Name: **Enrolment No:**	

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2022

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, Q6 has an internal choice
(2) Assume the appropriate value of missing data, if any.
(3) The thermodynamic terms have their usual meanings

SECTION A
(5Qx4M=20Marks)

S. No.		**Marks**	**CO**
Q 1	Discuss the Raoult's law for describing a general VLE problem. How does this equation get modified for (a) non-ideal gas phase, ideal liquid phase and (b) non-ideal gas phase, non-ideal liquid phase	**4**	**CO1**
Q2	What is Poynting correction factor and what is the use of this factor?	**4**	**CO1**
Q3	How would you calculate the constant pressure y-x data of a binary mixture using an average value of the relative volatility?	**4**	**CO1**
Q4	What is the effect of temperature on the equilibrium constant? Using van't Hoff equation, explain the effect of increasing the temperature on endothermic and exothermic reactions.	**4**	**CO1**
Q5	What are the characteristics of an ideal solution? What is Lewis–Randall rule?	**4**	**CO1**

SECTION B
(4Qx10M= 40 Marks)

Q6	In the synthesis of ammonia using Haber's process, stoichiometric amounts of nitrogen and hydrogen are sent to a reactor where the following reaction occurs $N_2 + 3H_2 \rightarrow 2NH_3$. The equilibrium constant for the reaction at 675 K may be taken equal to 2×10^{-4}. (a) Determine the percent conversion of nitrogen to ammonia at 675 K and 20 bar. (b) What would be the conversion at 675 K and 200 bar? OR From vapour–liquid equilibrium measurements for ethanol–benzene system at 318 K and 40.25 kPa it is found that the vapour in equilibrium with a liquid containing 38.4% (mol) benzene contained 56.6% (mol) benzene. The system forms an azeotrope at 318 K. At this temperature, the vapour pressures of ethanol and benzene are 22.9 and 29.6 kPa respectively. Determine the composition and total pressure of the azeotrope. Assume that van Laar equation applies to the system.	**10**	**CO2**

	The Van Laar coefficients can be obtained using relations as follows: $$A = \ln\gamma_1 \left(1 + \frac{x_2 \ln\gamma_2}{x_1 \ln\gamma_1}\right)^2$$ $$B = \ln\gamma_2 \left(1 + \frac{x_1 \ln\gamma_1}{x_2 \ln\gamma_2}\right)^2$$		
Q7	In a binary liquid system, the enthalpy of species 1 and 2 at constant T and P is represented by the following equation: $H = 400x_1 + 600x_2 + (40x_1 + 20x_2)x_1x_2$. Where H is in J/mol. Determine the (a) expression for $\overline{H}_1$ and $\overline{H}_2$ in terms of x_1 (b) numerical values of $\overline{H}_1^{\infty}$, $\overline{H}_2^{\infty}$, H_1 and H_2 in J/mol.	**10**	**CO3**
Q8	Derive an expression for entropy change of mixing for a binary ideal gas mixture. Calculate the minimum work required to separate air at 298 K and 1 bar in a steady flow process into the product stream of pure N_2 and O_2, also at 298 K and 1 bar.	**10**	**CO3**
Q9	Derive an expression for fugacity coefficient of a gas obeying the equation of state, $Z = a + bP + cP^2$, where P is in the bar. Determine fugacity of oxygen at 293 K and 100 bar, given that $a = 1$, $b = -10^{-4}$ and $c = 10^{-6}$.	**10**	**CO3**
SECTION-C **(2Qx20M=40 Marks)**			
Q10	For the system benzene (1)/Toluene (2), the following correlations provide a reasonable correlation for the activity coefficients: $\ln\gamma_1 = 1.5\,A\,x_2^2$ and $\ln\gamma_2 = 1.5\,A\,x_1^2$ Where A = 2.61+ 0.00523 T, T is in K In addition, the following Antoine equations provide vapor pressures: $\ln P_1^{sat} = 16.5 - \frac{3643.31}{T - 33.424}$ $$\ln P_2^{sat} = 14.26 - \frac{2665.54}{T - 53.424}$$ Where T is in K and vapor pressures are in kPa. Assuming the validity of modified Raoult's law. Develop an algorithm that can be employed in excel sheet or any programming tools to calculate bubble point T and the composition of the first bubble formed. Calculate T and y_i for P= 101.33 kPa and x_1 =0.75 (perform two iterations).		**CO4**

Q11	The van der Walls cubic EOS is given as $\left(P+\frac{a}{V^2}\right)(V-b)=RT$. Prove that the fugacity of gas following this EOS is given by $\ln f=\frac{b}{V-b}-\frac{2a}{RTV}+\ln\frac{RT}{V-b}$. [Hint: Make appropriate assumptions and derive the final expressions]		**CO2**