Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

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

Subject Code:2130504 **Date:02/06/2015**

Subject Name: PROCESS CALCULATION

Time:02.30pm-05.30pm **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: C=12, H=1, N=14, S=32, Ca=40, Na=23, Cl=35.5, Mg=24, O=16**

Q.1 **(a)** The conductance of a fluid flow system is defined as the volumetric flow rate, referred to a pressure of one torr (133.233 Pa). For an orifice, the conductance C can be computed from **07**

$$C = 89.2\ A\ (T/M)^{1/2}\ ft^3/s$$

where, A = area of opening, ft^2, T = temperature, ^0R, M = Molar mass

Convert the empirical equation in SI units.

(b) Define: (i) limiting reactant (ii) selectivity (iii) excess reactant (iv) law of conservation of energy (v) yield (vi) latent heat of vaporization (vii) calorific value of fuel **07**

Q.2 **(a)** The feed water to the reverse osmosis plant has dissolved solids to the extent of 5000 mg/L. The feed to product ratio (on mass basis) is 4:3. The treated water (product) from the plant contains 600 mg/L of solids. Find the dissolved solids in the reject stream. **07**

(b) The analysis of a sewage gas sample from a municipal sewage treatment plant is given below on a volume basis: Methane 68%, Carbon dioxide 30%, Ammonia 2%, and Traces of H_2S, SO_2, etc. Find (a) the average molar mass of the gas; and (b) the density of the gas at NTP. **07**

OR

(b) Heat capacity data for gaseous SO_2 are reported in standard data book and also by following equation $C^0_{mp} = 43.458 + 10.634 \times 10^{-3}\ T - 5.945 \times 10^5/\ T^2$ Calculate the heat required to raise the temperature of 1 kmol pure SO_2 from 300 to 1000 K, using the above equation. **07**

Q.3 **(a)** A sample of milliolite limestone, obtained from Porbandar, Gujarat, is found to contain 54.5% CaO (by mass). If this CaO is present as $CaCO_3$ in the limestone, find the content of $CaCO_3$ in the limestone. **07**

(b) A solution of sodium chloride in water contains 20% NaCl (by mass) at 333 K. The density of the solution is 1.127 kg/L. Find the molarity, normality and molality of the solution. **07**

OR

Q.3 **(a)** A 100 kg mixture of 27.8% of acetone (A) and 72.2% of chloroform (B) by mass is to be batch-extracted with a mixed solvent at 298 K (250 C). The mixed solvent of an unknown composition is known to contain water (S_1) and acetic acid (S_2). The mixture of the original mixture and the mixed solvent is shaken well, allowed to attain equilibrium, and separated into two layers. The compositions of the two layers are given below. **07**

Composition of immiscible Layers

	Composition, mass%			
Layer	A	B	S_1	S_2
Upper layer	7.5	3.5	57.4	3.16
Lower layer	20.3	67.3	2.8	9.6

Find (a) the quantities of the two layers, (b) the mass- ratio of the mixed solvent to the original mixture, and (c) the composition of the mixed solvent (mass basis).

(b) CO_2 dissolved to the extent of 38 liter per liter of solution of 27.5% by weight DAPOL. The volume of CO_2 gas measured at 101.325 kPa and 288.7 K. Find Wt% and mole% of CO_2 in solution. Density of the solution is 1.04 kg/L. Molecular weight of DAPOL is 89. **07**

Q.4 **(a)** The analysis of limestone gives 60% $CaCO_3$, 33.5% $MgCO_3$ and rest inerts. It is treated with 12% aqueous sulphuric acid by mass to obtain pure CO_2. An excess of 15% of the acid over the stoichiometric amounts is used to ascertain that the reaction goes to completion. Based on the treatment of 500 kg limestone, calculate: (a) the amount of 100% (by mass) sulphuric acid required, (b) the amount of the residue, (c) the analysis of the residue left in the vessel, and (d) the moles of CO_2 produced. **08**

(b) Discuss the importance of recycling and bypassing operation. **06**

OR

Q.4 **(a)** A fertilizer plant manufactures ammonia using water gas and producer gas as raw materials. The compositions of the gases are given below. **12**

	Analysis , % of by volume	
Component	Water gas	Producer gas
N_2	2	63
H_2	51	5
CO	43	25
CO_2	4	5
Ar	Nil	2
Total	100	100

Both the gases are mixed in proper proportions to provide a stoichiometric mixture of nitrogen and hydrogen after converting carbon monoxide to cabon dioxide using steam. Calculate:(a) the kmol of water gas and the producer gas required to obtain 100 kmol of dry mixed gas, (b)the analysis of dry mixed gas, and (c) the theoretical amount (in kg) of steam required to convert CO to CO_2 per 100 kmol of dry mixed gas.

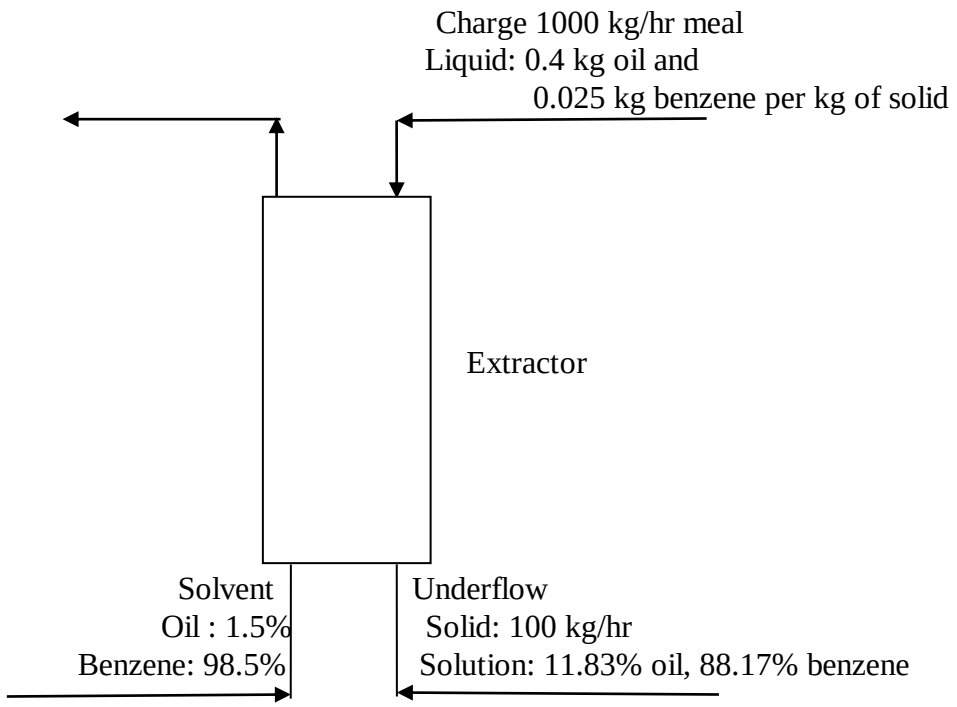
(b) Give classification of fuel in brief. **02**

Q.5 (a) A thermic fluid is used as a heating medium in a particular process. A pump sucks the thermic fluid at atmospheric pressure and 473 K. The circulation rate is 10000 L/h. The fluid discharged from the pump, passes through a heater where it receives the heat from the product gases of combustion. The heat transfer rate is 232.6 kW. The motor of the pump consumes 1.1 kW. The overall mechanical efficiency of the pump and motor is 50%. The pressure of the fluid at the outlet of the heater is 100 kPa g. Assume Kinetic energy change, potential energy change, friction losses and heat losses to the surrounding are negligible. If the mean specific gravity and mean heat capacity of the fluid are 0.75 and 2.68 kJ/(kg.K) respectively at the operating condition, calculate the outlet temperature of the fluid. **08**

(b) Explain standard heat of reaction, standard heat of formation and standard heat of combustion. **06**

OR

Q.5 (a) Oil is to be extracted from meal by a continuous counter current extractor. The unit is charged with 1000 kg/hr meal based on oil-free solids. Untreated meal contains 0.4 kg oil and 0.025 kg benzene per kg oil-free meal. Fresh solvent is benezene containing 1.5% oil (mass %). The ratio of the fresh solvent to the oil-fresh meal is kept at 0.065 kg/kg. The solid meal retains 0.507 kg solution per kg solid. The solution retained by the meal contains 11.83% oil (mass %). Make a complete material balance find and the composition and the amount of overflow from the extractor. The process is shown in diagram below. **09**



(b) A producer gas with the composition by volume, 27.3% CO, 5.4% CO_2, 0.6% O_2, 66.7 % N_2 is burnt with 20% excess air. If the combustion is 98% complete, calculate the composition by volume of the flue gases. **05**

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