Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

B.E. Sem-III Regular / Remedial Examination December 2010

Subject code: 130504 **Subject Name: Process Calculation**

Date: 16 /12 /2010 **Time: 10.30 am – 01.30 pm**

Total Marks: 70

Instructions:

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

Q.1 **(a)** **(i)**Define: **03**

(i) Conversion (ii) Yield (iii) Specific gravity of a gas

(ii) Vapour pressure of benzene in the temperature range of 280.65 K (7.5^{o} C) to **04**

377.15 K(104^{o}C) can be calculated. By using the following Antoine equation.

$$\log_{10} p = 6.9057 - \frac{1211.0}{t + 220.8}$$

where, p = vapour pressure in torr (mm Hg), t = temperature in ^{o}C .

Convert the equation in SI units.

(b) An aqueous solution of acetic acid of 35% concentration (by mass) has density 1.04 kg/L at 298.15 ^{0} K. Find the normality, molarity and molality of the solution. **07**

Q.2 **(a)** The analysis of a 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, etc.	Traces

Find i) the avg. molar mass of gas;

ii) the density of gas at NTP

(b) The spent acid from a nitrating process contains 33% H_2SO_4, 36% HNO_3 and 31% water by weight. This acid is to be strengthened by the addition of concentrated sulphuric acid containing 95% H_2SO_4 and concentrated nitric acid containing 78% HNO_3. The strengthened mixed acid is to contain 40% H_2SO_4 and 43% HNO_3. Calculate the quantities spent and concentrated acids that should be mixed together to yield 1500 kg of the desired mixed acid. **07**

OR

(b) A vent stream from an ethyl benzene plant has a composition: 66% H_2, 33% CH_4 and 1% other components (CO + C_2H_6 etc.). It is passed through a PSA Unit where hydrogen is recovered as 98% pure stream with 2% CH_4 as an impurity. Recovery of hydrogen is 85% at feed pressure of 50 bar. Calculate the composition of reject stream. **07**

Q.3 **(a)** The average molar mass of a flue gas sample is calculated by two different engineers. One engineer uses the correct molar mass of 28 for N_2 and determines the average molar mass to be 30.08, the other engineer, using an incorrect value of 14, calculates the average molar mass to be 18.74. **07**

(i) Calculate the volume % of N_2 in the flue gases (ii) If the remaining components of the flue gases are CO_2 and O_2, calculate the volume % of each of them.

(b) **(i)**Discuss methods of solving material balance problems without chemical reaction. **03**

(ii) Discuss the importance of recycling and bypassing operation. **04**

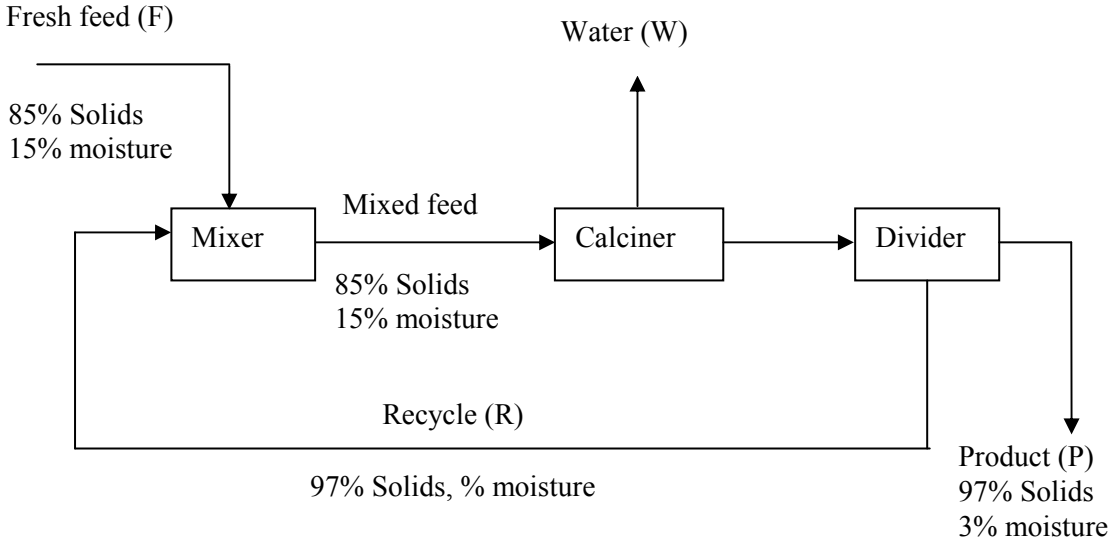
OR

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 contain 0.09 kg water vapor 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 0.2 kg/kg dry air humidity. **12**

(b) Define (i) Raoult's law (ii) Dalton's law **02**

Q.4 **(a)** A pilot plant reactor was charged with 50 kg naphthalene ($C_{10}H_8$) and 200 kg (98% by mass)H_2SO_4. The reaction was carried out for 3 hours at 433 K. The reaction goes near completion. The product distribution was found to be 18.6 % monosulphonate naphthalene ($C_{10}H_7\ SO_3H$) and 81.4 % disulphonate naphthalene ($C_{10}H_6\ 2SO_3H$). Calculate (i) the quantities of monosulphonate (MSN) and disulphonate (DSN) products, and (ii) The complete analysis of product. **07**

(b) In a particular drying operation, it is necessary to hold the moisture content of feed to a calciner to 15% (mass) to prevent lumping and sticking. This is accomplished by mixing the feed having 30% moisture (mass) with a recycle stream of dried material having 3% moisture (mass). The drying operation is shown in given figure. What fraction of the dried product must be recycled? **07**



OR

Q.4 **(a)** Heat capacity data for gaseous SO_2 are reported by following equation **07**
$C^0_{mp} = 43.458 + 10.634 \times 10^{-3} - 5.945 \times 10^5 / T^2$ Calculate the heat required to raise the temperature of 1 mol pure sulphur dioxide from 300 to 1000 K.

(b) 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 conventer 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**

Q.5 **(a)** (i) Explain standard heat of reaction and standard heat of combustion. **04**

(ii) In the production of sulfuric acid from anhydride , the gypsum is roasted with clay to obtain SO_2 and cement clinker. The reaction proceed as follows: **04**

$3CaSO_{4(g)} + SiO_{2(s)} \rightarrow 3CaoSiO_{2(g)} + 3SO_{2(g)} + 1.5O_{2(g)}$

Calculate the standard heat of reaction at 298.15K.

Data:

Component	ΔH_{f298K} kJ/mol
$CaSO_4$	-1432.7
SiO_2	-903.5
3CaO. SiO_2	-2879.0
SO_2	-296.81

(b) Discuss in brief Proximate and Ultimate analysis of coal. **06**

OR

Q.5 **(a)** A mixture containing 47.5% acetic acid and 52.5% water (by mass) is being separated by the extraction in a counter-current multistage unit. The operating temperature is 297 K and the solvent used is pure iso-propyl ether. Using the solvent in the ratio of 1.3 kg/kg feed, the final extraction composition on a solvent free basis is found to be 82% by mass of acetic acid. The raffinate is found to contain 14% by mass of acetic acid on a solvent free basis. Calculate the percentage of acid of the original feed which remains unextracted. **07**

(b) The Orsat analysis of the flue gases shows CO_2 = 12.4%, CO = 3.1%, O_2 = 5.4% and N_2 = 79.1% by volume. All the hydrogen but only 85% of the carbon in the fuel appears in the flue gases. Calculate the percent excess air used. Assume that negligible oxygen and nitrogen are present in the fuel. **07**

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