Charlie Nitschelm

Thermo HW 5

3. a) $\eta_{\text{Heat Engine}} = \frac{W}{Q_H} = 1 - \frac{T_L}{T_H} = 1 - \frac{27+273}{177+273} = .33 = 33\%$

b) $\beta = \frac{Q_L}{W} = \frac{Q_L}{Q_H - Q_L} = \frac{1}{\frac{T_H}{T_L} - 1} = \frac{1}{\frac{20+273}{-10+273} - 1} = 8.76$

c) $\beta = \frac{Q_H}{W} = \frac{Q_H}{Q_H - Q_L} = \frac{1}{1 - \frac{T_L}{T_H}} = \frac{1}{1 - \frac{273}{293}} = 14.65$

4. a) $\eta = \frac{W}{Q_H} = \frac{1mw}{5mw} = .2 = 20\%$

b) $\eta = \frac{W}{Q_H} = \frac{W}{W+Q_L} = \frac{1mw}{1mw + 3mw} = .25 = 25\%$

c) $\eta = \frac{W}{Q_H} = \frac{Q_H - Q_L}{Q_H} = \frac{6mw - 4mw}{6mw} = .33 = 33\%$

d) $\beta = \frac{Q_L}{W} = \frac{4\,kW}{1\,kW} = 4$

e) $\beta = \frac{Q_L}{W} = \frac{Q_H - W}{W} = \frac{6kw - 1kw}{1kw} = 5$

f) $\beta = \frac{Q_L}{W} = \frac{Q_L}{Q_H - Q_L} = \frac{4.5}{6 - 4.5} = 3$

g) $\beta_1 = \frac{Q_H}{W} = \frac{W + Q_L}{W} = \frac{1 + 4.5}{1} = 5.5$

h) $\beta_1 = \frac{Q_H}{W} = \frac{4.5}{\underline{\quad}} = 3$

i) $\beta_1 = \frac{Q_H}{W} = \frac{Q_H}{\underline{\quad}} = \frac{8}{\underline{\quad}} = 4$

$$C_v = \frac{dU}{dT}$$

5) $T\,ds = P\,dV + dU$

$$ds = \frac{P}{T}dV + \frac{dU}{T} \qquad P_v = RT \rightarrow \frac{P}{T} = \frac{R}{V}$$

$$ds = R\frac{dV}{V} + C_v\frac{dT}{T}$$

$$\int_{S_1}^{S_2} ds = R\int_{V_1}^{V_2}\frac{dV}{V} + C_v\int_{T_1}^{T_2}\frac{dT}{T}$$

$$\boxed{S_2 - S_1 = R\ln\frac{V_2}{V_1} + C_v\ln\frac{T_2}{T_1}}$$

6) $dU = \delta Q + \delta W$

$\delta Q \rightarrow 0$ $\qquad$ $\delta W \rightarrow -p\,dV$

and $H = U + pV \rightarrow dH = dU + p\,dV + V\,dp$

so, $dU = -P\,dV$ and $dH = -p\,dV + p\,dV + V\,dp = V\,dP$

Always, $dU = nC_v\,dT$ and $dH = nC_p\,dT$

$$dU = nC_v\,dT = -P\,dV \quad \text{and} \quad dH = nC_p\,dT = V\,dP$$

$$C_p = \frac{V\,dP}{n\,dT} \quad \text{and} \quad C_v = \frac{-P\,dV}{n\,dT}$$

constant

$$\gamma = \frac{C_p}{C_v} = \frac{dP|_P}{dV|_V} \rightarrow \gamma\int\frac{dV}{V} = -\int\frac{dP}{P} \rightarrow \gamma\ln V = -\ln P \longrightarrow$$

$\ln V^{\gamma} = \ln\frac{1}{P}$

$$\longrightarrow \text{so } PV^{\gamma} = \text{constant}$$

7) a) $C_{v\,air} = .718 \frac{kJ}{kg \cdot k}$

$s_2 - s_1 = C_v \ln \frac{T_2}{T_1} + R \ln \frac{v_2}{v_1}$

$s_2 - s_1 = .718 \cdot \ln \frac{350}{300} = \boxed{.11068 \frac{kJ}{kg \cdot K}}$

b) $s_2 - s_1 = .718 \ln \frac{T_2}{T_1} = .718 \ln \frac{1350}{130.} = .02706 \frac{kJ}{kg \cdot k}$