE,  $W_{\text{cycle}} = q_{\text{cycle}} = q_{1-2} + q_{2-3} + q_{3-1}$  ]

$$\begin{aligned} &= 0 + 412 - 280 \\ &= 132 \text{ kJ/kg} \end{aligned}$$

d) THERMAL EFFICIENCY =  $\frac{\text{WHAT YOU GET}}{\text{WHAT YOU PAY FOR}} = \frac{\text{NET WORK}}{\text{HEAT IN}}$

$$\eta_{\text{TH}} = \frac{132 \text{ kJ/kg}}{412 \text{ kJ/kg}} = 32\%$$