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 ï 1

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

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

Q ï 2

(a) Discuss the various form 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 ï 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 ï 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 ï 4

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

$$N_{2\,(g)} + 3\,H_{2\,(g)} \rightarrow 2\,NH_{3\,(g)}$$

For given reaction: ΔH^0 = - 92000 J / mol and ΔG^0 = - 33000 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.

$C_{P,\,N2}$ = 27.27 + 4.93 x 10^{-3} T, $C_{P,\,H2}$ = 27.01 + 3.51 x 10^{-3} T and $C_{P,\,NH3}$ = 29.75 + 25.11 x 10^{-3} T [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 ɔ$_1$, ln ɔ$_2$, ln ɔ$_3$.

(ii) Determines expressions (or values) for ln ɔ$_1$ for the limiting cases: X_1 = 0, x_l = 1, x_2 = 0, and x_3 = 0. [07]

OR

Q ï 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 ï 0.00523 T

$$\ln P_1^{sat} = 16.591 - \frac{3643.31}{T - 33.424} \qquad \ln P_2^{sat} = 14.253 - \frac{2665.54}{T - 53.424}$$

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

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

Q ï 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:

$$4NH_{3\,(g)} + 5O_{2\,(g)} \rightarrow 4NO_{\,(g)} + 6H_2O_{\,(g)}$$

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

$$2H_2S_{\,(g)} + 3O_{2\,(g)} \rightarrow 2H_2O_{\,(g)} + 2SO_{2\,(g)}$$ [07]

(b) In a laboratory 30 mol % of methanol ï water solution is to be prepared. How many m^3 of pure methanol and pure water are to be mixed to prepare 2 m^3 of desired solution?

Partial molar properties of methanol and water are given below.

Methanol: $\overline{V_1}$ = 38.632 cm^3 / mol, Water: $\overline{V_2}$ = 17.765 cm^3 / mol.

For the pure species at 25 ^{0}C, methanol: V_1 = 40.227 cm^3 / mol and water: V_2 = 18.068 cm^3 / mol. [07]

OR

Q ï 5

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

$$\Delta G^0 = \text{ï}\ RT \ln K$$

(b) The ammonia synthesis reaction written as: $0.5\ N_{2\,(g)} + 1.5\ H_{2\,(g)} \rightarrow NH_{3\,(g)}$ 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]

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

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