Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– III EXAMINATION – SUMMER 2015

Subject code: 130504 **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 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)** An industrial-strength drain cleaner contains 5 kg of water and 5 kg NaOH. What are the weight fraction and mole fraction of each component in the drain cleaner container? **03**

(b) The analysis of sewage gas sample from a municipal sewage treatment plant is given below on a volume basis. **04**

Ethane	65%
Carbon Monoxide	33%
Ammonia	2%
H_2S, SO_2	Traces

Find (a) the average molecular weight of the gas, and
(b) the density of the gas at STP

(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**

$h = 0.023\, G^{0.8} \times k^{0.67} \times c_p^{0.33} / (D^{0.2} \times \mu^{0.47})$

where h= heat transfer coefficient, Btu/(hr ft^2 ^{0}F)
G= mass velocity of liquid, lb/(ft^{2}s)
c_p= heat capacity, Btu/(lb ^{0}F)
D= diameter of tube, ft and
K=Thermal conductivity in Btu/(hr ft ^{0}F)
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 86 kg K_2CO_3 in 200 kg water at 293 K. Find molarity, normality and molality of the solution. Take sp. gravity of solution as 1.29. **07**

(b) A mixture of $CuSO_4.5H_2O$ and $FeSO_4.7\ H_2O$ weighs 100gm. It is heated in an oven at 378 K to evaporate the water of hydration. The mass of mixture after removal of water is 59.78gm. Calculate the mass ratio of $CuSO_4$ to $FeSO_4$ in the mixture. **07**

OR

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

Q.3 **(a)** Explain the following terms with reference to chemical process **07**

(1) Process flow diagram
(2) P & I diagram
(3) Degree of freedom
(4) Limiting component
(5) Recycling operation
(6) By passing operation
(7) Excess component

(b) 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**

OR

Q:3 Zinc sulphide ore containing 74% ZnS and 26% inerts are roasted in a burner. Assume complete combustion of the ore to SO_2 with dry air at 300K, 50% of the stoichiometric amount air required for the complete roasting of the ore. The gases are passed through V_2O_5 catalyst bed was nearly 98% of SO_2 gets converted to SO_3. The converter gases are passed through an absorption tower where all SO_3 is absorbed in the form of H_2SO_4 of 90% strength. It is desired to produce 1000 kg/h of 90% acid by spraying pure water at the top of absorption tower. **14**

Calculate: (a) the analysis of the burner gases, (b) the analysis of the converter gases, (c) the quantity of the ore to be roasted per hour and (d) the volumetric flow rate of the air entering the converter in m^3/h.

Q.4 The Analysis of limestone gives 60% $CaCO_3$, 33.5% $MgCO_3$ and rest inert. 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 residue (c) the analysis of the residue left in the vessel and (d) the moles of CO_2 produced. **14**

OR

Q.4 **(a)** Pyrite ore is roasted in chamber plant for making sulphuric acid. The gases leaving the roaster are at 775 K and have molar composition SO_2 = 7.09%, O_2 = 10.55%, SO_3 = 0.45% and N_2 = 81.91%. Calculate the heat content of 1 kmol gas mixture over 298.15 K by using the given heat capacity data: **07**

Component	a	b x10^3	c x 10^6	d x 10^9
SO_2	24.7706	62.9481	-44.2582	11.122
O_2	26.0257	11.7551	-2.3426	-0.5623
SO_3	22.0376	121.624	-91.8673	24.3691
N_2	29.5909	-5.141	13.1829	-4.968

Where, Cp is in KJ/Kmol K and T in K.

Q:4 **(b)** Using Watson equation, Calculate laten heat of vaporization of **07**

(1) acetone at 400 K
(2) carbon disulphide (CS_2) at 450 K

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

Q.5 **(a)** 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

(b) 10,000 kg of an aqueous solution containing 29.6% (by wt.) anhydrous sodium sulfate at 413 K is charged to the crystallizer. During the cooling operation, 5% of the initial water is lost by evaporation and $Na_2SO_4.10H_2O$ is crystallized out. The mother liquor is found to contain 18.3% (by wt.) anhydrous sodium sulfate. Calculate the yield of crystals and the quantity of mother liquor. **07**
Molecular wt. of Na_2SO_4 = 142

OR

Q.5 **(a)** Discuss Proximate and Ultimate analysis of coal **07**

(b) A furnace is fired with fuel oil. The Orsat analysis of flue gases by volume is as given below: **07**

CO_2 = 10.6%, O_2 = 6% and N_2 = 83.4%

Calculate:

(a) the percent excess air used and
(b) the C: H ratio in the fuel oil, assuming that the fuel does not contain nitrogen.