

B.E./B.TECH. Degree Examination, December 2020
Fifth Semester
CH16502- Chemical Engineering Thermodynamics II
(Regulation 2016)

Time: Three hours

Maximum : 80 Marks

Answer **ALL** questions

PART A - (8 X 2 = 16 marks)

1. Relative volatility means
 - a. is the ratio of pure component partial pressure of volatile component to the pure component vapor mixture of second component
 - b. is the ratio of pure component vapor pressure of volatile component to the pure component vapor mixture of second component
 - c. is the ratio of pure component liquid pressure of volatile component to the pure component vapor mixture of second component
 - d. is the ratio of pure component vapor pressure of volatile component to the real component vapor mixture of second component
2. Partial pressure is a function of vapor pressure is given by
 - a. Henry's law
 - b. Raoult's law
 - c. Lewis Randell law
 - d. Gibbs equation
3. Name ANY one local composition model for activity coefficients.
 - a. Non random Two liquid (NRTL) model
 - b. Redlich Kwong model
 - c. Redlich Kister model
 - d. Vanlaar model
4. Name the applications of Ternary liquid equilibrium
 - a. Ternary liquid equilibrium finds application in three component systems like extraction, leaching
 - b. Ternary liquid equilibrium finds application in two component systems like extraction, Leaching
 - c. Ternary liquid equilibrium finds application in three component systems like distillation
 - d. Ternary liquid equilibrium finds application in one component systems like extraction, leaching
5. Differentiate between molar volume and partial molar volume.
6. Clearly distinguish between ideal and non-ideal solutions.
7. Name local composition models for activity coefficients.

8. Mention the significance of the term “feasibility of a reaction”.

PART B - (4 X16 = 64 marks)

9. (a) (i) The volume of an aqueous solution of NaCl at 298 K was measured for a series of molalities (moles of solute per kg of solvent) and it was found, that the volume varies with molality according to the following expression. **(8)**
- $$V = 2.003 \times 10^{-3} + 0.1662 \times 10^{-4} m + 0.177 \times 10^{-5} m^{1.5} + 0.12 \times 10^{-6} m^2$$
- Where m is the molality and V is in m^3 . Calculate the partial molar volumes of the components at $m = 0.1 \text{ mol / kg}$.
- (ii) Show that when Henry's law is applicable for component 1, Lewis-Randall rule is applicable for component 2. **(8)**

(OR)

- (b) The enthalpy at 300K and 1 bar of a binary liquid mixture is **(16)**
- $$H = 400X_1 + 400 X_2 + X_1X_2 (40X_1 + 20X_2)$$
- where H is in J/mol for the stated temperature and pressure, determine:
- (i) Expressions for H_1 and H_2 in terms of X_1
- (ii) Numerical values for the pure component enthalpies H_1 and H_2
- (iii) Numerical values for the partial molar enthalpies at infinite dilution H_1 and H_2 .
10. (a) Using the criterion of phase equilibrium, show that the change in entropy during phase changes can be calculated from the latent heat of phase change and the absolute temperature as $\Delta S = \Delta H/T$. **(16)**

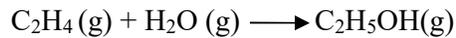
(OR)

- (b) (i) Prove that multiple phases at the same T and P are in equilibrium when chemical potential of each species is the same in all places. **(8)**
- (ii) An equimolar solution of Benzene and Toluene is totally evaporated at 363K temperature, the vapor pressure of benzene and toluene are 135.4 KPa and 54 KPa respectively. What are the pressures at the beginning and the end of the vaporization process? **(8)**
11. (a) The azeotrope of the benzene(1) – ethanol(2) system has a composition of 44.8% (mol) ethanol with a boiling point of 341 K at 101.3 kPa. At this temperature the vapor pressure of benzene is 68.9 KPa and that of ethanol is 67.4 KPa. What are the activity coefficients in a solution containing 10% alcohol? Use Van Laar model. **(16)**

(OR)

- (b) Discuss about the Various Activity Coefficient Composition models and their applications in analyzing the Phase equilibrium for Binary systems under Isothermal and Isobaric conditions. (16)

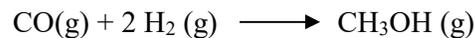
12. (a) Ethanol can be manufactured by the vapor phase hydration of Ethylene according to the reaction. (16)



The feed to a reactor in which the above reaction takes place in a gas mixture containing 25 mole% Ethylene and rest of Steam. Estimate the product composition, if reaction occurs at 125°C and 1atm. The value of ΔG_0 for the above reaction at 125°C is 1082 calories.

(OR)

- (b) Methanol is produced by the following reaction (16)



The standard heat of formation of CO (g) and CH₃OH (g) at 298 K are (-110,500) J/mol and (-200,700) J/mol respectively. The standard free energies of formation are (-137,200) J/mol and 162,000 J/mol respectively.

- i) Calculate the standard free energy change and determine whether the reaction is feasible at 298K.
- ii) Determine the equilibrium constant at 400K assuming that the heat of reaction is constant.
- iii) Derive an expression for standard free energy of reaction as function of temperature if the specific heats of the components are:

$$C_p : 3.376 R + 0.557 * 10^{-3} RT - 0.031 * 10^5 RT^{-2} \text{ for CO}$$

$$C_p : 3.249 R + 0.422 * 10^{-3} RT + 0.083 * 10^5 RT^{-2} \text{ for H}_2$$

$$C_p : 2.211 R + 12.216 * 10^{-3} RT - 3.450 * 10^{-6} RT^2 \text{ for CH}_3\text{OH}$$