Seat No.: _____ **Enrolment No._____**

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–III (NEW) - EXAMINATION – SUMMER 2017

Subject Code: 2130504 **Date: 02/06/2017**

Subject Name: Process Calculation

Time: 10:30 AM to 01:30 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, Na= 23, K= 39, Cl= 35.5, N= 14**

			MARKS
Q.1		**Short Questions**	**14**
	1	The value of gas constant 'R' is _____ m^3 atm/kmol K	
	2	At NTP, 1 atm = _____ mH_2O	
	3	Define: Normality and Molarity.	
	4	A sample of water contains 2000 ppm solids. Express the concentration of solids in the sample in weight percent.	
	5	Draw and explain with block diagram, distillation operation for a binary system.	
	6	Define "Tie" and "Inert" material with example.	
	7	If cooling tower water available at 298 K is used at a rate of 1500 kg/h for heat duty of 119647.78 kJ/h, calculate the outlet temperature of water assuming specific heat of water to be 4.187 kJ/kg K.	
	8	Calculate the quantity of ethylene required for the production of 100 kg ethylene oxide. $C_2H_4 + ½ O_2 \rightarrow C_2H_4O$	
	9	What is the composition of 100 kg 20 % oleum ?	
	10	In the production of sulphur trioxide, 100 kmol of SO_2 and 200 kmol of O_2 are fed to a reactor. The product stream is found to contain 80 kmol of SO_3. Find the percentage conversion of SO_2.	
	11	Define: Latent heat of vaporization and latent heat of sublimation	
	12	State Hess's Law of constant heat summation	
	13	Convert: Wavelength 9000A^o to nm	
	14	Iron metal weighing 500 lb occupies a volume of 29.25 L. Calculate the density of Fe in kg/dm^3.	
Q.2	**(a)**	Explain Ideal gas law, Dalton's law and Raoult's law.	**03**
	(b)	A sample of caustic flakes contains 74.6% Na_2O by weight. Determine the purity of flakes.	**04**
	(c)	Carbon dioxide is dissolved to the extent of 38 litres per litre of solution containing 27.5 wt. % A [mol. wt.= 79]. The volume of gas is measured at 101.325 kPa at 288 K. Calculate the weight % and mole % CO_2 in the solution. Density of the solution is 1.04 kg/L.	**07**
		OR	
	(c)	An aqueous solution of K_2CO_3 is prepared by dissolving 43 kg of K_2CO_3 in 100 kg of water at 293 K. Calculate the normality, molarity and molatity of the solution. Density of the solution is 1.3 kg/l.	**07**
Q.3	**(a)**	In a textile mill, a double effect evaporator system concentrates weak liquor	**03**

containing 4% (by mass) caustic soda to produce lye containing 25% solids (by mass). Calculate the evaporation of water per 100 kg feed in the evaporator.

(b) Explain recycle, bypass and purge streams with suitable diagram. **04**

(c) Pure sulphur is burnt in a sulphur burner using dry air. Oxygen is used 20% excess above that required for the complete combustion of sulphur to SO_3. The burner efficiency is such that only 30% of the sulphur burns to SO_3 and the remainder burns to SO_2. Calculate: (a) the analysis of the resulting mixture in mole% and (b) the weight of the gas produced per kg of sulphur burnt. **07**

OR

Q.3 **(a)** Define: (a) Yield (b) Conversion (c) Limiting and excess reactant **03**

(b) 100 kg mixture of 27.8% of acetone (A) and 72.2% of chloroform (B) by mass is to be batch-extracted with a mixed solvent at 25° C. The mixed solvent of an unknown composition is known to contain water (S_1) and acetic acid (S_2). The mixture of the original mixture and the mixed solvent is shaken well, allowed to attain equilibrium, and separated into two layers. The compositions of the two layers are given below. Find the quantities of the two layers. **04**

	Composition, mass%			
Layer	A	B	S_1	S_2
Upper Layer	7.5	3.5	57.4	31.6
Lower Layer	20.3	67.3	2.8	9.6

(c) It is required to make 1000 kg of 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 and 44.3% H_2O, (ii) aqueous 90% HNO_3, and (iii) aqueous 98% H_2SO_4. All percentages are by mass. Calculate the quantities of each of the three acids required for blending. **07**

Q.4 **(a)** Explain: (i) Watson equation and (ii) Riedel Equation. **03**

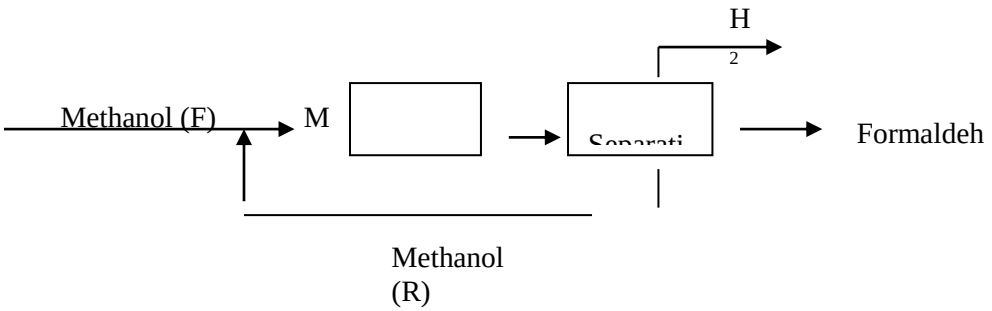
(b) Define the following terms with reference to air-water humidification operation: **04**

(1) Dry-bulb temperature
(2) Absolute humidity
(3) Humid heat
(4) Dew point

(c) Formaldehyde is produced by dehydrogenation of methanol. **07**

$$CH_3OH \rightarrow HCHO +$$

The per pass conversion is 67%. The product leaving the reactor is fed to a separation unit battery where formaldehyde is separated from methanol and hydrogen. The separated methanol is recycled to the reactor. If the production rate of formaldehyde is 1000 kg/h, calculate: (a) the combined feed ratio and (b) the flow rate of methanol required to the process (as fresh feed). As shown in the figure, the following operation is taking place in the dehydrogenation plant.



OR

Q.4 **(a)** Define and explain the following terms: **03**

(1) Heat of formation

(2) Heat of combustion

(3) Heat of reaction

(b) Differentiate between: (i) Sensible Heat and latent heat (ii) Endothermic and exothermic reactions. **04**

(c) Calculate the consumption of 96% NaCl and 93% H_2SO_4 to produce 500 kg of HCl if the conversion is 92%. The reaction that takes place is as follows: **07**

$$2\ NaCl + H_2SO_4 \rightarrow Na_2SO_4 + 2$$

Q.5 **(a)** In a double effect evaporator plant, the second effect is maintained under vacuum of 475 Torr. Find the absolute pressure in kPa, bar and psi. **03**

(b) Crude oil is found to contain 87.1% carbon, 12.5% hydrogen and 0.4% sulphur (by mass). Its GCV at 25°C is measured to be 45071 kJ/kg oil. Calculate its NCV at 25°C. Latent heat of water vapor at 25°C = 2442.5 kJ/kg **04**

(c) A mixture of aniline and water containing 11.8% by weight of aniline is cooled from 100 °C to 40 °C with the help of cooling water. Find the amount of heat removed by cooling 100 kg of aniline mixture. The specific $Cp = a + bT + cT^2$ (kcal/kg °C) **07**

Where constants a, b, c are:

For aniline: a= 1.407, b= 2.467 X 10^{-3}, c= -6.08 X 10^{-6}

For water: a= 0.6741, b= 2.8 X 10^{-3}, c= 8.3 X 10^{-6}

OR

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^o_p. **03**

Data:

$C^o_p = a + bT + cT^2 + dT^3$, kJ/(kmol. K)

Gas	a	b X 10^3	c X 10^6	d X 10^9
Liquid	21.3655	64.2841	-41.0506	9.7999

(b) Discuss proximate and ultimate analysis of coal. **04**

(c) The orsat analysis of the flue gases by mole is as given below: CO_2- 11.4%, O_2- 4.2% and N_2- 84.4%. Assuming that complete combustion takes place. Calculate (i) the % excess air (2) find the C:H ratio in the fuel. **07**

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