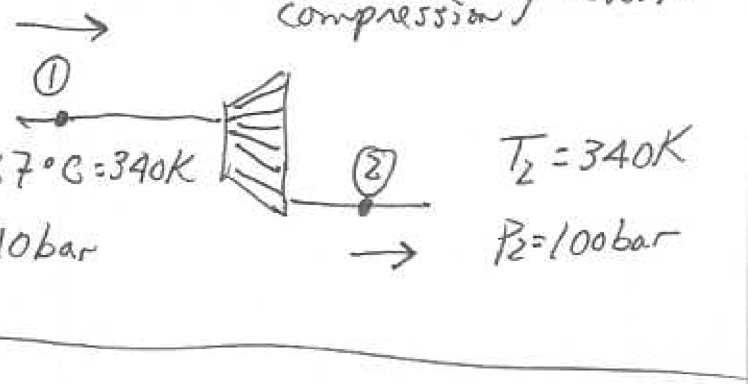
11.84 Ethylene. ΔKE = ΔPE = 0
S.S.

isothermal compression; reversible



$\frac{\dot W}{\dot m} = ?$ $\frac{\dot Q}{\dot m} = ?$

Entropy Balance

$$\cancel{\frac{dS}{dt}} = \sum_j \frac{\dot Q_j}{T_j} + \sum_i \dot m_i s_i - \sum_e \dot m_e s_e + \cancel{\dot\sigma_{c.v.}}$$

S.S.   reversible

$$\hookrightarrow \frac{\dot Q}{\dot m} = T(s_2 - s_1)$$

C.O.E.

$$\cancel{\frac{dE}{dt}} = \dot Q - \dot W + \sum_i \dot m_i \left(h_i + \cancel{\frac{V_i^2}{2}} + \cancel{gz_i}\right) - \sum_e \dot m_e \left(h_e + \cancel{\frac{V_e^2}{2}} + \cancel{gz_e}\right)$$

$$\frac{\dot W}{\dot m} = \frac{\dot Q}{\dot m} + (h_1 - h_2)$$

So what we need is Δs and Δh

$$\bar s_2 - \bar s_1 = \underbrace{(\bar s_2^* - \bar s_1^*)} - \bar R\left[\left(\frac{\bar s^* - \bar s}{\bar R}\right)_2 - \left(\frac{\bar s^* - \bar s}{\bar R}\right)_1\right]$$

$$= \boxed{s^\circ(T_2) - s^\circ(T_1) - R\ln\left(\frac{P_2}{P_1}\right)}$$

Ethylene   MW = 28.05 kg/kmol $T_c = 283K$ $P_c = 51.2$ bar

$\boxed{T_R = 1.20}$ $\boxed{P_{R1} = 0.195}$ $\boxed{P_{R2} = 1.95}$

From Fig A-5 $\left(\frac{\bar s^* - \bar s}{\bar R}\right)_1 = 0.1$ $\left(\frac{\bar s^* - \bar s}{\bar R}\right)_2 = 1.25$

11.84 (continued)

$$\bar{s}_2 - \bar{s}_1 = \underbrace{\cancel{\bar{s}^\circ(T_2) - \bar{s}^\circ(T_1)}}_{0} - \bar{R}\ln\left(\frac{P_2}{P_1}\right) - \bar{R}\left[\left(\frac{\bar{s}^*-\bar{s}}{\bar{R}}\right)_2 - \left(\frac{\bar{s}^*-\bar{s}}{\bar{R}}\right)_1\right]$$

$$\bar{s}_2 - \bar{s}_1 = -\left(8.314\,\frac{kJ}{kmole\cdot K}\right)\ln\left(\frac{100\,bar}{10\,bar}\right) - \left(8.314\,\frac{kJ}{kmole\cdot K}\right)\left[1.25 - 0.1\right]$$

$$\bar{s}_2 - \bar{s}_1 = -28.70\,\frac{kJ}{kmole\cdot K}$$

$$s_2 - s_1 = -1.02\,\frac{kJ}{kg\cdot K}$$

$$\therefore\ \frac{\dot{Q}}{\dot{m}} = (340K)\left(-1.02\,\frac{kJ}{kg\cdot K}\right)$$

$$\boxed{\frac{\dot{Q}}{\dot{m}} = -348\ kJ/kg}$$

$$\bar{h}_2 - \bar{h}_1 = \underbrace{\cancel{\bar{h}_2^* - \bar{h}_1^*}}_{\text{0 for an ideal gas when } \Delta T = 0} - \bar{R}T_c\left[\left(\frac{\bar{h}^*-\bar{h}}{\bar{R}T_c}\right)_2 - \left(\frac{\bar{h}^*-\bar{h}}{\bar{R}T_c}\right)_1\right]$$

From Fig. A-4

$$\left(\frac{\bar{h}^*-\bar{h}}{\bar{R}T_c}\right)_1 = 0.1 \qquad \left(\frac{\bar{h}^*-\bar{h}}{\bar{R}T_c}\right)_2 = 1.9$$

$$\bar{h}_2 - \bar{h}_1 = \left(-8.314\,\frac{kJ}{kmole\cdot K}\right)(283K)\left[1.9 - 0.1\right] = -4235.2\,\frac{kJ}{kmole}$$

$$h_2 - h_1 = -151\ kJ/kg \Rightarrow h_1 - h_2 = 151\ kJ/kg$$

$$\therefore\ \boxed{\frac{\dot{W}}{\dot{m}} = -197\ kJ/kg}$$