Name: Enrolment No:	UPES – UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2019

Course: Engineering Thermodynamics — **Semester : III**
Program: B. Tech. (APE-Gas) — **Time : 3 hr**
Course Code: MECH 2001 — **Max. Marks : 100**

Instructions: Assume any missing data. The notations used here have the usual meanings. Draw the diagrams, wherever necessary.

SECTION - A (2 × 10 = 20 marks)
(Answer all the questions)

S. No.		Marks	CO
1.	A stream of warm water is produced in a steady flow mixing process by combining 1 kg/s of cold water at 298.15 K with 0.8 kg/s of hot water at 348.15 K. During mixing, heat is lost to surroundings at the rate of 30 kW. What is the temperature of the warm water stream? Assume the specific heat of water is 4.18 kJ/kg-K.	**10**	**CO2**
2.	Explain absorption refrigeration system with the help of a schematic diagram. Derive a relation to estimate the COP of absorption refrigeration system.	**10**	**CO5**

SECTION - B (5 × 12 = 60 marks)
(Answer all the questions)

S. No.		Marks	CO
3.	An inventor has devised a complicated nonflow process in which 1 mol of air is the working fluid. The net effects of the process are claimed to be: - A change in state of air from 523.15 K and 3 bar to 353.15 K and 1 bar - A production of 1800 J of work - The transfer of an undisclosed amount of heat to a heat reservoir at 303.15 K Determine whether the claimed performance of the process is consistent with the second law. Assume that air is an ideal gas for which $C_p = (7/2)R$.	**12**	**CO2**
4.	A mass m of liquid water at temperature T_1 is mixed adiabatically and isobarically with an equal mass of liquid water at temperature T_2. Assuming constant C_p, show that $$S_G = 2\, m\, C_p \ln \frac{(T_1 + T_2)/2}{\sqrt{T_1\, T_2}}$$	**12**	**CO2**

	and prove that this is positive. What would be the result if the masses of water were different, say m_1 and m_2.		
5.	Calculate Z and V for ethane at 323.15 K and 15 bar by the following equations: (a) the truncated virial equation, with the following experimental values of virial coefficients: B = -156.7 cm^3/mol, C = 9650 cm^6/mol^2. (b) the truncated virial equation, with the value of B from generalized Pitzer correlations. Virial coefficients B^0 and B^1 are: $B^0 = 0.083 - \frac{0.422}{T_r^{1.6}}$ and $B^1 = 0.139 - \frac{0.172}{T_r^{4.2}}$ For ethane: T_c = 305.3 K, P_c = 48.72 bar and ω = 0.1.	**12**	**CO3**
6.	1 kmol of ethylene is contained in a 0.6 m^3 steel vessel immersed in a constant temperature bath at 200 ^0C. Determine the pressure developed by the gas by each of the following: (a) ideal gas equation (b) van der Waals equation (c) Redlich/Kwong equation For ethylene: T_c = 283.1 K, P_c = 51.17 bar and parameters assigned for equations of state are:	**12**	**CO3**

Equation of state	$\alpha(T_r)$	Σ	E	Ω	ψ	Z_c
Van der Waals (vdW)	1	0	0	1/8	27/64	3/8
Redlich/Kwong (RK)	$T_r^{-1/2}$	1	0	0.08664	0.42748	1/3

7.	A Carnot refrigerator has tetrafluoroethane as the working fluid. For T_C =261.15 K and T_H = 311.15 K, determine (a) the heat addition per kg of fluid (b) the heat rejection per kg of fluid (c) the mechanical power per kg of fluid for each of the four steps (d) the coefficient of performance ω for the cycle Thermodynamic properties of Saturated tetrafluoroethane are given in Table 1.	**12**	**CO5**

SECTION – C (1 × 20 = 20 marks)
(Answer all the questions)

8.(a)	What do you understand by retrograde condensation? Explain with the help of a PT diagram.	**5**	**CO4**
(b)	The expressions for activity coefficient of species 1 and 2 in a binary liquid mixture at a given T and P are: $$\ln\gamma_1 = x_2^2\,(0.273 + 0.096\,x_1)$$ $$\ln\gamma_2 = x_1^2\,(0.273 - 0.096\,x_1)$$ (i) Determine the implied expression for G^E/RT. (ii) Generate expressions of $\ln\gamma_1$ and $\ln\gamma_2$ from the results of (i).	**15**	
	OR		
8.(a)	Develop a general equation for calculation of $\ln\hat{\phi}_i$ values from compressibility factor data.	**8**	
(b)	Determine the Dew point of a mixture containing 48% ethane (1), 25% propane (2), 15% iso-butane (3) and rest iso-pentane (4) at 333.15 K. K-values for Systems of light hydrocarbons are given in Figure 1.	**12**	

Table: 1 Thermodynamic properties of Saturated Tetrafluoroethane

Temperature (K)	Saturation pressure MPa	Liquid density kg/m^3	Specific volume of vapor m^3/kg	Enthalpy (kJ/kg)		Entropy (kJ/kg-K)	
	P	ρ^l	V^v	H^l	H^v	S^l	S^v
261.15	0.18516	1331.8	0.10749	184.16	391.55	0.9410	1.7351
309.15	0.91172	1163.2	0.02241	250.41	417.78	1.1715	1.7129
313.15	1.0165	1146.5	0.01999	256.35	419.58	1.1903	1.7115

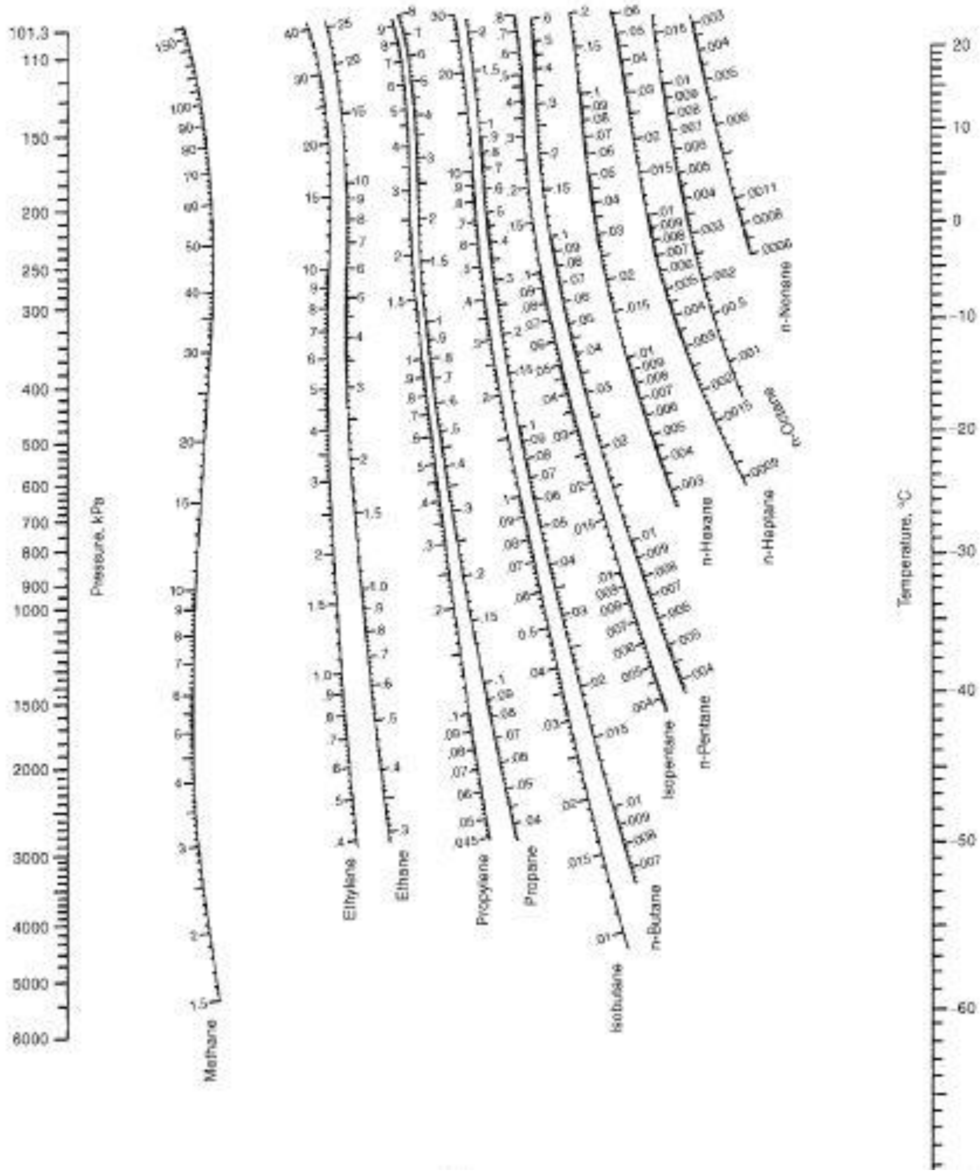

Figure 1. K values for Systems of light hydrocarbons – Low Temperature