Thermo HW 10

$\eta = \frac{w_s'}{\Delta H_{rxn}}$

ethanol + O_2 = $H_2O + CO_2$

$C_2H_5OH + 2O_2 = 3H_2O + 2CO_2$

$C_2H_5OH + 3O_2 \rightarrow 3H_2O + 2CO_2$

$\Delta H_{rxn} = \sum (H_{product} - H_{reactant}) = 3H_{H_2O} + 2H_{CO_2} - H_{eth} - 3H_{O_2}$

$\Delta H_{rxn} = 3(-285830) + 2(-393520) - (-277690) - 3(0)$

$= -1366840$

$w_s' = G_2 - G_1 = \Delta G_{rxn} = 3(-237180) + 2(-394360) - (-174890) - 0$

$= -1325370$

$\therefore \eta_{ethanol} = \frac{\Delta G}{\Delta H} = \frac{-1325370}{-1366840} = 0.97$

$H_2 + \frac{1}{2}O_2 \rightarrow H_2O$

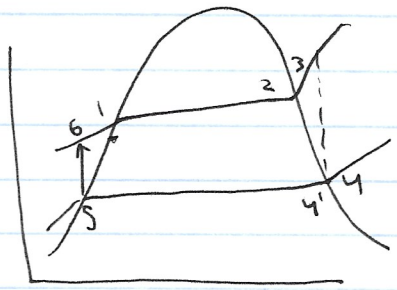
$\Delta H_{rxn} = -285830 - 0 - 0 = -285830$

$\Delta G_{rxn} = -237180 - 0 - 0 = -237180$

$\eta_{H_2} = \frac{-237180}{-285830} = 0.83$

$\eta_{ethanol} = 0.97 > \eta_{H_2} = 0.83$

2.) $W_{s,net} = 500\,MW$ $\quad T_1 = 650^\circ C$ (3) $\quad P_1 = 9\,MPa$ (3,6) $\quad$ Condenser @ $0.03\,MPa$ (4,5)



$-W_{s,TE} = H_3 - H_4$

$W_{s,Pump} = H_6 - H_5$

$\eta_\theta = \frac{-W_{s,net}}{Q_H} = 1 - \frac{H_4 - H_5}{H_3 - H_6}$

$\dot{m} = ?$

a.) $H_3 = 3755.2$

$S_3 = S_4 = 7.0954$ $\quad \therefore$ Sat mix

$q = \frac{S - S^L}{S^V - S^L} = \frac{7.0954 - 0.9441}{7.7675 - 0.9441} = 0.902$

$H_4' = (1-q)H^L + qH^V$

$= (1 - 0.902)(289.27) + 2624.6 \cdot 0.902 = 2394.6 \frac{kJ}{kg}$

$-W_{s,TE} = 3755.2 - 2394.6 = \boxed{1361 \frac{kJ}{kg}}$

b.) $H_6 = V(P_6 - P_5) + H_5 = 0.001022 \frac{m^3}{kg}(9 - 0.03)MPa + 289.27 \frac{kJ}{kg}$

$= 298.4 \frac{kJ}{kg}$

$W_{s,Pump} = H_6 - H_5 = 298.4 - 289.27 = \boxed{9.17 \frac{kJ}{kg}}$

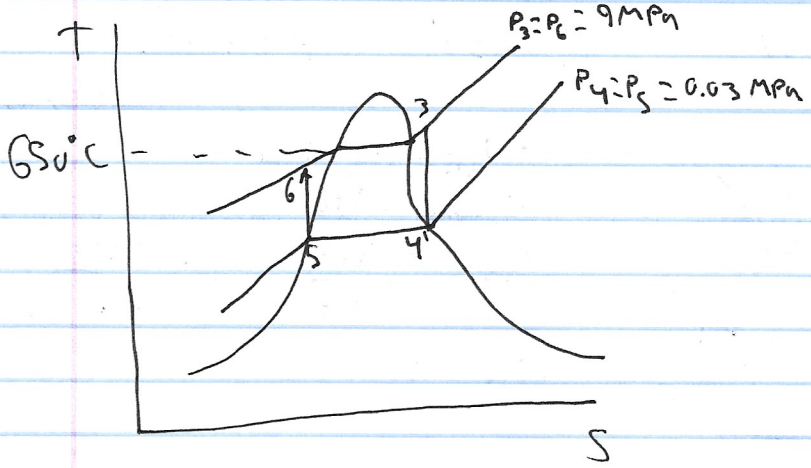
c.) $\eta_\theta = 1 - \frac{H_4' - H_5}{H_3 - H_6} = 1 - \frac{2394.6 - 289.27}{3755.2 - 298.4} = \boxed{0.39}$

d.) $\eta_\theta = \frac{W_{s,net}}{Q_H} \rightarrow Q_H = \frac{W_{s,net}}{\eta_\theta} = \frac{500\,MW}{0.39} = 1282051 \frac{kJ}{s}$

$\eta_\theta = 1 - \frac{Q_C}{Q_H} \rightarrow Q_C = Q_H(1 - \eta_\theta) = 1282051(1 - 0.39)$

$= \boxed{780810\,kW}$

d.) $Q_C = \dot{m}(H_4' - H_5) \rightarrow \dot{m} = \frac{Q_C}{H_4' - H_5} = \frac{780810}{(2394.6 - 289.27)} = \boxed{371 \frac{kg}{s}}$


T
650°C
$P_3 = P_6 = 9 MPa$
$P_4 = P_5 = 0.03 MPa$
3
6
5
4'
S

$\frac{kJ}{sec} \cdot 4.2 \frac{kJ}{kg \cdot K} \cdot K$

3.) $Q = \dot{m}\Delta H \quad \therefore \dot{m} = \frac{Q}{\underbrace{H_2 - H_1}_{\Delta H^{vap}}}$

$\therefore \dot{m} = \frac{Q_c}{\Delta H_{vap}} = \frac{1500 MW}{2441.7 \frac{kJ}{kg}} = 614.3 \frac{kg}{sec}$

4.) $\Delta T = 0.2°C \qquad \dot{V} = 5 m^3/s$

$Q = \dot{m}\Delta H$ — no phase change

$-C_p \Delta T$

$\therefore Q = \dot{m} C_p \Delta T \Rightarrow \Delta T = \frac{Q_c}{\dot{m} C_p} = \frac{1500 kW}{5 m^3/s \cdot 4.2 \frac{kJ}{kg \cdot K}}$

$Q_c = \dot{m} \cdot \Delta H = \dot{m} C_p \Delta T$

$Q_c = 5 \frac{kJ}{s} \cdot 1000 \frac{kg}{m^3} \cdot 4.18 \frac{kJ}{kg \cdot K} \cdot 0.2 K = 4180 \frac{kJ}{s}$

$= 4.2 MW$