ChE 312 Chemical Engineering Thermodynamics
Winter 2023 March 6th 2023

Exam #2

Name _____ Student ID _____

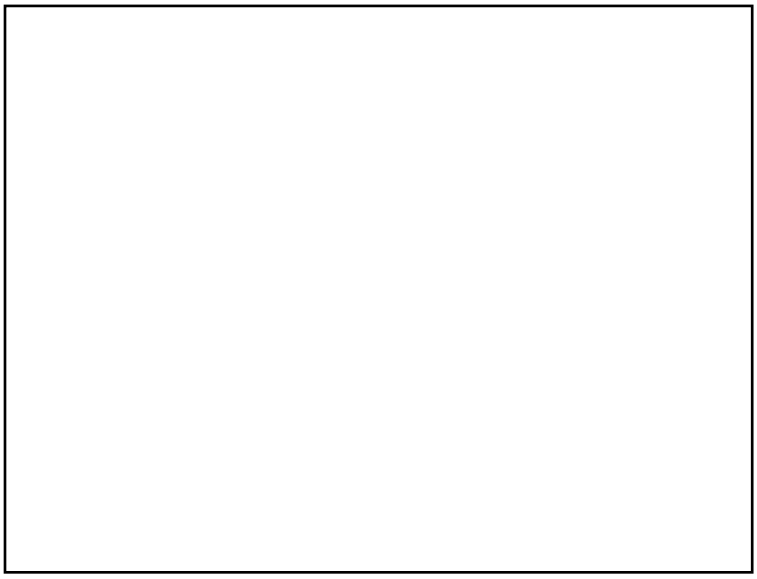
Exam Guidelines:

- Non-graphing calculator and pencil/pens are permitted.
- One 8.5 x 11" sheet of paper with only your own handwriting is allowed (both sides ok).
- No textbook or other resources.
- All other materials, books, and cell phones should be zipped in your backpack.
- Show all your work and provide complete explanations to receive credit.
- Time = 50 minutes

Extra Space for your work below:

1. Liquid-phase fugacity: The activity coefficient of acetone infinitely diluted in butanol is $\gamma_1^{\infty} = 2.2$ at 293 K.
    a. Are the intermolecular interactions between acetone and butanol (unlike interactions) weaker or stronger than the like interactions? Why?

    b. Qualitatively draw a graph of the fugacity of acetone in butanol at 293 K as a function of its mole fraction. Make sure you label the line for the ideal fugacity (Lewis-Randall reference state), the pure acetone fugacity, the Henry's law constant line and the Henry's Law constant value.



x_1

c. Acetone and butanol follow the 2-suffix Margules model. Calculate the A parameter of the model (in J/mol).

d. Some special strains of Clostridium acetobutylicum produce acetone and butanol in a ratio of 30:70. Calculate the pressure of the mixture at 293 K. The saturation pressures of acetone and butanol are P_1^{sat} = 24 kPa and P_2^{sat} = 0.7 kPa, respectively.

e. Calculate the gas phase mole fractions of acetone and butanol.

f. The mixture is heated to 507 K. Assume that gas phases behave ideally and calculate the pressure above the mixture, assuming that the A parameter is independent of temperature. The saturation pressures are P_1^{sat} = 45 bar and P_2^{sat} = 18 bar for acetone and butanol, respectively. You may also ignore the Poynting correction.

g. Check if the assumption that the Poynting correction is negligible is correct by calculating the Poynting correction for both acetone and butanol. The molar volumes are v_1 = 0.074 L/mol and v_2 = 0.091 L/mol, for acetone and butanol. An expression for R in convenient units is R = 0.08314 L bar mol^{-1} K^{-1}.

h. Gas phases are obviously not ideal in this pressure. However, a fully rigorous calculation of the pressure yields an error of only about 7%, most of which is due to the Poynting correction. Why is this?