EXAM II
Open Books and Notes

For all calculations, you may assume φ's are 1.

1. 50 points

The following equations have been reported for the activity coefficients of species 1 and 2 in a binary liquid mixture at constant T (neglect any pressure effects):

$$\ln\gamma_1 = x_2^2(0.273 + 0.096x_1) \quad \ln\gamma_2 = x_1^2(0.273 - 0.096x_2)$$

a. 10 points

Find an expression for g^E/RT

b. 20 points

From the expression you found for g^E/RT from part a), generate the corresponding equations for $\ln\gamma_1$ and $\ln\gamma_2$.

c. 20 points

Test the thermodynamic consistency of the original equations for $\ln\gamma_1$ and $\ln\gamma_2$ and use this result to comment on what you found in part 1b).

2. 50 points

At atmospheric pressure (1 atm = 101.3 kPa), benzene(1), and isopropanol (2) form an azeotrope of composition 0.667 mole fraction component 1 and 0.333 mole fraction component 2 which boils at 71.5°C. Using the Van Laar equations for correlation of activity coefficients, and assuming the Van Laar parameters are independent of temperature, find the total pressure and composition of the gas phase in equilibrium with a liquid of composition 0.4 mole fraction of component 1 and 0.6 mole fraction of component 2 at 60.0°C.

Data:

vapor pressures in kPa	71.5°C	60.0°C
benzene	77.39	52.36
isopropanol	65.04	38.89

A form of the Van Laar equation for a binary mixture is as follows:

$$\ln(\gamma_1) = \frac{A}{\left(1 + \frac{Ax_1}{Bx_2}\right)^2} \qquad \ln(\gamma_2) = \frac{B}{\left(1 + \frac{Bx_2}{Ax_1}\right)^2}$$

Parameters for this form of the equation can be derived as follows:

$$\mathbf{A} = \ln\gamma_1\left(1 + \frac{\mathbf{x_2}\ln\gamma_2}{\mathbf{x_1}\ln\gamma_1}\right)^2 \qquad \mathbf{B} = \ln\gamma_2\left(1 + \frac{\mathbf{x_1}\ln\gamma_1}{\mathbf{x_2}\ln\gamma_2}\right)^2$$