ChE-304 Problem Set 6

Week 7

Problem 1

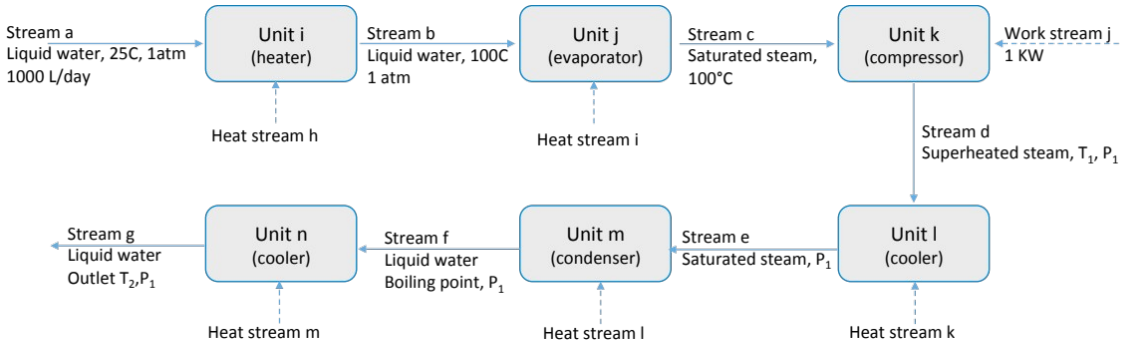
The Margules model represents the excess Gibbs energy for a binary mixture as a simple function of the mole fraction of each component multiplied by an empirical parameter:

$$\overline{G}_E / RT = A\, x_1 x_2$$

From this model, could you derive a formula that describes the activity coefficient of substance 1 (i.e. γ_1) in a mixture with just two components (1 and 2)?

Problem 2

Last week, we came up with the following flowsheet and specifications for the slingshot process:



Assume that we specify T_2. We can also assume that the pump is a reversible adiabatic compression. Do we have enough information to fully characterize this system?

Recall that the total number of required specifications for independent streams is:

$$N_{specifications} = N_{streams,Q} + N_{streams,W_{el}} + 2\,N_{streams,W_{mech}} + N_{streams,material}\left(2 + N_c\right)$$

Problem 3

Last week, we started analyzing the Slingshot process by drawing a flowsheet and by calculating the temperature and pressure of the fluid after compression.

At this temperature and pressure, is the fluid in its liquid or vapor phase? Once you have determined the phase, you can calculate the enthalpy and entropy of the fluid at this temperature.

Coefficients needed for the Antoine equation and the Cp equation of water and the standard enthalpy and entropy are shown below (from the NIST webbook).

Antoine's equation:

$$C_P(T) = A_\alpha + B_\alpha T + C_\alpha T^2 + D_\alpha T^3 + \frac{E_\alpha}{T^2}, \text{ where } T = \frac{temperature \in K}{1000}$$

Antoine's parameters, valid 370-573K:
A = 3.55959 B = 643.748 C = -198.043

Cp equation coefficients, vapor phase:
A = 30.092 B = 6.832514 C = 6.793435 D = -2.53448 E = 0.082139

Standard enthalpy and entropy, vapor phase:
Standard enthalpy, kJ/mol = -241.83 Standard entropy, J/molK = 188.84

Cp equation coefficients, liquid phase:
A = -203.6060 B = 1523.290 C = -3196.413 D = 2474.455 E = 3.855326

Standard entropy, liquid phase, J/molK = 69.95
Enthalpy of vaporization, water at 100C, kJ/mol = 40.6
Critical temperature, pressure of water: 647.3K, 221.2 bar