Paper Code: CH503	**Roll No.**									

B. Tech.
(SEM. V) THEORY EXAMINATION, 2016-17
CHEMICAL ENGINEERING THERMODYNAMICS

Time: 3 Hours **Total Marks: 100**

Note: (1) Attempt all questions
(2) All questions carry equal marks.
(3) In case of numerical problems assume data wherever not provided

Q1. Attempt any four parts of the following: **5x4=20**

(a) State the various law of thermodynamics and explain briefly the importance
(b) Distinguish between state function and path function with suitable example.
(c) Derive the expression for the energy balance for open system.
(d) A steel casting weighing 2 kg has an initial temperature of 773.15 K; 40 kg of water initially at 298.15 K is contained in a perfectly insulated steel tank weighing 5 kg. The casting is immersed in the water and the system is allowed to come to equilibrium. What is its final temperature? Ignore any effect of expansion and contraction, and assume constant specific heat 4.18 kJ/kg K for water and 0.50 kJ/kg K for steel.
(e) Prove that $\Delta S_{Total} \geq 0$
(f) In a steady state flow process, 1 mol/s of air at 600 K and 1 atm is continuously mixed with 2 mol/s of air at 450 K and 1 atm. The product stream is at 400 K and 1 atm. Determine the rate of heat transfer and rate of entropy generation for the process. Assuming that air is an ideal gas with Cp = (7/2)R, that the surroundings are at 300 K, and the kinetic and potential energy changes are negligible.

Q2. Attempt any four parts of the following: **5x4=20**

(a) Prove that $\mu_i^{ig} = G_i^{ig} + RTln\, x_i$

Where
μ_i^{ig}= Chemical potential of species i in an ideal gas mixture
G_i^{ig} = Gibbs energy of an ideal gas mixture
R = Gas constant
T= Temperature
x_i = Mole fraction in vapour.

(b) What is poynting correlation? Also derive poynting correlation.
(c) Discuss the effect of temperature and pressure on fugacity.
(d) Define dew point and bubble point temperature
(e) Derive the relation between activity co-efficient and excess chemical potential.
(f) If the molar density of a binary mixture is given by the empirical expression:
$\rho = a_0 + a_1 x_1 + a_2 x_1^2$ find the corresponding expression for $\overline{V_1}$and $\overline{V_2}$.

Q3. Attempt any two parts of the following: **10x2=20**

(a) What do you think of the phase rule? Explain P-x-y and T-x-y diagrams with neat sketches.

(b) The vapour pressure of acetone(1)/ acetonitrile (2) and nitro methane (3) can be represented by Antoine equations as $\ln P_1^{sat} = 14.3916 - \frac{2795.82}{T+230}$, $\ln P_2^{sat} = 14.2724 - \frac{2745.47}{T+224}$, $\ln P_3^{sat} = 14.2043 - \frac{2972.64}{T+209}$ where P_1^{sat}, P_2^{sat} and P_3^{sat} are in kPa and T is in ^{0}C. Assume that the system follows Raoult's law. Calculate

(i) P and y_1 at T = 75^0C, x_1= 0.3, x_2 =0.4,

(ii) P and x_1 at T = 80^0C, y_1= 0.3, y_2 =0.4,

(c) For the system of ethyl ethanoate(1)/ n- heptanes (2) at 343.15 K

$ln\gamma_1 = 0.95x_2^2$ $\quad$ $ln\gamma_2 = 0.95x_1^2$

$P_1^{Sat} = 79.80\ kPa$ $\quad$ $P_2^{Sat} = 40.50\ kPa$

Assuming the system follows Modified Raoult's law

(i) Make a BUBL P calculation for T= 343.15 K, x_1= 0.05.

(ii) Make a DEW P calculation for T= 343.15 K, y_1= 0.05.

(iii) What is azeotrope composition and pressure at T= 343.15 K.

Q4. Attempt any two parts of the following: **10x2=20**

(a) The water –gas shift reaction CO(g) + H_2O(g)→ CO_2(g) + H_2 (g) is carried out under different sets of conditions described below. Calculate the fraction of steam reacted in each case. Assume the mixture behave as an ideal gas.

(i) The reactant consists of 1 mole of H_2O vapour and 1 mole of CO. The temperature is 1100K and pressure is 1 bar.

(ii) Same as (i) except that 2 mole of N_2 is included in the reactants.

(iii) The reactant consists of 2 mole of H_2O vapour and 1 mole of CO. Other conditions are same as that of (i).

(iv) The initial mixture consists of 1 mole of H_2O, 1 mole of CO and 1 mol of CO_2. Other conditions are same as that of (i).

(v) Same as that of (i) except that temperature is 1650K

(b) Derive an expression for the effect of temperature on the equilibrium constant for a mixture.

(c) Estimate the equilibrium constant for the reaction

C_2H_4 (g) + H_2O (g) → C_2H_5OH (g) at 600K the data given are as follows

ΔG_{298}^0= -8494 J/g-mole

ΔH_{f298}^0 for C_2H_5OH (g)= -235308 J/g-mole

ΔH_{f298}^0 for C_2H_4 (g) = 52283 J/g-mole

ΔH_{f298}^0 for H_2O (g) = -241826 J/g-mole.

Q5. Attempt any two parts of the following: **10x2=20**

(a) Develop relation between the gamma/ phi of VLE.

(b) Describe the liquid/ liquid equilibrium.

(c) Explain the terms- equilibrium and stability