UNIVERSITY OF GHANA

B.Sc ENGINEERING
FIRST SEMESTER EXAMINATION: 2015/2016
DEPARTMENT OF FOOD PROCESS ENGINEERING
FPEN 303: THERMODYNAMICS II (2 Credits)

Answer FOUR questions: **TIME: TWO (2) HOURS**

Question 1

a) Show that for species in equilibrium in vapour and liquid phases, the chemical potential of is the same in both phases for each species at constant T and P.

(a) A ternary gas mixture contains 20 mol % A, 40 mol % B, and 40 mol % C. At a pressure of 60 atm and a temperature of 75°C, the fugacity coefficient of components A, B and C in this mixture are 0.4, 0.6 and 0.8 respectively. What is the fugacity of the mixture?

Question 2

a) Starting from the Gibbs free energy expression at constant temperature, i.e.

$$dG^{ig} = V^{ig}dP$$

write the defining equation for fugacity and fugacity coefficient. Why are they useful concepts in solution thermodynamics?

b) Assuming that a local carbonated drink 'minerals,' contain only CO_2 (1) and H_2O (2), determine the compositions of the vapour phase in a sealed can of 'minerals' and the pressure exerted on the can at 15°C. Henry's constant for CO_2 in water at 15°C is about 900 bar. Vapour pressure of water at this temperature is 0.0170 bar. Assume CO_2 mole fraction in the liquid phase is 0.01.

Question 3

For the system ethyl ethanoate (1)/n-heptane (2) at 443.15K, assuming the validity of the modified Raoult's law

a) Make a BUBL P calculation for T=443.15K, x_1=0.05
b) Make a DEW P calculation for T=443.15 K, y_1=0.05
c) Determine if the system forms an azeotrope

Given the following data:

$ln\gamma_1 = 0.95x_2^2$; $ln\gamma_2 = 0.95x_1^2$; $P_1^{sat} = 79.80\ kPa$; $P_2^{sat} = 40.50\ kPa$

Question 4

A mixture containing equimolar amounts of benzene (1), toluene (2), and ethylbenzene (3) is flashed to a temperature of 110°C and pressure of 110 kPa. Determine the equilibrium mole fraction $\{y_i\}$ of the vapour phase formed and the molar fraction V of the vapour formed. Assume that Raoult's law applies

$P_1^{sat} = 226.3\ kPa$; $P_2^{sat} = 110.5\ kPa$; $P_3^{sat} = 38.1\ kPa$

Question 5

a) The following reaction for the production of ethanol reaches equilibrium at 400°C and 4 bar:

$$CH_3CHO\ (g) + H_2(g) \Rightarrow C_2H_5OH\ (g)$$

If the system initially contains 2 mol H_2 for each mole of acetaldehyde, what is the composition of the system at equilibrium? (You may leave the answer in the form of a polynomial in ε, the reaction coordinate.)

b) What would be the effect of reducing the pressure to 1 bar.

Assume ideal gases.

Compound	$\Delta H^o_{f,298}$ (J/mol)	$\Delta G^o_{f,298}$(J/mol)
CH_3CHO	-166,190	-128,860
C_2H_5OH	-235,100	-168,490