Reg. No.										

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MANIPAL INSTITUTE OF TECHNOLOGY

IV SEMESTER B.TECH (CHEMICAL ENGINEERING)

END SEMESTER EXAMINATIONS, MAY 2016

SUBJECT: CHEMICAL ENGINEERING THERMODYNAMICS-II [CHE 2201]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 100

Instructions to Candidates:

- Answer **ALL** questions.
- Missing data, if any, may be suitably assumed.

1A.	The molar enthalpy of a binary solution at constant T and P is given by the relation $H = 500x_1 + 1000x_2 + (50x_1 + 40x_2)x_1x_2$ where H is in J/mol. Determine $\overline{H_1}$ and $\overline{H_2}$ as functions of x_1 and the numerical values of the pure component enthalpies H_1 and H_2 .	**08**
1B.	Calculate the fugacity of CO at 400 bar using the following data at 273 K. P, bar: 25, 50, 100, 200, 400, 800, 1000 Z: 0.9890, 0.9792, 0.9741, 1.0196, 1.2482, 1.8057, 2.0819 (a) Using ideal gas behavior (b) Using the compressibility data.	**08**
1C.	Derive the expression for showing the effect of temperature and pressure on chemical potential.	**04**
2A.	Derive different forms of Gibbs-Duhem equation.	**06**
2B.	The concept of an ideal gaseous solution is less restrictive than that of an ideal gaseous solution. Justify the statement. Explain Raoult’s law.	**04**
2C.	Derive an expression for fugacity coefficient of a gas obeying the following equation of state $P = \dfrac{RT}{V-b} - \dfrac{a}{T^{0.5}(V+b)V}$ where a and b are empirical constants.	**10**
3A.	Discuss with a sketch, the boiling point diagram at constant pressure.	**10**
3B.	Discuss positive and negative deviation from ideality in non-ideal solutions.	**05**

Table for 1B:

P, bar	25	50	100	200	400	800	1000
Z	0.9890	0.9792	0.9741	1.0196	1.2482	1.8057	2.0819

3C.	The system n-pentane(1)- n-hexane(2)-n-heptane(3) forms an ideal solution. Given the vapour pressure of the components at 70^{0}C, $P_1^S = 2129.57\ Torr$, $P_2^S = 785.82\ Torr$, $P_3^S = 303.99\ Torr$. Determine the composition of the (a) Liquid which is in equilibrium with a vapour of composition y_1=0.45, y_2=0.3 and y_3=0.25 at 70^{0}C. (b) Vapour which is in equilibrium with a liquid of composition x_1=0.25, x_2=0.35 and x_3=0.4 at 70^{0}C.	**05**
4A.	The system Chloroform (1) and Acetone (2) forms a maximum boiling azeotrope at 64.5^{0}C and 760 Torr with x_1=0.655. Determine the van Laar constants and draw the P-x-y diagram for the system at 64.5^{0}C. Given the Antione constants (see table below)	**10**
4B.	Vapour liquid equilibrium data for the system methanol (1)- benzene (2) at 313 K are given below (see tables below). Use the zero area method to determine the thermodynamic consisteny of the data.	**10**
5A.	The equilibrium constant at 298 K for the vapour phase hydration of ethylene to ethanol according to the reaction $C_2H_4 + H_2O \rightarrow C_2H_5OH$ is 14.86 and the standard heat of reaction at 298 K is -45.95×10^3 J. The specific heat data is as follows (see table below). Determine the values of integration constants.	**06**
5B.	Ammonia synthesis reaction is represented by $N_2 + 3H_2 \rightarrow 2NH_3$ The reactant stream consists of 1 mol N_2, 3 mol H_2 and 2 mol argon. The temperature and pressure of the reaction are 675 K and 20 bar. The equilibrium constant for the reaction is 2×10^{-4}. Determine how the conversion of nitrogen is affected by the presence of argon.	**08**
5C.	For a mixture of acetic acid and toluene containing 0.486 mole fraction toluene, the partial pressures of acetic acid and toluene are found to be 0.118 bar and 0.174 bar respectively at 343 k. The vapour pressures of pure components at this temperature are 0.269 bar and 0.181 bar for toluene and acetic acid respectively. The Henry's constant for acetic acid is 0.55 bar. Calculate the activity and activity coefficient for acetic acid in the mixture. (a) Based on Lewis- Randall rule (b) Based on Henry's law.	**06**

Table for 4A:

	A	B	C
Chloroform (1)	6.9546	1170.966	226.232
Acetone (2)	7.1171	1210.595	229.664

Tables for 4B:

x_1	0	0.141	0.227	0.304	0.402	0.468	0.552
y_1	0	0.507	0.524	0.531	0.540	0.543	0.548
P, kPa	24.46	46.52	47.45	48.32	48.54	48.73	48.78

x_1	0.643	0.702	0.750	0.834	0.878	0.896	0.915	1.00
y_1	0.566	0.578	0.578	0.641	0.670	0.723	0.753	1.000
P, kPa	48.81	47.61	47.65	46.01	44.52	43.35	42.99	35.12

Table for 5A:

	c_p, J/mol K
Ethylene	$11.886 + 120.12 \times 10^{-3}T - 36.649 \times 10^{-6}T^2$
Water	$30.475 + 9.652 \times 10^{-3}T + 1.189 \times 10^{-6}T^2$
Ethanol	$29.358 + 166.9 \times 10^{-3}T - 50.09 \times 10^{-6}T^2$