55

SY

DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE

End Semester Examination – December 2019

Course: B. Tech in Chemical/Petrochemical Engineering **Sem: III**

Subject: Chemical Process Calculations (BTCHC302) **Marks: 60**

Date: 12/12/2019 **Duration:- 3 Hr.**

Instructions to the Students:

1. **Answer any five questions**
2. **Necessary data required is provided in the respective questions**

		(Level/CO)	Marks
Q. 1	**Answer the following.**		
(A)	The heat transfer coefficient for a stream to another is given by $h=16.6C_pG^{0.8}/D^{0.2}$ Where h = Heat transfer coefficient in $Btu/(h)(ft)^2(^0F)$ D = Flow diameter, in G = Mass velocity, $lb/(s)\ (ft)^2$ C_p = Specific heat, $Btu/\ (lb)\ (^0F)$ Convert this equation to express the heat transfer coefficient in $kcal/(h)(m)^2(^0C)$ With D= flow diameter in m, G= mass velocity in $kg/(m)^2s$ And Cp = Specific heat, $kcal/\ (kg)\ (^0C)$.	Apply	**06**
(B)	Differentiate between steady state and unsteady state mass balance.	Remember	**02**
(C)	A solution of caustic soda in water contains 20% NaOH by weight. The density of solution is 1196 kg/m^3. Find the Molality and Molarity of the solution.	Apply	**04**
Q.2	**Solve the following.**		
	A mixture of NH_3 and air at 730 mm Hg and 30 °C contains 5.1 % NH_3. The gas is passed through an absorption tower at the rate of 100 m^3/hr where NH_3 is removed. The gases leave the tower at 725 mm Hg and 20 °C having 0.05% NH_3. Calculate (a) the rate of flow of gas leaving the tower and (b) weight of NH_3 absorbed in kg/hr. **OR** The waste acid from nitrating process contains 23% HNO_3; 57% $H2SO_4$; 20% water. This acid is to be concentrated to 27% HNO_3, 60% % $H2SO_4$ by addition of 93% $H2SO_4$ and 90% HNO_3. Calculate the weight of acids needed to obtain 1000kg of desired acid.	Evaluate	**12**
Q.3	**Solve <u>any two</u> of the following.**		
(A)	Natural gas has the following composition in volumetric percent: CH_4 – 80%; C_2H_6 – 15%; N_2 – 5% Calculate (a) composition in weight %, (b) average molecular weight, and (c) Density at standard condition.	Apply	**06**
(B)	Hypo crystals $Na_2S_2O_3$. $5H_2O$ are to be produced at a rate of 2000 kg/h. A 60% $Na_2S_2O_3$ solution is cooled to 293 K from 333 K. The solubility at 293 K is 70 parts anhydrous salt per 100 parts of water. Estimate the amount of feed needed.	Apply	**06**
(C)	A solution of organic colloids is to be concentrated from 20 to 60 percent solids in an evaporator. The evaporator must evaporate 20 000 kg of water per hour. What is the rate of feed and concentrated solutions per hour?	Apply	**06**

Q. 4 Answer the following:

An evaporator concentrates 10,000 kg/hr of 20% KNO_3 solution to 50% KNO_3. The concentrated liquor is sent to a crystallizer where crystals of KNO_3 are formed and separated. The mother liquor from the crystallizer is recycled and mixed with the evaporator feed. The recycle stream is a saturated solution containing 0.6 kg KNO_3/ kg water. The crystals carry 4% water. Compute water evaporated and crystals formed. Evaluate **12**

OR

In a process for concentration of 1000 kg of freshly extracted orange juice containing 12.5 wt % solids, the juice is strained, yielding 800 kg of strained and 200 kg of pulpy juice. The strained juice is concentrated in a vacuum evaporator to give an evaporated juice of 58 % solids. The 200 kg of pulpy juice is bypassed around the evaporator and mixed with the evaporated juice in a mixer to improve the flavor. This final concentrated juice contains 42 wt % solids. Calculate the concentration of solids in the strained juice, the kg of final concentrated juice, and the concentration of solids in the pulpy juice.

Q.5 Solve <u>any two</u> of the following.

(A) A well stirred storage vessel contains 10,000 kg of a dilute methanol solution having a methanol concentration of 5% (by wt). A constant flow of 500 kg/min of pure water is suddenly introduced into the tank and a constant rate of withdrawal of 500 kg/min of solution is started. These two flows are continued and remain constant. Calculate the time required for the alcohol to drop to 1.0 % (by wt). Also, calculate the concentration of methanol in the tank after one hour. Apply **06**

(B) A butane isomerization process produces 70 kmol/h of pure isobutane. A purge stream removed continuously contains 85% n butane and 15% impurity (mole %). The feed stream is n-butane containing 1% impurity (mole %). If once through conversion is 70%, find the flow rates of the feed, purge and recycle streams. Apply **06**

(C) In the Deacon process for manufacturing chlorine, hydrochloric acid gas is oxidized with air. The reaction taking place is: $4\,HCl + O_2 \rightarrow 2\,Cl_2 + 2\,H_2O$. If the air is used in excess of 30% of that theoretically required, and if the oxidation is 80% complete, calculate the composition by volume of dry gases leaving the reaction chamber. Apply **06**

Q.6 Answer the following.

(A) Heat capacity of air can be approximately expresses as $Cp = 26.693 + 7.365 \times 10\text{-}3\ T$ where Cp is in J/(mol)(K) and T is in K. Find the heat given off by 1 mole of air when cooled at 1 atmospheric pressure from 500 °C to -100 °C. Apply **06**

(B) One mole of methane undergoes complete combustion in a stoichiometric amount of air. The reaction proceeds as $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$. Both the reactants and the products are in gas phase. $\Delta H°_{298} = -730$ kJ/mol of methane. If the average specific heat of all the gases/vapour is 40 J/(mol k), Find the maximum temperature rise of the exhaust gases in °C. Apply **06**

*****Paper End *****