Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

B. E. - SEMESTER – IV • EXAMINATION – WINTER 2012

Subject code: 140504 Date: 31/12/2012

Subject Name: Fundamental Chemical Engineering Calculations & Stoichiometry

Time: 02.30 pm - 05.00 pm Total Marks: 70

Instructions:

1. **Attempt any five questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Atomic Weights: C: 12, H: 1, O: 16, S: 32, Zn: 65.4, K: 39. Mg: 24.3, N: 14, Cu: 63.5, Fe: 55.8, Ca: 40, Na: 23**

Q.1 (a) The conductance of a fluid flow system for an orifice meter is given by 04

$$C = 89.2\,A\sqrt{T/M} \ \text{ft}^3/\text{s}$$

Where A = area of opening in ft^2, T = temperature in ^oR and M = molar mass. Convert the empirical equation into SI units.

(b) A plane travels at twice the speed of sound. Assume the speed of sound is 1100 ft/sec. How fast it is going in km/hr? 03

(c) Calculate the density of superheated steam at 10 MPa a and 350 ^0C using (i) the ideal gas law and (ii) the Van der Waals equation. The value of T_C and P_C for water is 647.11 K and 22.076 MPa respectively. 07

Q.2 (a) A sample of coal from West Bengal is found to contain 67.2% carbon and 22.3% ash (mass basis). The refuse obtained at the end of combustion is analyzed to contain 7.1% carbon and rest ash. Compute the original carbon remaining un-burnt in the refuse. 07

(b) Cracked gas from a petroleum refinery has the following composition by volume: methane 45%, ethane 10%, ethylene 25%, propane 7%, propylene 8%, *n*-butane 5%. Find (i) the average molecular weight of the gas mixture, (ii) the composition by weight, and (iii) specific gravity of the gas mixture. 07

OR

(b) A solution of sodium chloride in water contains 20% sodium chloride (by mass) at 60 ^oC. The density of the solution is 1.127 kg/L. Find the molarity, normality and molality of the solution. 07

Q.3 (a) Slabs of building boards contain 16% moisture. They are dried to a water content of 0.5% by circulating hot air over them. The outgoing air contains 0.09 kg water vapour per kg dry air. Calculate the quantity of fresh air required per 1000 kg/h net dry board, if the fresh air is supplied at 301 K and 101.325 kPa containing 0.02 kg/kg dry air humidify. 07

(b) Discuss about the use of recycle and bypass operation in industry. 07

OR

Q.3 (a) The analysis of the gas entering the secondary converter in a contact sulphuric acid plant is 4% SO_2, 13% O_2 and 83% N_2 (on volume basis). The gas leaving the converter contains 0.45% SO_2 on SO_3 free basis (by volume). Calculate the percentage of SO_2 entering the converter getting converted to SO_3. 07

(b) (i) Define Limiting reactant and Excess reactant 07
(ii) What is meant by percentage Conversion and percentage Yield?

Q.4 (a) Pyrites fines are roasted in chamber plant for making sulphuric acid. The gases leaving the roaster are at 775 K. Calculate the heat content of 1 kmol gas mixture over 298.15 K. The heat capacity data and molar composition of leaving gases are given in the table: 07

Constants	% Composition	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
SO_2	7.09	24.77	62.94	-44.25	11.12
O_2	10.55	26.02	11.75	-2.34	-0.56
SO_3	0.45	22.03	121.62	-91.86	24.36
N_2	81.91	29.59	-5.14	13.18	-4.96

(b) (i) Calculate the vapor pressure of n-hexane at 32°C and water at 122°C using Antoine equation. 04

$$\ln p_V = A - \frac{B}{T + C}$$

Component/Constants	A	B	C
n-hexane	14.0568	2825.42	-42.7089
water	16.5362	3985.44	-38.9974

(ii) Calculate the latent heat of vaporization for m-xylene at T_B using Riedel equation given that Pc = 3535 kPa and Tc = 617.05 K, T_B = 412.2 K 03

OR

Q.4 (a) Water is pumped from well 40 m deep at the rate of 2 L/s into an atmospheric storage tank 12 m above the ground level. A heater puts 50 kW energy to avoid freezing during transfer. An 18 kW heat is lost at constant rate. A 1.8 kW pump is used with 55% efficiency. Assume the kinetic energy change negligible. Calculate the change in internal energies between the storage tank and the bottom of well. 07

(b) A mixture of Benzene and water containing 16.6 % (Mass %) ethanol, is sub-cooled in the overhead condenser of the distillation tower from 450 K to 380 K with the help of cooling water at the rate of 7500 kg/hr. Find the heat removal rate of the sub-cooling zone of the condenser. Molecular weight of benzene and water is 78 and 18 g/gmole respectively. The constant for benzene and water are given as follows: 07

Constants	Benzene	Water
a	-484.365	50.845
$b \times 10^3$	5056.235	213.08
$c \times 10^6$	-14292.204	-631.398
$d \times 10^9$	14419.754	648.746

Q.5 (a) An absorption tower is used to absorb CO_2 in an aqueous monoethanol amine ($HOCH_2CH_2NH_2$) solution. The volumetric flow rate of incoming dry gas is 1000 m^3/hr at 318 K and 1 atm pressure. The CO_2 content of the gas is 10.4 mole%, while the outgoing gas mixture contains 4.5 mole % CO_2. A 3.2 Molar MEA solution is introduced at the top of the column at the rate of 0.625 L/s. The dissolved CO_2 concentration of the entering solution is 0.166 kmole/kmole MEA solution. Represent the process with neat schematic diagram. Find the concentration of dissolved CO_2 in the solution leaving the tower. The specific volume of gas at given operating condition is 26.107 m^3/kmol. 07

(b) Define the following terms with supporting equations: (i) Absolute humidity (ii) Relative humidity (iii) Humid heat 07

OR

Q.5 (a) Define the following unit operation with their at least one industrial application. (i) Distillation (ii) Liquid-liquid extraction and (iii) Drying. 07

(b) A solution of ethyl alcohol containing 8.6% alcohol is fed at the rate of 1000 kg/h to a continuous distillation column. The distillate contains 95.5% alcohol and the waste solution from bottom carries 0.1% alcohol. All percentages are by mass. Represent the process with neat schematic diagram. Calculate the (i) mass flow rate of top and bottom product and (ii) percentage loss of alcohol. 07

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