Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
Online End Semester Examination, May 2021

Course: Thermodynamics -II | **Semester: IV**
Program: B. Tech (CE+RP) | **Time: 3 hrs**
Course Code: CHCE 2016 | **Max. Marks: 100**

Instructions: (1) Answer **ALL** questions
(2) Assume the appropriate value of missing data, if any.
(3) The thermodynamic terms have their usual meanings as described in the class

SECTION A (60 M)

S. No.		Marks	CO
Q 1	How would you calculate the constant pressure y-x data of a binary mixture using an average value of the relative volatility?	**6**	**CO1**
Q2	What can be the industrial applications of T-xy and P-xy VLE data?	**6**	**CO1**
Q3	What are the critical solution temperatures regarding partially miscible liquid systems?	**6**	**CO4**
Q4	What are the available degrees of freedom in the following non-reactive equilibrium systems? (a) Two partially immiscible liquid phases in equilibrium with their vapors (b) A mixture of benzene and toluene undergoing a simple distillation operation.	**6**	**CO1**
Q5	Enlist any two applications of both the solid-liquid equilibria and liquid-liquid equilibria?	**6**	**CO4**
Q6	How will you obtain the value of the equilibrium constant of a chemical reaction from the value of standard Gibb’s free energy? Discuss the feasibility of a chemical reaction using the value of standard Gibb’s free energy.	**6**	**CO3**

SECTION B (50 M)			
Q7	A group of students from the Department of Chemical Engineering, UPES Dehradun, were asked to carry out the experiments on a binary system of ethanol and water (for example) to obtain the data on activity coefficients. The students performed several experiments and generated a set of data at constant temperature and pressure and obtained the values of the activity coefficients of ethanol (1) and water (2) as $\gamma_1 = \exp\left[x_2^2\left(2x_1 + 0.5\right)\right]$ and $\gamma_2 = \exp\left[x_1^2\left(-2x_2 + 1.5\right)\right]$. Being a chemical engineer can you examine the correctness of their estimation?	**10**	**CO2**
Q8	The following reaction proceeds in a gas phase system, $CO + H_2O \rightleftharpoons CO_2 + H_2$. The reaction proceeds at 100 kPa and 827 ^oC. The standard Gibbs free energy of the reaction is - 9,143.2 J/mol. If 1 mol of CO and 2 mol of H_2O is supplied continuously into the system. Find the equilibrium composition of all the components.	**10**	**CO3**
Q9	Show that the following equations provide the criteria of equilibrium under certain constraints (a) $(dU)_{S,V} = 0$ (b) $(dA)_{T,V} = 0$ (c) $(dG)_{T,P} = 0$. Terms have their usual meanings.	**10**	**CO4**
Q10	A hypothetical gas (1) follows an equation of state, P (V-*b*) = RT. For this gas *b* = 0.1391 l/mol. This gas undergoes condensation in a vessel and is assumed to be in equilibrium with the condensed liquid at 400 K and 1000 atm. Calculate the residual Gibbs free energy of the vapor phase at 400 K and 1000 atm. The thermodynamic terms have their usual meanings.	**10**	**CO3**

Q11	The synthesis of ammonia takes place in a gas phase system according to the reaction $0.5N_2 + 1.5H_2 \rightleftharpoons NH_3$ A mixture consisting of 0.5 mol N_2, and 1.5 mol H_2 is continuously fed to the reactor. The equilibrium mixture behaves as an ideal gas. Obtain an expression for the extent of reaction in terms of the equilibrium constant, K and total pressure, P.	**10**	**CO4**
SECTION C (20 M)			
Q12	For the system acetone (1)/methyl acetate (2), the following correlations provide a reasonable correlation for the activity coefficients: $\ln\gamma_1 = 1.7Ax_2^2$ and $\ln\gamma_2 = 1.7\,Ax_1^2$ Where A = 2.771+ 0.00523 T In addition, the following Antoine equations provide vapor pressures: $$\ln P_1^{sat} = 16.59158 - \frac{3643.31}{T - 33.424}$$ $$ln\,P_2^{sat} = 14.25326 - \frac{2665.54}{T-53.424}$$ Where T is in K and vapor pressures are in kPa. Assuming the validity of modified Raoult's law (a) calculate T and y_i for P= 101.33 kPa and x_1 =0.75 (perform two iterations) (b) calculate T and x_i for P= 101.33 kPa and y_1 =0.55 (perform two iterations)	**20**	**CO1**