Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– IV (NEW) EXAMINATION – SUMMER 2015

Subject Code: 2143507 **Date: 05/06/2015**

Subject Name: Fundamentals of Stoichiometry

Time: 10:30 AM to 01:00 PM **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Atomic mass: N=14, O=16, H=1, C=12, Na=23, Cl=35.5, S=32**

Q.1 **(a)** Altimeter is used to determine the height of airplane above the mean sea level by measuring the atmospheric pressure. An altimeter displays the height of airplane is 10 000 m, which is equivalent to the atmospheric pressure of 30 kPa. Convert this value of pressure in atm, psi, bar, mmHg, Torr, kgf/cm^2, N/m^2. **07**

(b) NaCl solution is prepared by dissolving 25 g of NaCl in 500 g of pure water. Calculate the concentration of this solution in Normality, Molarity and Molality. Consider the density of solution = 1.08 kg/L. **07**

Q.2 **(a)** 8000 kg/h of solution containing 15 % methanol (CH_3OH) is continuously fed to a distillation column. Distillate is found to contain 98 % of methanol and Bottoms stream from the column carries 1 % methanol. All percentages are by weight. Calculate (1) the mass flow rates of distillate and bottom product and (2) the percent loss of methanol in the bottoms stream. **07**

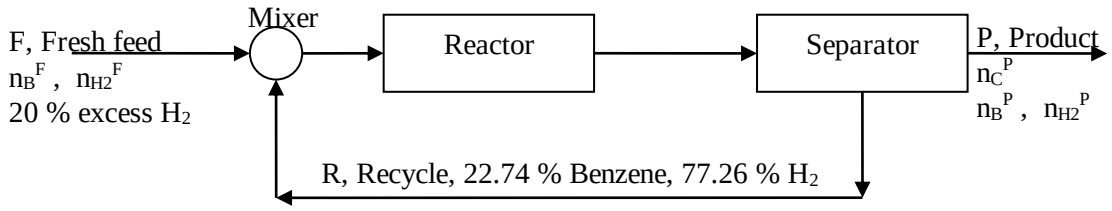
(b) A gas mixture has the following composition by mole: Ethylene (C_2H_4) = 31 %, Benzene (C_6H_6) = 25 %, Oxygen (O_2) = 2 %, Methane (CH_4) = 15 %, Ethane (C_2H_6) = 20 % and rest Nitrogen (N_2). Find: i) the average molecular weight of the gas mixture, ii) and the density of the mixture in kg/m^3 at 101.3 kPa and 300 K. **07**

OR

(b) Wood containing 40 % moisture is dried to 5 % moisture. What mass of water in kg is evaporated per kg of dry wood? **07**

Q.3 **(a)** Cyclohexane (short form C) can be made by the reaction of benzene (short form B) with hydrogen according to the following reaction: $C_6H_6 + 3H_2 \rightarrow C_6H_{12}$ **10**

For the process shown in the figure, determine the ratio of the recycle stream to the fresh feed stream if the overall conversion of benzene is 95% and the single-pass conversion through the reactor is 20%. Assume that 20% excess hydrogen is used in the fresh feed, and that the composition of the recycle stream is 22.74 mol % benzene and 78.26 mol % hydrogen.



(b) Define i) limiting reactant, ii) excess reactant, iii) extent of reaction iv) yield. **04**

OR

Q.3 (a) In the Deacon process for the manufacturing chlorine, hydrochloric acid gas is oxidized with air. The reaction taking place is: $4HCl + O_2 \rightarrow 2Cl_2 + 2H_2O$. If the air is used in excess of 50 % of that theoretically required, and if the oxidation is 80 % complete, calculate the composition by volume of dry gases leaving the reaction chamber. **07**

(b) If 100 mol of feed contains 40 mol CH_4, 50 mol Cl_2, and 10 mol N_2 fed to the reactor where the % conversion of methane (limiting reactant) is 67 %. The reaction takes place in the reactor is $CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$. Determine i) the extent of reaction and ii) and production composition in mol %. **07**

Q.4 (a) A heat exchanger uses 12000 kg/hr of cooling water, which enters the exchanger at 295 K. The hot oil, which is required to be cooled at the rate of 6000 kg/hr, enters at 425 K and leaves at 340 K. The mean heat capacity of oil is 2.5 kJ/(kg K) and that of water is 4.184 kJ/(kg K). Calculate the outlet temperature of water. Mention the assumptions made to carry out calculations. **07**

(b) Calculate mean molal heat capacity, C_{pm} of Carbon monoxide (CO) in the temperature range 298.15 K and 373.15 K. The expression for Cp is **07**

$$Cp = 26.586 + 7.582 \times 10^{-3}\, T - 1.12 \times 10^{-6}\, T^2.$$

Where C_p is in kJ/(kmol K) and T is in K.

OR

Q.4 (a) Calculate enthalpy of superheated steam in kJ/kg at 573.15 K and 1 atm pressure, relative to liquid at 298.15 K. **07**

Data: Boiling point of water = 100 °C (at 1 atm), Mean C_p of liquid water = 74.1 J/(mol K), Mean C_p of water vapour = 35.1 J/(mol K), Enthalpy of vaporization of water at 1atm = 40.706 kJ/mol.

(b) Define the following terms: **07**

i. Dry-bulb temperature, ii. Wet bulb temperature, iii. Latent heat, iv. Sensible heat, v. Absolute humidity, vi. Relative humidity, vii. Saturation humidity

Q.5 (a) 1 mol of pure CO is mixed with 100 % excess air and it is burned. Only 80 % of CO burns. The reactants are entering at 373 K and the products are leaving at 573 K. Calculate the amount of heat to be added or removed per kmol of CO fed to the reactor. Standard heat of formation in kJ/mol at 298 K are –110.6 for CO and –393.51 for CO_2. The mean molal heat capacity between 298K and T K in kJ/(kmol K) are **10**

Component	Mean molal heat capacity, C_{pm} in kJ/(kmol K)	
	at T = 373 K	at T = 573 K
CO	29.22	30.61
CO_2	--	43.77
O_2	29.84	30.99
N_2	29.17	29.66

(b) What is an adiabatic flame temperature? State its significance and explain the procedure for its calculation. **04**

OR

Q.5 (a) Calculate the heat of reaction at 575 K for the reaction: $SO_{2(g)} + ½\, O_{2(g)} = SO_{3(g)}$. Consider $Cp° = a + b\,T + c\,T^2$, where Cp° is in kJ/(kmol K) and T is in K. The standard heat of reaction at 298 K is -98.91 kJ/kmol and the constants a, b and c for each component are: **10**

Component	a	$b \times 10^3$	$c \times 10^6$
SO_2	24.771	62.948	–44.258
O_2	26.026	11.755	–2.343
SO_3	22.036	121.624	–91.87

(b) Define standard heat of formation and standard heat of combustion. **04**

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