Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–IV (New) EXAMINATION – WINTER 2015

Subject Code:2140406 **Date:28/12/2015**

Subject Name: STOICHIOMETRY

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. **Mol. Wt:** Na = 23, K=39, O= 16, H=1, N=14, C=12, Mg=24, Ca=40, S=32, Cl=35.5

Q.1 **(a)** Single effect evaporator concentrating weak liquor containing 4% solids to 55% solids (by weight) is fed with 5000 kg/h of weak liquor. Calculate: a) water evaporated per hour, and b) flow rate of thick liquor. **07**

(b) It is required to make 1000 kg mixed acid containing 60% H_2SO_4, 32% HNO_3, and 8% water by blending (i) the spent acid containing 11.3% HNO_3, 44.4% H_2SO_4, 44.3% H_2O, (ii) aqueous 90% HNO_3 and (iii) aqueous 98% H_2SO_4. All % are by weight. Calculate the quantities of each of the three acids required for mixing. **07**

Q.2 **(a)** Classify the material balance. Discuss the various methods involved for solving material balance problems without chemical reactions. **07**

(b) The average molecular mass of a flue gas sample is calculated by two different engineers. One engineers uses the correct molecular mass of 28 for N_2 and determines the average molecular mass to be 30.08, the other engineers, using an incorrect value of 14, calculates the average molecular mass to be 18.74. (a) Calculate the volume% of N_2 in the flue gases. (b) If the remaining components of the flue gases are CO_2 and O_2, calculate the volume % of each of them. **07**

OR

(b) A sample of aqueous triethanolamine (TEA) solution contains 47% TEA (on volume basis). If density of pure TEA is 1125 kg/m^3, find the weight % of TEA in the solution **07**

Q.3 **(a)** An aqueous solution of acetic acid of 35% concentration (by weight) has density 1.04 kg/L at 298 K (25°C). Find the molarity, normality and molality of the solution. **07**

(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 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**

OR

Q.3 **(a)** Monochloroacetic acid (MCA) is manufactured in a semi batch reactor by the action of glacial acetic acid with Cl_2 gas at 373 K in presence of PCl_3 catalyst. MCA thus formed will further react with Cl_2 form dichloroacetic acid (DCA). To prevent the formation of DCA, excess acetic acid is used. A small scale unit which produces 5000 kg/day MCA, requires 536 kg/day of Cl_2 gas. Also, 263 kg/day of DCA is separated in the crystallizer to get almost pure MCA product. Find % conversion of Cl_2, % yield of MCA and selectivity. **07**

(b) What will be the composition of gases obtained by burning pure FeS_2 with 60% excess air? Assume that the reaction proceeds in the following manner. **07**

$$4FeS_{2(s)} + 11O_{2(g)} \longrightarrow 2Fe_2O_{3(s)} + 8SO_{2(g)}$$

Q.4 **(a)** In the Deacon process for the manufacture of chlorine, a dry mixture of hydrochloric acid gas and air is passed over a heated catalyst which promotes oxidation of acid. Air is used 30% in excess of that theoretically required. Calculate the weight of air supplied per kg of the acid. The reaction taking place is $4HCl + O_2 \rightarrow 2Cl_2 + 2H_2O$. **07**

(b) Find out the value of the universal gas constant R in following units: **07**

a) atm.lit/gmol.K
b) J/gmol.K
c) cm^3.atm/kmol.K
d) kPa.m^3/kmol.K

OR

Q.4 **(a)** Define: i) yield, ii) limiting component, iii) excess reactant, iv) conversion, v) selectivity, vi) inert, vii) process flow sheet. **07**

(b) A heat exchanger for cooling a hot hydrocarbon liquid 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 water. **07**

Q.5 **(a)** A stream of carbon dioxide flowing at a rate of 100 kmol/min is heated from 298 K to 383 K. Calculate the heat that must be transferred using C_p^o data given below: **07**

C_p^o (kJ/kmol.K) = $a + bT + cT^2 + dT^3$

Gas	**a**	**b × 10^3**	**c × 10^6**	**D × 10^9**
CO_2	21.3655	64.2841	-41.0506	9.7999

(b) Differentiate between: (i) Sensible heat and latent heat (ii) Endothermic and exothermic reactions (iii) Internal energy and external energy **07**

OR

Q.5 **(a)** Soyabeen seeds are extracted with n-hexane in batch extractors. The flaked seeds contain 18.6% oil, 69.0% solids and 12.4% moisture. At the end of the extraction process, de-oiled cake (DOC) analysis yields 0.8% oil, 87.7% solids and 11.5% moisture. Find the percentage recovery of oil. All percentages are by mass. **07**

(b) 1000 kg of sodium carbonate solution containing 25% sodium carbonate is subjected to evaporative cooling, during which process 15% of the water present in the solution is evaporated. From the concentrated solution $Na_2CO_3.10H_2O$ crystallizes out. Calculate how much crystals would be produced if the solubility of $Na_2CO_3.10H_2O$ is 21.5 gm per 100 gm of water. **07**

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