Enrolment No./Seat No_____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE- SEMESTER–III (NEW) EXAMINATION – WINTER 2024

Subject Code: 3130508 Date: 10-12-2024

Subject Name: Material & Energy Balance Computation

Time: 10:30 AM TO 01:00 PM Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

			MARKS
Q.1	**(a)**	Define Fundamental and Derived Units with examples	**03**
	(b)	In a double effect evaporator plant, the second effect is maintained under a vacuum of 400 torr. Determine the absolute pressure in kgf/cm2, kPa, atm, N/m2, bar, psi, atm and mmHg	**04**
	(c)	The diameter and height of a vertical cylindrical tank are 5 ft and 6 ft 6 in respectively. It is full up to 80% height with carbon tetrachloride, the density of which is 1.6 kg/L. Determine the mass in kilograms and pounds. Determine change in mass (kg and lb) if the tank is filled upto 85% of height.	**07**
Q.2	**(a)**	Define the following terms : (i) sensible heat (ii) latent heat (iii) heat capacity	**03**
	(b)	Describe the material balance of drying operation	**04**
	(c)	A solution of caustic soda contains 20% NaCl by weight. Taking density of solution as 1.196 kg/l find the normality, molarity and molality of the solution.	**07**
		OR	
	(c)	An aqueous solution of K_2CO_3 is prepared by dissolving 43 gm K_2CO_3 in 100 gm water at 20 ^oC. Find molarity, normality and molality of the solution. Take the density of solution as 1.3 gm/cm^3	**07**
Q.3	**(a)**	Define: (a)Yield (b)Conversion (c)Limiting reactant (d)Excess reactant	**03**
	(b)	Briefly explain ideal gas law	**04**
	(c)	Soyabean seeds are extracted with hexane in batch extractors. The flaked seeds are found to contain 18.6% oil, 69% solid and 12.4% moisture (by weight). At the end of the extraction process, cake (meal) is separated from hexane-oil mixture. The cake is analysed to contain 0.8% oil, 87.7% solids and 11.5% moisture (by weight). Find the percentage recovery of oil.	**07**
		OR	
Q.3	**(a)**	Define Raoult's law. Enlist the applications and limitations of Raoult's law?	**03**
	(b)	In a production of chlorine gas by oxidation of hydrochloric acid gas, air is used 30 % in excess of that theoretically required. Based on 4 kmol HCl, Calculate; (a) The weight ratio of air to HCl gas in feed. (b) If oxidation is 85% complete, calculate the composition off product stream on mole basis.	**04**
	(c)	The dilute acid containing 25% H_2SO_4 is concentrated by commercial grade sulphuric acid containing 98% H_2SO_4 to obtain desired acid containing 65% H_2SO_4.Find the quantities of the acids required to make 1000 kg of desired acid.	**07**
Q.4	**(a)**	List out the classification of material balance problems.	**03**

(b) Explain important of material and energy balance computations in chemical engineering **04**

(c) Monochloroacetic acid (MCA) is manufactured in a semi batch reactor by the action of glacial acetic acid with chlorine gas at 100 °C in the presence of PCl3 catalyst. MCA thus formed will further react with chlorine to 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 4536 kg/day of chlorine gas. Also, 263 kg/day of DCA is separated into crystallizer to get almost pure MCA product. Find the % conversion, % yield of MCA. **07**

OR

Q.4 **(a)** Differentiate Endothermic and Exothermic reaction. **03**

(b) In manufacturing of Sulfur trioxide (SO_3), feed to a reactor consist of of 50 kmol SO_2 and 150 kmol air. Calculate the % excess air is used. **04**

(c) A natural gas has the following composition on mole basis: CH4 – 84%, C2H6 – 13% and rest are N_2. Calculate the heat to be added to heat 10 kmol of natural gas from 298 K to 523 K using heat capacity data given below: **07**

$$Cp = a+bT+ cT^2 + dT^3 \text{ in kj/kmol}$$

Gas	a	$bx10^3$	$cx10^6$	$dx10^9$
CH4	19.2494	52.1135	11.973	-11.3173
C2H6	5.4129	178.0872	-67.3749	8.7147
N2	29.5909	-5.141	13.1829	-4.968

Q.5 **(a)** What is the difference between recycling and bypassing operations in the chemical industry? Discuss the importance of recycling and bypassing operations in the chemical industry **03**

(b) The GHV (gross heating value) of gaseous n-butane is 2877.40 kJ/mol at 298 K 25°C). Calculate its NHV (net heating value) in kJ/mol and kJ/kg. Latent heat of Water vapour at 298 K (25°C) = 2442.5kJ/kg **04**

(c) A mixture of aniline and water, containing 11.8 (mass%) aniline, is sub cooled in the overhead condenser of the distillation column from 100 to 40°C (373 K to 313 K) with the help of cooling water at the rate 8000 kg/h. Find the heat removal rate of the subcooling zone of the condenser. **07**

OR

Q.5 **(a)** Give the classification of fuel in brief. **03**

(b) Crude oil is analysed to contain 87% carbon, 12.5% hydrogen and 0.5% sulphur (by weight). Calculate the net calorific value of crude oil at 298 K (25°C) **04**

(c) Discuss Ultimate analysis and proximate analysis of coal **07**

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