Seat No.: _____ *Enrolment No._____*

GUJARAT TECHNOLOGICAL UNIVERSITY

BE SEM-III Examination May 2012

Subject code: 130504

Subject Name: Process Calculation

Date: 10/05/2012 **Time: 02.30 pm – 05.30 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 Weights: C:12, H:1, O:16, S:32, Cl:35.5, N:14, Ca:40, K:39, Cu:63.5, Fe:55.8,Na:23,Zn : 65**

Q.1 **(a)** A force equal to 17.635 kgf is applied on a piston with a diameter of 6 cm. Find the pressure exerted on the piston in kPa, bar and psi. **03**

(b) Ethanol is present in the aqueous solution to the extent of 1000 mg/l. Find TOC and ThOD of the solution in mg/l. **04**

(c) In case of liquids, the local heat transfer coefficient for long tubes and using bulk temperature properties is expressed by the empirical equation **07**

$h = 0.026\ G^{0.8} \times k^{0.67} \times c_p^{0.33} / (D^{0.2} \times \mu^{0.47})$

where h= heat transfer coefficient, $Btu/(h.ft^2.{}^0F)$

G= mass velocity of liquid, $lb/(ft^2.s)$

c_p= heat capacity, $Btu/(lb.{}^0F)$

D= diameter of tube, ft and

K=Thermal conductivity in $Btu/(h.ft.{}^0F)$

μ = viscosity of liquid, (lb/ft.s)

Convert the empirical equation into SI units.

Q.2 **(a)** An aqueous solution of K_2CO_3 is prepared by dissolving 44 g K_2CO_3 in 100 g water at 293 K. Find molarity, normality and molality of the solution. Take density of solution as 1.3 kg/lit. **07**

(b) The analysis of sewage gas sample from a municipal sewage treatment plant is given below on a volume basis. **07**

Methane	68%
Carbon dioxide	30%
Ammonia	2%
H_2S, SO_2	Traces

Find (a) the average molecular weight of the gas; and (b) the density of the gas at NTP.

OR

(b) A weight of 1.20 kg of Carbon dioxide occupies a volume of 33 liter at 300 K. Using the Van der Waals equation of state, calculate the pressure. **07**

Data: For CO_2 , take a = 3.60 $[(m^3)^2\text{-kPa}]/(kmol)^2$

and b = 4.3 x 10^{-2} $m^3/kmol$

Q.3 **(a)** A sample of coal from Andrew Yules colliery. West Bengal is found to contain 67.2% carbon and 22.3% ash (weight basis). The refuse obtained at the end of combustion is analyzed to contain 7.1% carbon and the rest ash. **07**

Compute the % of the original carbon remaining burnt in the refuse.

(b) A spent solution of Chloroacetic acid (Mol. Wt.: 94.5) in ether (Mol. Wt.:74.0) contains 20 mole % Chloroacetic acid. It is desired to make 1 ton of a saturated solution at 298 K. Find the quantities of spent solution and Chloroacetic acid required to make the above solution. **07**

Data**:** Solubility of Chloroacetic acid in ether is 190g/100g ether at 298 K.

OR

Q.3 A mixture of pyrites and zinc sulphide ore is burnt in a burner. The mixtures contains 75% pyrites and 25% zinc sulphide ore. The pyrites yield 92% FeS_2 and rest gangue. The zinc sulphide ore contains 68% ZnS and rest inerts. A sample of cinder yields 3.5% S. 70% of S in the cinder in the form of SO_3, absorbed in it, and rest is unoxidized FeS_2. All percentage are by weight. Based on 100 kg of mixed charge, calculate: (a) the amount of cinder formed with its analysis and (b) the percentage of sulphur left in the cinder based on the total sulphur charged. **14**

Q.4 **(a)** Discuss recycling and bypassing and parallel operation. **04**

(b) Discuss process flow diagram and process instrumentation diagram **03**

(c) Selective dehydrogenation of alkanes to alkenes is a well established process. In this process, dehydrogenation of i-butane is carried out on a platinum impregnated catalyst at 50kPa g and 773 K. The feed to the reactor is pure i-butane along with 0.75kmol H_2 per kmol of i-butane. Hydorgen stream contains 90% H_2 and 10% methane (by mole). Following reactions are known to take place. **07**

$$\underset{\text{i-butane}}{\textbf{i-}C_4H_{10}} = \underset{\text{i-butylene}}{\textbf{i-}C_4H_8} + H_2$$

$$\underset{\text{i-butane}}{\textbf{i-}C_4H_{10}} = \underset{\text{propylene}}{C_3H_6} + CH_4$$

Literature reports 50% per pass conversion in a battery of three reactors with 80% yields of i-butylene. Calculate the composition of the product stream leaving the final reactor.

OR

Q.4 **(a)** A heat exchanger for cooling hot oil uses 10000 kg/hr of cooling water, which enters the exchanger at 294 K. The hot oil at the rate of 5000 kg/hr enters at 423 K and leaves at 338 K and has an average heat capacity of 2.51 KJ/kg K. Calculate the outlet temperature of the water. **07**

(b) Liquid benzene, C_6H_6 at 303 K is mixed and dissolved continuously in liquid toluene, C_7H_8 at 373 K in the molar proportion 3:2 in an insulated mixing tank. If the heat of mixing is assumed to be zero, what is the temperature of the mixed solution? **07**

Heat capacity data for Benzene and Toluene

Temperature, K	Heat capacity(c), KJ/kg.K	
	Benzene	Toluene
283	1.591	1.524
338	2.018	-
358	-	2.236

Assume the variation of the heat capacity is linear with temperature, i.e. c = a + bT KJ/(kg.K)

Where a and b are constants.

Solve the problem by using the data given in Table.

Q.5 **(a)** Using Watson equation, Calculate laten heat of vaporization of **07**
(a) acetone at 313K (40^oC) and
(b) carbon disulphide (CS_2) AT 413 K

T_1 (Boiling point temp)	component	Laten heat of vap at T_1, K (KJ/kmol)	T_c	n
329.4	Acetone(C_3H_6O)	29121	508.1	0.38
319.0	CS_2	26736	552.0	0.38

(b) Isothermal and isobaric absorption of SO_2 is carried out in a packed tower containing Raschig rings. The gases enter the bottom of the tower containing 14.8% SO_2 by volume. Water is distributed at the top of the column at the rate of 16.5 lit/s. The total volume of the gas handled at 101.3 kPa and 303 K is 1425 m^3/h. The gases leaving the tower are found to contain 1.2 % SO_2 by volume. Calculate the % SO_2 by mass in the outlet water. **07**

OR

Q.5 **(a)** A solution of ethyl alcohol containing 8.6% alcohol is fed at the rate of 1000 kg/hr to a continuous distillation column. The product (distillate) is a solution containing 95.5% alcohol. The waste solution from the column carries 0.1% of alcohol. All percentages are by mass. Calculate (a) the mass flow rates of top and bottom products in kg/h and (b) the percentage loss of alcohol. **07**

(b) Define the following terms with reference to air-water humidification operation: **07**

(1) Dry-bulb temperature
(2) Absolute humidity
(3) Percentage humidity
(4) Relative humidity
(5) Humid heat
(6) Humid volume
(7) Dew point

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