Name: **Enrolment No:**	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, May 2023

Programme Name: B. Tech Chemical Eng. (Spl. Refining and Petrochemicals)
Semester : IV
Course Name : Thermodynamics 2 **Time : 3 hrs**
Course Code : CHCE2016 **Max. Marks: 100**
Nos. of page(s) : 02
Instructions: (1) **This is an OPEN BOOKS and OPEN NOTES Examination.**
(2) Assume the appropriate value of missing data, if any.
(3) The thermodynamic terms have their usual meanings

(Answer all questions)

S. No.		Marks	CO
1.	A binary mixture of n-pentane and benzene exists in the vapor liquid equilibria in a vessel at 289 K and 33.3 kPa. The excess Gibbs free energy of the binary system can be described using the two-suffix Margules equation with A =1816 J/mol. $\ln \gamma_1 = \frac{A}{RT} x_2^2$ and $\ln \gamma_2 = \frac{A}{RT} x_1^2$. where R is the universal gas constant and T is the temperature in K. At this condition of temperature pressure find the relationship between vapor phase and liquid phase compositions of n-pentane.	**25**	**CO4**
2.	Consider a binary mixture prepared using hypothetical species (1) and (2) in the vapor liquid equilibrium at 298 K temperature and 9000 kPa pressure. The vapor phase is supposed to follow the following equation of state $Z - 1 = \frac{P^2}{RT}(Ay_1y_2 + B)$; where A/RT=-2.0×10^{-4} bar $^{-2}$ and B/RT=8×10^{-5} bar $^{-2}$ and y_1, y_2 are the composition of both species in vapor phase. The saturation vapor pressure of the second component can be taken as 7000 bar and the activity coefficient $\ln \gamma_2 = -7(1 - x_1^2)$.	**15+15 +10**	**CO2, CO3 and CO4**

	(a) Determine the molar volume of the mixture and partial molar volume of species 2. (b) Derive the expression for fugacity and fugacity coefficient of species in the vapor phase (c) Find the mole fraction of species 2 in liquid phase under vapor liquid equilibria		
3.	The ammonia gas supplied to the refrigeration system of the refinery is supposed to follow the van der Walls equation of state. 500 cm^3/ mol of ammonia gas is expanded in an isentropic turbine. at 623 K before it enters into the refrigeration system which is at atmospheric pressure (discharge pressure of the turbine). The heat capacity of the ammonia can be considered constant as C_P = 80 kJ/kg K. The van der Walls constants for ammonia can be considered as $a = 90\times10^5 (atm - cm^6 - mol^{-2}), b = 90 (cm^3 / mol)$. Find the exit temperature of ammonia from the turbine. [Hint: Use both TdS equations and find different temperature]	**35**	**CO1, CO3**