Reg No.:_____ **02000CH204052003** Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Fourth semester B.Tech examinations (S), September 2020

Course Code: CH204

Course Name: CHEMICAL ENGINEERING THERMODYNAMICS (CH)

Max. Marks: 100 Duration: 3 Hours

Specify the assumptions used, if any, for all questions

PART A

Answer any two questions. Each question carries 15 marks.

1	a)	Explain the principle of corresponding states and bring out its applications.	5
	b)	Carbon tetrachloride boils at 349.8 K at a pressure of 1 bar. Determine its boiling point at 3 bar pressure. The latent heat of vapourization of CCl_4 is 30 kJ/mol.	5
	c)	Define fugacity. Derive an expression to determine the fugacity of a pure gas.	5
2	a)	List the limitations of first law of thermodynamics and explain how they are overcome by the second law.	6
	b)	A liquid is taken in a vessel fitted with a stirrer. The stirrer is run for half an hour by a 3 hp motor. During this process, 1000 kJ/h heat is dissipated to the surroundings. Determine the change in internal energy of the liquid.	5
	c)	What is an equation of state? Write van der Waals equation and explain the correction terms incorporated.	4
3	a)	Explain the significance of Joule Thomson inversion curve	3
	b)	100 m3 of carbon dioxide initially at 423 K and 50 bar is to be isothermally compressed in a frictionless cylinder and piston device to a final pressure of 300 bar. Assuming ideal gas behaviour, i). Write the general expression for energy balance and denote the terms used. ii). Calculate the volume of compressed gas (at 300 bar). iii). Calculate the work required for compression. iv). Calculate the heat flow on compression.	12

PART B

Answer any two questions. Each question carries 15 marks

4	a)	Define chemical potential. Discuss its importance in Chemical Engineering Thermodynamics.	5

b) The partial molar volume of species 1 in a binary solution at constant temperature and pressure is given by $\bar{V}_1 = V_1 + \alpha \ {x_2}^2$ *where* α *is a constant*. Derive the equation for $\bar{V}_2$ and the expression for molar volume of the solution. 10

5 a) What are the different criteria for phase equilibrium? 4

b) A binary vapour mixture contains 50 mole % A and 50 mole % B at 300 K and 101.3 kPa. This mixture is compressed isothermally to liquify it. The liquid can be considered as an ideal solution. The vapour pressures of A and B are 140 kPa and 118 kPa respectively. Determine 7

i). The pressure at which condensation occurs

ii). Composition of liquid formed.

c) Explain any one method to check the consistency of vapour liquid equilibrium data. 4

6 a) Explain Lewis Randall rule and derive Raoult's law from it. 6

b) With the help of neat sketches explain positive and negative deviations from ideality. Bring out the characteristics of corresponding azeotropes formed. 7

c) 2 kg of an azeotropic mixture of A and B with 80 mole % A is partially vapourized such that 0.6 kg of liquid is converted to vapour. Predict the composition of vapour formed and the composition of the remaining liquid. Justify the result. 2

PART C

Answer any two questions. Each question carries 20 marks.

7 a) Pure N_2O_4 at a low temperature is diluted with air and heated to 298 K and 1 bar. The following reaction occurs. $N_2O_4\,(g) \leftrightarrow 2\,NO_2(g)$ If the mole fraction of N_2O_4 in the reaction mixture before dissociation is 0.2, calculate the percentage of decomposition and equilibrium compositions of N_2O_4 and NO_2. The standard free energy change for the reaction at 298 K is 4644.7 J/mol. 12

b) Explain flash vapourization operation and develop the mass balance equations. Explain how the fraction vapourized can be calculated. 8

8 a) Vapour mixture of components A and B with 60% mole fraction of A is cooled at constant pressure of 100 kPa. If the components are immiscible in liquid phase, determine the three phase equilibrium temperature and the vapour phase composition at this temperature. The vapour pressures of pure components versus temperature data are given below: 12

T (K)	338	343	348	353	358	363	368	373
P_A^S (kPa)	22.3	26.9	32.3	38.5	45.7	53.8	63.1	73.7
P_B^S (kPa)	24.8	30.9	38.2	47.0	57.4	69.6	83.9	100.6

b) Define extent of reaction. Derive the relationship between mole fraction of components taking part in a reaction and extent of reaction. 8

9 a) With neat diagram explain the effect of pressure on vapour liquid equilibrium involving a partially miscible liquid phase. 5

b) Determine the maximum percentage of ethane that may get dehydrogenated to ethylene at 750 K and 5 bar, by the reaction $C_2H_6\,(g) \longrightarrow C_2H_4\,(g) + H_2\,(g)$. The standard free energy of the reaction at 750 K is 42.593 kJ. What will be the conversion if the pressure is reduced to 0.5 bar? 15