1. One stream containing a mixture of 20 mol% $A$ and 80 mol% $B$ is fed at a rate of 100 mol/s and is mixed with another stream containing a mixture of 30 mol% $A$ and 70 mol% $C$ that is fed at a rate of 100 mol/s. Both streams are fed at the same temperature $T = 300 \, K$, and heat is removed or added at a rate $\dot{Q}$ (in kW) to maintain an isothermal process and one outlet stream at $T = 300 \, K$ at steady state. The enthalpy for the ternary mixture at $T = 300 \, K$ is given by the following empirical relationship:

$$h\left(\text{in} \frac{J}{mol}\right) = 100 \, x_A + 150 \, x_B + 300 \, x_C + 25 \, x_A x_B + 15 \, x_A x_C + 10 \, x_B x_C + 10 \, x_A x_B x_C$$

a) (20 pts) Determine the rate of heat removal or addition (in kW) to maintain an isothermal process and $\Delta h_{mix}$ (in $kJ/mol$) of the outlet stream.

b) (30 pts) Evaluate the partial molar enthalpy of $B$, $\bar{H}_B$ (in $kJ/mol$), in the outlet stream.

2. A binary liquid mixture containing 10 mol% $A$ and 90 mol% $B$ is in equilibrium with a vapor phase composed of $A$ and $B$ at $T = 400K$. Assume that the liquid satisfies the Wilson equation, i.e. the activity coefficients are given by

$$\ln(y_A) = -[\ln(x_A + \Lambda_{AB} x_B) - x_B W_{AB}]$$

$$\ln(y_B) = -[\ln(x_B + \Lambda_{BA} x_A) + x_A W_{AB}]$$

where

$$W_{AB} = \left(\frac{\Lambda_{AB}}{x_A + \Lambda_{AB} x_B} - \frac{\Lambda_{BA}}{x_B + \Lambda_{BA} x_A}\right)$$

At $T = 400K$, the saturation pressures of pure $A$ and $B$ are $P_A^{sat} = 2 \, \text{bar}$ and $P_B^{sat} = 6 \, \text{bar}$, respectively, while the Wilson parameters were found to be $\Lambda_{AB} = 0.75$ and $\Lambda_{BA} = 0.20$. Assume that the vapor phase behaves as an ideal gas (i.e. all fugacity coefficients can be assumed to be 1) and neglect Poynting factors (assumed to be 1 also).

a) (30 pts) Evaluate the system pressure and the composition of the vapor.

b) (20 pts) Determine the molar excess Gibbs energy of the liquid phase, i.e. find $g^E$ (in $J/mol$).