Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FOURTH SEMESTER B.TECH DEGREE EXAMINATION(S), DECEMBER 2019

Course Code: CH204

Course Name: CHEMICAL ENGINEERING THERMODYNAMICS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any two questions. Each question carries 15 marks.

1	a)	Define the terms state function and path function.Give Examples.	(3)
	b)	Derive expressions for entropy changes of isobaric and isothermal processes for an ideal gas.	(4)
	c)	Draw the PV diagram for water and explain the regions involved and define critical properties.	(8)
2	a)	Derive expression for first law of Thermodynamics applied to an open system. List the assumptions, if any.	(5)
	b)	Define open, closed and isolated systems.	(3)
	c)	One mole of a gas at 325K expands isothermally from an initial volume of 0.04 m^3 to a final volume of 0.01 $m^{3.}$ During the process, the gas rejects 30J of heat to the surroundings. Determine the work of expansion if the gas obeys the van der Waals equation of state. van der Waals constants may be taken as a= 0.94 J m^3/mol^2 and b= 9x 10^{-5} m^3/mol	(7)
3	a)	Explain vapour compression refrigeration cycle with a neat schematic diagram.	(5)
	b)	Differentiate between equilibrium state and steady state.	(2)
	c)	Prove that $\left(\frac{\partial C_P}{\partial P}\right)_T = -\mu\left(\frac{\partial C_P}{\partial T}\right)_P - C_P\left(\frac{\partial \mu}{\partial T}\right)_P$ where C_P and μ are specific heat at constant pressure and Joule Thomson coefficient respectively.	(4)
	d)	Prove that enthalpy change for an isothermal process is zero for an ideal gas.	(4)

PART B

Answer any two questions. Each question carries 15 marks

4 a) Derive expressions for the effect of temperature and pressure on activity coefficient. (5)

b) State Lewis-Randall rule. Explain the conditions under which a binary mixture obeys LR rule. (3)

c) 30%(mol) of component A in binary solution with component B is known to form an azeotrope at a temperature of 346.2 K and 101.3kPa. At this temperature the saturation vapour pressures of A and B are 42.4 kPa and 74.8 kPa respectively. Apply van Laar equation to calculate the composition of a vapour phase in equilibrium with an equimolar liquid solution at 346.2 K. Also determine the total pressure at this condition. (7)

5 a) Derive Gibbs Duhem equation in terms of activity coefficients of components in a binary mixture. (5)

b) Construct the constant temperature phase diagram at 373 K and boiling point diagram at 1 bar pressure for a binary mixture obeying Raoult's law. The saturation vapour pressures of the components are given by Antoine equations as (10)

$$\ln P_1^S = 13.8858 - \frac{2788.51}{T - 52.41} \quad \text{and} \quad \ln P_2^S = 14.0045 - \frac{3279.47}{T - 60}$$

Where P is in kPa and T is in K.

6 a) The activity coefficients of a binary mixture based on the Lewis Randall rule are given by $\ln \gamma_1 = A x_2^2$ and $\ln \gamma_2 = A x_1^2$ (9)

Derive expressions for activity coefficients based on Henry's law in terms of composition.

b) Differentiate between positive deviation and negative deviation from ideality with the help of P-x-y diagrams. (6)

PART C

Answer any two questions. Each question carries 20 marks.

7 a) Illustrate with a neat sketch the VLE for a binary mixture of partially miscible components. (9)

b) Derive van't Hoff equation (5)

c) Analyse how the presence of excess reactant and presence of product in the initial reaction mixture affects the equilibrium conversion of a reaction. (6)

8 a) The vapour pressure of two immiscible liquid components 1 and 2 are given by (12)

$\ln P_1^S = 14.00976 - \frac{3103.010}{T - 53.413}$ and $\ln P_2^S = 16.287 - \frac{3816.44}{T - 46.11}$ respectively

where P is in kPa and T in K. The three phase equilibrium temperature for the system is given as 357.52 K

Determine the dew point temperature and the composition of the first drop of liquid formed when the vapour mixture of these species containing (i) 25% of component 1 and (ii) 75% of component 1. The total pressure may be taken as 101.3 kPa.

b) Ammonia synthesis reaction is carried out at 298 K and 50 bar. The equilibrium constant for this reaction, K_p is given as 1.3 x 10^{-2}. If the feed to the reactor contained 50% Hydrogen, 25% Nitrogen and the rest an inert gas, determine the composition of the product gas stream leaving the reactor. (8)

9 a) Explain the characteristic features of VLE at high pressure (4)

b) Outline the application of K value in bubble point and dew point equilibria calculations. (4)

c) Ethylene is formed at 1 bar and 1500 K by the following simultaneous reactions (12)

$C_2H_2 \rightarrow 2C + H_2$ K_1=5.2

$2C + 2H_2 \rightarrow C_2H_4$ K_2=0.1923

If the feed gas mixture consists of 2 moles of Acetylene and 3 moles of Hydrogen, calculate the equilibrium composition of the reaction mixture. Assume ideal gas behaviour.