HW 1.4

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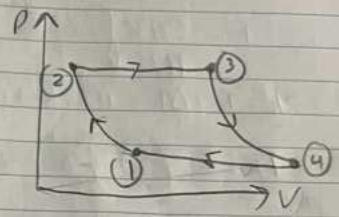
9-88) $P_1 = 70 kPa$ $r_p = 10$

$T_1 = 273 K$ $C_p = 1.005 kJ/kg \cdot K$

$m = 1 kg$ $K = 1.4$

$Q_s = 500 kW$



$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$$

$$= (r_p)^{\frac{k-1}{k}}$$

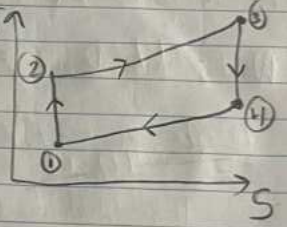
$$= (273°K)(10)^{0.4/1.4}$$

$$= 527.08 K$$

$$Q_s = (m)(C_p)(T_3 - T_2)$$

$$500 = 1(1.005)(T_3 - 527.08)$$

$$T_3 = 1,024.59 K$$



$$\frac{T_3}{T_4} = \left(\frac{P_3}{P_4}\right)^{\frac{k-1}{k}}$$

$$T_4 = (10)^{\frac{0.4}{1.4}}$$

$$= 530.66 K$$

$$P = (m)(C_p)\left[(T_3 - T_4) - (T_2 - T_1)\right]$$

$$= 1.005\left([1,024.59 - 530.68) - (527.01 - 273K)\right.$$

$$= \boxed{241.02 kW}$$

$$\eta = \frac{P}{Q_s}$$

$$= \frac{241.029}{500}$$

$$= \boxed{48.20\%}$$

9-99) $P_1 = 100 kPa$
$T_1 = 308°C = 581 K$
$k = 1.4$

$T_3 = 800°C = 1073 K$
$W_{net} = 115 kW$

$$T_2 = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$$

$$T_2 = 581K \left(10\right)^{\frac{0.4}{1.4}}$$
$$= 1123 K$$

$T_6 = T_2 + \Delta T = 1123K + 10.8K = 1133K$

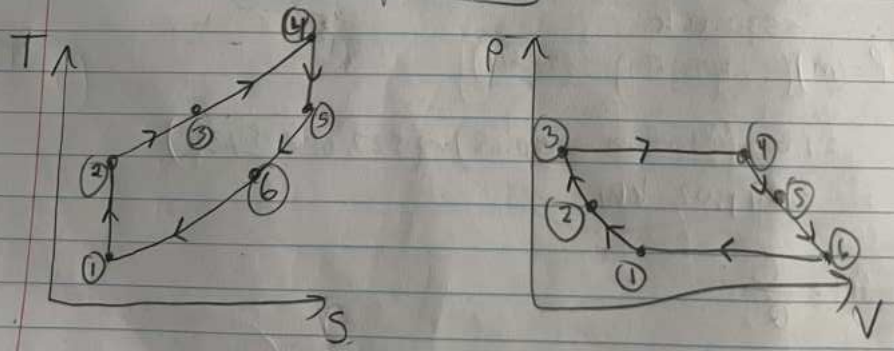
$$T_4 = T_3 \left(\frac{P_1}{P_2}\right)^{\frac{k-1}{k}} = 1073(10)^{-0.286} = 550.7K$$

$T_5 = T_4 - \Delta T = 550.7K - 10.8K = 539.9K$

$W_{net} = Q_{in} - Q_{out} = 115 kW$

$258 kW - 143 kW = \boxed{115 kW}$ → Heat rejection

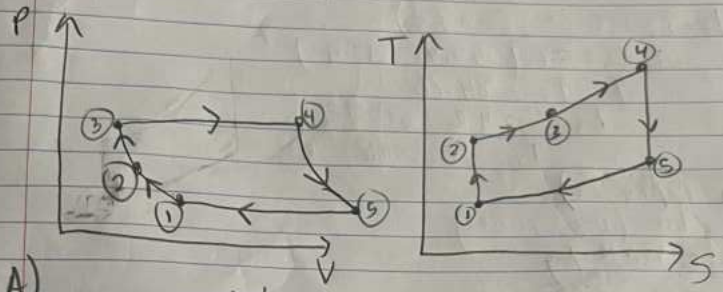
Heat Addition = $\boxed{258 kW}$



9-107) $T_1 = 310\,K$ $r_p = 7$

$T_3 = 1,150\,K$

$k = 1.4$



A)

$T_2 = T_1 (r_p)^{\frac{k-1}{k}}$

$= 310 (7)^{\frac{0.4}{1.4}}$

$= 310 (1.745)$

$= 540.95\,K$

$\eta_c = \frac{T_2 - T_1}{T_2 - 1}$

$0.75 = \frac{540.95 - 310}{T_2 - 310}$

$T_2 - 310 = \frac{230.95}{0.75}$

$T_2 = 617.93\,K$

$T_5 = \frac{T_4}{r_p^{\frac{k-1}{k}}}$

$= \frac{1150}{7^{0.4/1.4}}$ $= \frac{1150}{1.745} = 659.03\,K$

$\eta_t = \frac{T_4 - T_5}{T_4 - T_5}$

$0.82 = \frac{1,150 - T_5}{1150 - 659.03}$

$1150 - T_5 = 0.82(490.97)$

$\boxed{T_5 = 783\,K}$

B)

$$0.65 = \frac{T_3 - T_2}{T_5 - T_2}$$

$T_3 - T_2 = 0.65(T_5 - T_2)$

$T_3 - T_2 = 0.65(747.40 - 617.93)$

$T_3 - T_2 = 84.16$

$T_3 = 84.16 + 617.93$

$T_3 = 702.09K$

$q_{in} = C_p(T_4 - T_3)$

$= 1.005(1150 - 707.09)$

$= 450\ kJ/kg$

$W_T = C_e(T_4 - T_5)$

$= 1.005(1150 - 747.4)$

$= 419.61\ kJ/kg$

$W_c = C_p(T_2 - T_1)$

$= 1.005(617 - 310)$

$= 309.47$

$W_{net} = W_T - W_c$

$= 47.61 - 309.47$

$= \boxed{108\ kJ/kg}$

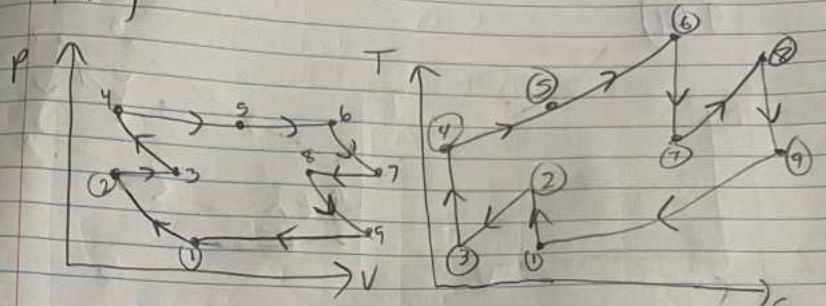
C)

$= \frac{W_{net}}{q_{in}}$

$= \frac{108\ kJ/kg}{450\ kJ/kg}$

$= \boxed{22.5\%}$

9-119)



$T_1 = 300\,k$ $\quad T_{in} = 1200k$

$T_2 = 420k$ $\quad T_{out} = 850k$

$P_{r2} = 4.15$ $\quad h_2 = 411.21$

$P = \frac{1}{3}(238) = 79.33$

$w_{in} = 2(h_2 - h_1)$

$= 2(411.21 - 300.31)$

$w_{3in} = 221.31 \ kJ/kg$

$w_t = 2(h_5 - h_6)$

$= 2(1278 - 946)$

$= 663.158$

$w_{net} = (w_t) - (w_3)$

$= 663.158 - 221$

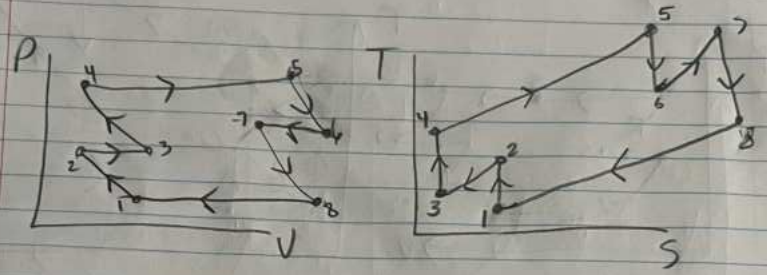
$= 441.33$

$\dot{W} = \dot{m} w_{net}$

$(110)(103) = \dot{m}(441.33)$

$\dot{m} = 249.24 \ kJ/s$

9-121)



$T_1 = 300k$

$h_2 = h_4 = 411.26\ kJ/kg$

$T_5 = T_7 = 1200k$

$= 1277.79\ kJ/kg$

$\frac{P_3}{P_R} = \frac{238}{3} = 79.33$

$\eta = \frac{h_2 - h_1}{h_2 - h_1}$

$h_2 = \frac{411.26 - 300}{0.86} + 300.19 = 429.34\ kJ/kg$

$h_2 = h_4 = 429.34\ kJ/kg$

$\eta_{turbine} = 90\% = 0.90$

$h_6 = 1277.79 - 0.9(1277 - 946) = 979.5\ kJ/kg$

$h_6 = h_8 = 979.5\ kJ/kg$

$\frac{W_C}{W_T} \frac{258.3}{596.59} = 0.43 = 43\%$

heat addition: $(h_5 - h_4) + (h_7 - h_6)$

$= (1277.7 - 429.34) + (1272.7 - 979.5)$

$= 1146.74 \text{ kJ/kg}$

thermal $= \frac{W_T - W_C}{Q_{in}} = \frac{596.58 - 258.3}{1146.74}$

$= 0.295 = 29.5\%$

$Q_{in} = 1146.74 - 0.78\,(979.4 - 429)$

$= 717.69 \text{ kJ/kg}$

thermal $\frac{W_T - W_C}{Q_{in}} = \frac{596.58 - 258.3}{717.69}$

$= 0.4713 = 47.13\%$