

Seat No.: _____

Enrolment No. _____

GUJARAT TECHNOLOGICAL UNIVERSITY
BE - SEMESTER-V • EXAMINATION – SUMMER 2013

Subject Code: 150503

Date: 21-05-2013

Subject Name: Chemical Engineering Thermodynamics – II

Time: 10.30 am - 01.00 pm

Total Marks: 70

Instructions:

1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.

Q ñ 1

(a) State Lewis - Randall rule and Henry's law. Derive the mathematical expression for fugacity and fugacity coefficient. [07]

(b) Explain in brief: ideal solutions and non-ideal solutions. [07]

Q ñ 2

(a) Discuss the various forms of Gibbs-Duhem equations in detail. [07]

(b) Explain effect of temperature, pressure and total stoichiometric coefficient on equilibrium constant. Also discuss relation of equilibrium constants to composition. [07]

OR

(b) Define azeotropes and explain the minimum boiling and maximum boiling azeotropes with suitable examples. [07]

Q ñ 3

(a) Explain the equilibrium conversion in heterogeneous system and multireaction system with at least one example. [07]

(b) Mention different activity coefficient model equations. Explain any one of them in detail. [07]

OR

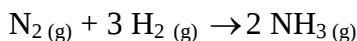
Q ñ 3

(a) Explain the reaction coordinate and its physical significance. Explain the different factors affecting equilibrium conversions. [07]

(b) Derive the expression of vapor composition at equilibrium using flash vaporization [07]

Q ñ 4

(a) Calculate standard Gibbs free energy change and equilibrium constant at 700 K for the reaction:



For given reaction: $\Delta H^0 = -92000 \text{ J/mol}$ and $\Delta G^0 = -33000 \text{ J/mol}$. The standard heat of formation and free energy of NH_3 at 298 K is -46000 J/mol and -16500 J/mol respectively. Specific heat for nitrogen, hydrogen and ammonia is given below and should be in J/mol K.

$$C_{P, \text{N}_2} = 27.27 + 4.93 \times 10^{-3} T, C_{P, \text{H}_2} = 27.01 + 3.51 \times 10^{-3} T \text{ and } C_{P, \text{NH}_3} = 29.75 + 25.11 \times 10^{-3} T \quad [07]$$

(b) The excess Gibbs energy of a particular ternary liquid mixture is represented by the empirical expression with parameters A_{12} , A_{13} , and A_{23} functions of T and P only:

$$\frac{G^E}{RT} = A_{12} x_1 x_2 + A_{13} x_1 x_3 + A_{23} x_2 x_3$$

(i) Determine the implied expressions for $\ln \gamma_1$, $\ln \gamma_2$, $\ln \gamma_3$.

(ii) Determines expressions (or values) for $\ln \gamma_i$ for the limiting cases: $X_1 = 0$, $x_1 = 1$, $x_2 = 0$, and $x_3 = 0$. [07]

OR

Q ñ 4 For the system methanol and methyl acetate, the following equation provide reasonable correlation for activity coefficient.

$$\ln \gamma_1 = A X_2^2$$

$$\ln \gamma_2 = A X_1^2$$

$$A = 2.771 - 0.00523 T$$

$$\ln P_1^{\text{sat}} = 16.591 - \frac{3643.31}{T - 33.424}$$

$$\ln P_2^{\text{sat}} = 14.253 - \frac{2665.54}{T - 53.424}$$

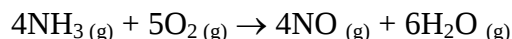
(i) Calculate T and $\{y_i\}$ for $P = 101.33 \text{ kPa}$, $X_1 = 0.85$

(ii) Calculate T and $\{X_i\}$ for $P = 101.33 \text{ kPa}$, $y_1 = 0.40$ [14]

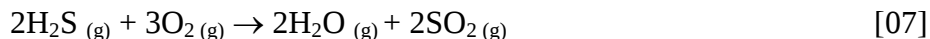
Q ñ 5

(a) Discuss the application of equilibrium criteria to chemical reaction and develop expressions for the mole fractions of reacting species as functions of the reaction coordinate for:

A system initially contains 2-mol NH_3 and 5-mol O_2 undergoing the reaction:



A system initially contains 3-mol H_2S and 5-mol O_2 undergoing the reaction:



(b) In a laboratory 30 mol % of methanol in water solution is to be prepared. How many m³ of pure methanol and pure water are to be mixed to prepare 2 m³ of desired solution?

Partial molar properties of methanol and water are given below.

Methanol: $\bar{V}_1 = 38.632 \text{ cm}^3 / \text{mol}$, Water: $\bar{V}_2 = 17.765 \text{ cm}^3 / \text{mol}$.

For the pure species at 25 °C, methanol: $V_1 = 40.227 \text{ cm}^3 / \text{mol}$ and water: $V_2 = 18.068 \text{ cm}^3 / \text{mol}$. [07]

OR

Q no 5

(a) Using the fundamental properties relation for single phase reaction, show that [07]

$$\Delta G^0 = -RT \ln K$$

(b) The ammonia synthesis reaction written as: $0.5 \text{ N}_{2(g)} + 1.5 \text{ H}_{2(g)} \rightarrow \text{NH}_{3(g)}$ with 0.5 mol nitrogen and 1.5 mol hydrogen as the initial amounts of reactants and with the assumption that the equilibrium mixture is an ideal gas, show that: [07]

$$\varepsilon_e = 1 - (1 + 1.299KP)^{-0.5}$$
