Reg No.:_______________ Name:__________________________

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

Course Code: CH204

Course Name: CHEMICAL ENGINEERING THERMODYNAMICS (CH)

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any two questions. Each question carries 15 marks.

1 a) State the first law of thermodynamics and write down its mathematical statement with reference to a closed system. (4)

b) Derive expression for the shaft work required in isothermal compression of an ideal gas. (4)

c) Derive Clausius-Clapeyron equation from Maxwell's equation. (7)

2 a) Derive expression for critical pressure ratio of a convergent divergent nozzle stating the assumptions clearly. (8)

b) The equation $V = 0.0561\left(\frac{1}{P} - 0.0046\right)$ where V is in m^3/mol and P is in bar may be used to define the pressure volume relation of a pure gas at low pressure at 600 K. Calculate the fugacity of the gas at the given condition. (7)

List the assumptions made if any.

3 a) Explain the absorption refrigeration cycle with a neat diagram. (7)

b) Prove that C_p and C_v of an ideal gas are not affected by pressure or volume change. (8)

PART B

Answer any two questions. Each question carries 15 marks

4 a) Deduce Raoult's law from Lewis Randall rule. State the assumptions involved. (4)

b) Obtain Gibbs-Duhem equation in terms of chemical potential. (4)

c) Derive the coexistence equation. State its application. (7)

5 a) Derive the phase rule for a non-reacting system. (5)

b) Ethyl alcohol and hexane forms an azeotrope at 33.2% (mol) ethanol. The (10) mixture boils at 331.9 K at 101.3 kPa. At 331.9 K, the vapour pressures are 44.25 kPa and 72.24 kPa for ethanol and hexane respectively. Determine the van Laar constants for the mixture. Also determine the total pressure and the composition of vapour in equilibrium with a liquid mixture containing 40% Ethanol, at 331.9 K.

6 a) Prove that if one of the components in a binary mixture shows positive deviation from ideality, then the other component will also show positive deviation from ideality. (7)

b) Explain the effect of temperature and pressure on fugacity quantitatively. (8)

PART C

Answer any two questions. Each question carries 20 marks.

7 a) Steam distillation is a separation process used for essential oils. Justify and explain the principle with a neat phase diagram. (10)

b) Derive the relation between conversion and extent of reaction. (5)

c) Explain the significance of pressure of decomposition with an example. (5)

8 a) Components A and B are partially miscible at room temperature. With the help of a neat phase diagram, explain the three phase equilibria at constant pressure. (8)

b) Methanol is synthesised in a catalytic reactor at a pressure of 300 bar and 625 K by the following reaction (12)

$CO(g)+2H_2(g)\rightarrow CH_3OH(g)$.

Determine the percentage conversion of CO if the feed to the reactor is a gas mixture containing 30% CO, 65% H_2 and the rest an inert gas. The equilibrium constants K_f and K_ϕ may be taken as 4.9 x 10^{-5} and 0.35 respectively.

9 a) Explain the effect of pressure on the T-x-y phase diagram of Vapour- Liquid-Liquid Equilibria (VLLE). (5)

b) Illustrate how a ternary equilibrium can be represented by triangular coordinates. (5)

c) The reaction $N_2(g)+O_2(g)\rightarrow 2NO(g)$ is carried out at 2700 ^{0}C and 2025 kPa. The reaction mixture initially comprises of 20 mol% oxygen, 70 mol% nitrogen and the rest an inert gas. The standard Gibbs free energy change for the reaction is 113.83 kJ/mol at the given conditions. Calculate the partial pressures of all species in the equilibrium reaction mixture. Make suitable assumptions, if required. (10)