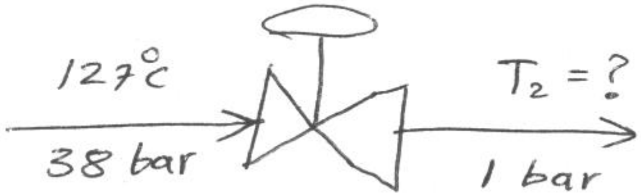
Example

Propylene gas



Find T_2 and ΔS for this process

For a throttling valve $\Delta H = 0$

$$\Rightarrow \left(H_2^{ig} + H_2^{R}\right) - \left(H_1^{ig} + H_1^{R}\right) = 0$$

at state 2 $P = 1$ bar $\Rightarrow$ propylene gas may be assumed ideal gas $\Rightarrow H_2^R = 0$

$$\Rightarrow \left(H_2^{ig} - H_1^{ig}\right) - H_1^R = 0$$

$$\int_{T_1}^{T_2} C_p^{ig}\, dT - H_1^R = 0$$

For propylene:

$\omega = 0.14$ $\quad T_c = 365.6\ K$ $\quad P_c = 46.65$ bar

$$C_p^{ig} = R\left(1.637 + 22.706 * 10^{-3}\, T - 6.915 * 10^{-6}\, T^2\right)$$

$Tr_1 = 1.095$ $\quad Pr_1 = 0.815$

using Lee/Kesler generalized correlations at T_{r_1} & P_{r_1}

$$\left(\frac{H^R}{RT_c}\right)^0 = -0.863$$

$$\left(\frac{H^R}{RT_c}\right)^1 = -0.534$$

} by interpolation (verify yourself)

$$\left(\frac{S^R}{R}\right)^0 = -0.565$$

$$\left(\frac{S^R}{R}\right)^1 = -0.496$$

} //

$$H_1^R = (H^R)^0 + \omega (H^R)^1 = -2.85 * 10^3 \ \frac{J}{mol}$$

$$S_1^R = (S^R)^0 + \omega (S^R)^1 = -5.275 \ \frac{J}{mol \cdot K}$$

$$\Rightarrow \int_{127+273.15}^{T_2} R(1.637 + 22.706 * 10^{-3} T - 6.915 * 10^{-6} T^2)\, dT$$

$$- (-2.85 * 10^3) = 0$$

$$R\left[1.637(T_2 - 400.15) + 22.706 * 10^{-3}\left(\frac{T_2^2}{2} - \frac{(400.15)^2}{2}\right) - 6.915 * 10^{-6}\left(\frac{T_2^3}{3} - \frac{(400.15)^3}{3}\right)\right] + 2.85 * 10^{+3} = 0$$

by trail and error $T_2 \simeq 363.3\ K$ ③

$$\Delta S = (S_2^{ig} + S_2^R) - (S_1^{ig} + S_1^R)$$

($S_2^R \rightarrow 0$, i.g.)

$$= \Delta S^{ig} - S_1^R$$

$$= \int_{T_1}^{T_2} \frac{C_p^{ig}}{T}\, dT - (-5.275)$$

- R ln(P2/P1)

$$= 22.774 + 5.275 = 28.048\ \frac{J}{mol \cdot K}$$

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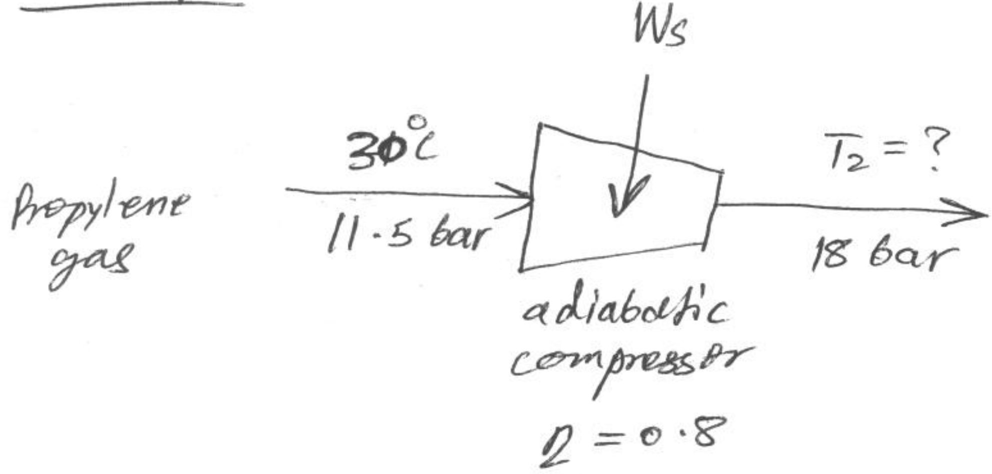

Find T_2 & W_s

step #1

assume isentropic compressor $\Rightarrow \Delta S = 0$.

$$\int_{T_1}^{T_2'} \frac{C_p^{ig}}{T}\, dT + \left(S_2^R - S_1^R\right) - R\ln(P2/P1) = 0$$

$$R\left[1.637 \ln\left(\frac{T_2'}{303.15}\right) + 22.706\times10^{-3}\left(T_2' - 303.15\right) - 6.915\times10^{-6}\left((T_2')^2 - (303.15)^2\right)\right] + \left[S_2^R - (R\ -0.337)\right] = 0$$

$f(T_2') = 0$ (Note: S_2^R is unknown since T_2' is unknown)

guess T_2' find S_2^R and check $f(T_2') \overset{?}{=} 0$

by trail and error $T_2' = 324.12\ K$

$$\Rightarrow \Delta H' = \underbrace{\Delta H^{ig} + \left(H_2^R - H_1^R\right)}_{\text{evaluated at } T_1 \,\&\, T_2'} = 963\ \frac{J}{mol}$$

step 2

$$\Delta H = \frac{\Delta H'}{2} = 1203.8 \ \frac{J}{mol}$$

$$\Rightarrow 1203.8 = \int_{T_1}^{T_2} C_p^{ig}\, dT + \left(H_2^R - H_1^R\right)$$

$$R\Big[1.637\left(T_2 - 303.15\right) + 22.706*10^{-3}\left(T_2^2 - 303.15^2\right) - 6.915*10^{-6}\left(T_2^3 - 303.15^3\right)\Big] + \Big[H_2^R - \left(RT_c - 0.407\right)\Big]$$

$$- 1203.8 = 0$$

$F(T_2) = 0$ (note: H_2^R is unknown since T_2 is unknown)

Find T_2 by trail and error

$$\Rightarrow T_2 \cong 327 \ K$$

$$W_s = \Delta H = 1203.8 \ \frac{J}{mol}$$