

UNIVERSITY OF GHANA
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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 CO₂ (1) and H₂O (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 CO₂ in water at 15°C is about 900 bar. Vapour pressure of water at this temperature is 0.0170 bar. Assume CO₂ 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:

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

Question 4

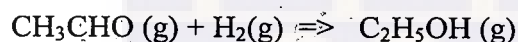
A mixture containing equimolar amounts of benzene (1), toluene (2), and ethylbenzene (3) is flashed to a temperature of 110°C and pressure of 110 kPa. Determine the equilibrium mole fraction $\{y_i\}$ of the vapour phase formed and the molar fraction V of the vapour formed.

Assume that Raoult's law applies

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

Question 5

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



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	$\Delta H_{f,298}^\circ$ (J/mol)	$\Delta G_{f,298}^\circ$ (J/mol)
CH_3CHO	-166,190	-128,860
$\text{C}_2\text{H}_5\text{OH}$	-235,100	-168,490