Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE – SEMESTER – VI EXAMINATION – WINTER 2015

Subject Code:163502 **Date:17 /12/ 2015**

Subject Name: Material & Energy Balance Calculations

Time:2:30pm to 5:00pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Atomic weight: H: 1, C: 12, N: 14, O: 16, S: 32, Cl: 35.5, Cu=63.5.**

Q.1 **(a)** convert 1 atm into equivalent N/m^2, m H_2O, ft H_2O, psi ,in Hg , mm Hg and kg_f/cm^2 **07**

(b) A weight of 1.10 kg of Carbon dioxide occupies a volume of 33 liter at 300 K. Using the Van der Waals equation of state, calculate the pressure. Data: For CO_2 , take a = 3. 60 $[(m^3)^2\text{-kPa}]/(kmol)^2$and b = 4.3 x 10^{-2} $m^3/kmol$. **07**

Q.2 **(a)** Explain Recycle, Purge, bypass with suitable diagram and also define the overall and single pass fraction conversion. **07**

(b) In an electrochemical cell, the current is passed at the rate of 1130 amperes for 18000 s through a solution containing copper sulphate. At the end of the process, 1.12 m^3 of oxygen (at STP) is collected. Find (a) amount of copper liberated, and (b) the current efficiency of the cell **07**

OR

(b) 1 kg nitrogen is mixed with 3.5 m^3 of hydrogen at 300 K and 101.3 kPa and sent to the ammonia converter. The product leaving the converter analyzed 13.7 % ammonia, 70.32 % hydrogen and 15.98 % nitrogen. **07**

i. Identity the limiting reactant.
ii. What is the present excess of excess reactant?
iii. What is the present conversion of the limiting reactant?

Q.3 **(a)** 2000 kg of wet solids containing 70 % solids by weight are fed to tray dryer where it is fried by hot air. The product finally obtained is found to contain 1% moisture by weight, calculate: (1) kg of water removed from wet solids (2) kg of the product obtained. **07**

(b) The average molecular weight of the flue gas sample is calculated by two different engineers. One engineer used the correct molecular weight of N_2 as 28, while the other used an incorrect value of 14. They got the average molecular weight as 30 and the incorrect one as 18.74. Calculate the % volume of N_2 in the flue gases. If the remaining gases are CO_2 and O_2 calculated their compositions also. **07**

OR

Q.3 **(a)** The feed to a continuous fractioning column analyzed by weight 28 % benzene and 72 % toluene. The analysis of the distillate shows 52 % (by weight) benzene and 5 % benzene was found in the bottom product. Calculate the amount of distillate and bottom product for 100 kg of feed. **07**

(b) A weak acid containing 12.5 % H_2SO_4 and the rest water is fortified by adding 500 kg of concentrated acid containing 80 % H_2SO_4. Determine the amount of the solution obtained if it contains 18.5 % H_2SO_4? **07**

Q.4 **(a)** Pure methane is heated from 303 K to 523 K at atmospheric pressure. Calculate the heat added per kmol methane using the following data: **07**

$$C_p = 19.2494 + 52.1135 \times 10^{-3}T + 11.973 \times 10^{-6}T^2 - 11.317 \times 10^{-9}T^3 \ {}^{KJ}/_{(kmol\ K)}$$

(b) Calculated the enthalpy of zinc vapour at 1200 ^{0}C and atmosphere pressure, relative to solid at 10 ^{0}C. **07**

Data: Melting point of Zn = 419 ^{0}C (at 1 atm)
Boiling point of Zn = 907 ^{0}C (at 1 atm)
Mean C_p of solid Zn = 0.105 kcal/kg ^{0}C
Mean C_p of liquid Zn = 0.109 kcal/kg ^{0}C
Heat of fusion of Zn = 1660 kcal/kgmole
Heat of vaporization of Zn = 26900 kcal/kgmole
Mean Cp of Zinc vapour = 4.97 kcal/kgmole ^{0}C
Atomic weight of Zn = 65.4 kg/kgmole

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OR

Q.4 **(a)** A heat exchanger for cooling a hot hydrocarbon liquid uses 10000 kg/h of cooling water, which enters the exchanger at 294 K. The hot oil at the rate of 5000 kg/h enters at 423 K and leaves at 338 K and has an average heat capacity of 2.5 kJ/kg K. Calculate the outlet temperature of water. **07**

(b) Using Watson equation, calculate latent heat of vaporization of **07**

(a) Acetone at 313K
(b) Carbon disulphide (CS_2) at 413 K.

T_1 (boiling point temp)	Component	Latent heat of vaporization at T_1, K (KJ/kmol)	T_c	n
329.4	Acetone (C_3H_6O)	29121	508.1	0.38
319	CS_2	26736	552.0	0.38

Q.5 **(a)** Calculate the theoretical flame temperature of gas having 20 % CO and 80 % N_2 burnt with 150 % excess air. Both air and gas are being at 25 ^{0}C. **07**

Data: heat of formation of CO_2 = -94,052 cal /gmol , CO = -26,412 cal/ gmol at 25 ^{0}C. C_{pm} : CO_2 = 12.1 , O_2 = 7.9 , N_2 = 7.55 cal/ gmol K.

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

i. Dry-bulb temperature
ii. Wet bulb temperature
iii. Latent heat
iv. Absolute humidity
v. Percentage humidity
vi. Dew point
vii. Humid heat

OR

Q.5 **(a)** Pure CO is mixed with 100 percent excess air and completely burned at constant pressure. The reactants are originally at 400 K. Determine the heat added or removed if the products leave at 600 K. The standard heat of reaction at 298 K is 282.99 kJ per mol CO burned. The mean specific heats applicable in the temperature range of this problem are 29.10, 29.70 and 41.45 J / mol K respectively for CO, O_2, N_2 and CO_2. **07**

(b) The heat of combustion of methane, carbon and hydrogen are -890.4 kJ/mol, -393.51 kJ/mol and -285.84 kJ/mol respectively. Calculate the heat of formation of methane. **07**

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