Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V (NEW) - EXAMINATION – SUMMER 2017

Subject Code: 2150503 **Date: 01/05/2017**

Subject Name: Chemical Engineering Thermodynamics-II

Time: 02:30 PM to 05:00 PM **Total Marks: 70**

Instructions:

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

MARKS

Q.1 **Short Questions** **14**

1 Define the excess properties.
2 Define an azeotrope.
3 Write modified Raoult's law and explain all terms involved.
4 List out various methods for the evaluation of partial molar properties.
5 In an ideal gas mixture, fugacity of a species is equal to its .....
6 Write down the phase rule.
7 How many parameters are involved in NRTL model?
8 Define chemical potential.
9 Define partial molar properties.
10 Define activity coefficient.
11 What is the gamma-phi formulation of VLE?
12 For the chemical equilibrium $A + 2B \longrightarrow 2C$, the value of the equilibrium constant, K is 10. What is the value of the equilibrium constant for the reaction written in reverse? $2C \longrightarrow A + 2B$
13 Write an expression for the equilibrium constant for the formation of two moles of ammonia gas (NH_3) from nitrogen and hydrogen in their standard states $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$
14 Define the reaction coordinate.

Q.2 **(a)** Write in brief on various methods for evaluating the equilibrium constant. **03**

(b) The following data gives the composition v/s total pressure for the system chloroform(1) / ethyl alcohol(2) at 328 K: **04**

x_1	0.0331	0.9652
P, kPa	40.84	84.88

Vapour pressures of chloroform and ethyl alcohol at 328 K are 82.35 and 37.30 kPa respectively. Estimate the constants in the Margules equation.

(c) Explain the minimum boiling and maximum boiling azeotropes with suitable examples. **07**

OR

(c) Discuss any two group of contribution methods to determine activity coefficient. **07**

Q.3 **(a)** Write a brief note on ideal solutions and non-ideal solutions. **03**

(b) Develop expressions for the mole fractions of reacting species as functions of the reaction coordinate for **04**

i) A system initially containing 2 mol of NH_3 & 5 mol of O_2 and undergoing the reaction

$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$

(ii) A system initially containing 3 mol of H_2S & 5 mol of O_2 and undergoing the reaction

$2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(g) + 2SO_2(g)$

(c) Derive the Gibbs-Duhem equation. 07

OR

Q.3 (a) Discuss Lewis-Randall rule and its significance. 03

(b) Explain any two methods for estimating fugacity of a pure gas. 04

(c) Acetic acid is esterified in the liquid phase with ethanol at 100°C (373.15 K) and atmospheric pressure to produce ethyl acetate and water according to the reaction: 07

$CH_3COOH_{(l)} + C_2H_5OH_{(l)} \rightarrow CH_3COOC_2H_{5(l)} + H_2O_{(l)}$

If initially there is one mole of each acetic acid and ethanol, estimate the mole fraction of ethyl acetate in the reacting mixture at equilibrium. The value of ΔH°_{298} and ΔG°_{298} for the above reactions are – 3640 J and – 4650 J respectively. Assume that the heat of reaction is independent of temperature and the liquid mixture behaves as ideal solution.

Q.4 (a) Write in brief a note on feasibility of chemical reactions. 03

(b) A gas obeys the equation P (V – b) = RT. For this gas b = 0.0391 dm^3/mol. Calculate the fugacity and fugacity coefficient of the gas at 1000 °C and 1000 atm. 04

(c) The ammonia synthesis reaction written as: 07

$0.5\ N_{2(g)} + 1.5\ H_{2(g)} \rightarrow NH_{3(g)}$ 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:

$$\acute{\varepsilon}_e = 1 - (1 + 1.299\ KP)^{-0.5}$$

OR

Q.4 (a) Discuss the criteria for equilibrium and stability. 03

(b) Show that for a binary system, Henry's law is valid for component '1' then Lewis Randall rule is valid for component '2'. 04

(c) Explain PT diagram and write a brief note on retrograde condensation with its application. 07

Q.5 (a) Discuss the effect of temperature and pressure on chemical potential. 03

(b) Discuss about liquid – liquid equilibrium (LLE). 04

(c) Assuming the validity of Raoult's law, do the following calculations for the system of acetone (1), acetonitrile (2) and nitromethane (3). 07

i) Given $x_1 = 0.30$ and $x_2 = 0.40$, T = 75°C, find y_1 and P.

ii) Given $y_1 = 0.45$ and $y_2 = 0.35$, T = 80°C, find x_1 and P.

$\ln P^{sat} = A - [B / (t + C)]$ where P^{sat} is in kPa and t is in °C.

Component	A	B	C
Acetone (1)	14.3916	2795.82	230.0
Acetonitrile (2)	14.2724	2945.47	224.0
Nitromethane (3)	14.2043	2972.64	209.0

OR

Q.5 (a) Write a short note on flash vapourization. 03

(b) Draw block diagrams for DEW P calculations. Write all necessary equations. 04

(c) Discuss various methods for checking the consistency of experimental VLE data. 07

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