Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

I SEMESTER M.TECH. (CHEMICAL ENGINEERING)

ENDSEM EXAMINATIONS, NOV 2017

SUBJECT: ADVANCED THERMODYNAMICS-I [CHE 5101]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.

1A.	Determine the molar volume of liquid ammonia using RK equation of state at 321.55 K and $1.95 \times 10^6\ Pa$. The values of RK constants $a = 0.48383\ Pa(m^3/mol)^2$, $b = 2.5902 \times 10^{-5}\ m^3/mol$.	**04**
1B.	Calculate the pressure developed when a tank of 0.9 m^3 is filled with 150 kg of the component and the tank is exposed to the surroundings where the temperature is 573 K. The properties of the component are mol.wt. 92.14 g/mol, Tc= 594.0K, Pc= $42.15 \times 10^5\ N/m^2$, w=0.263. (Use two parameter and three parameter compressibility factor Pitzer's correlation).	**06**
2A.	Using the concept of partial molar property, derive the expressions for partial molar volume of the components in a binary solution.	**05**
2B.	Derive the different forms of Gibbs-Duhem equation.	**05**
3A.	Prove that if Henry's law is obeyed by component 1 in a binary solution over certain concentration range, Lewis-Randall rule (Raoult's law) will be obeyed by component 2 over the same concentration range.	**3.5**
3B.	With the help of suitable diagram, discuss the effect of pressure on T-x-y diagram.	**3.5**
3C.	The system n-pentane(1) – n-hexane(2) – n-heptane(3) forms an ideal solution. Determine the composition of the 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°C. The vapour pressure of the components are 2129.57 Torr, 785.82 Torr and 303.99 Torr for n-pentane(1), n-hexane(2) and n-heptane(3) respectively.	**03**

4A. Chloroform(1)- methanol(2) forms an azeotrope at 760 Torr, 53.5°C and x_1=0.65. Using the van Laar model draw the P-x-y diagram (5 set of data) at 53.5°C. What type of azeotrope is this? **07**

The Antoine constants are given below

	A	B	C
Chloroform(1)	6.95465	1170.966	226.232
Methanol(2)	8.08097	1582.271	239.726

4B. A vapour mixture of 20 mole percent methane, 30 mole percent ethane and 50 mole percent propane is available at 30°C and 800 kPa. Making use of the K factors determine the pressure at which condensation begins if the mixture is isothermally compressed. Also estimate the composition of the first drop of liquid that forms. **03**

5A. The equilibrium constant at 420 K for the vapour phase hydration of ethylene to ethanol according to reaction **06**

$C_2H_4 + H_2O \rightarrow C_2H_5OH$

is 6.8×10^{-2} and standard heat of reaction at 298 K is -45.95×10^3 J. The specific heat data as follows

	$C_p, J/mol\ K$
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	$29.358 + 166.9 \times 10^{-3}T - 50.09 \times 10^{-6}T^2$

Formulate general relationships for estimating the equilibrium constant and standard free energy change as functions of temperature.

5B. Ammonia synthesis reaction is represented by **04**

$N_2 + 3H_2 \rightarrow 2NH_3$

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 $20 \times 10^5\ N/m^2$. The equilibrium constant for the reaction is 2×10^{-4}. Determine the conversion of nitrogen to ammonia.