Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– III (NEW) EXAMINATION – SUMMER 2022

Subject Code:3133606 Date:11-07-2022

Subject Name:Fundamentals of Material & Energy Balance Calculations

Time:02:30 PM TO 05:00 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)**	In a multiple effect evaporator system, the second effect is maintained under vacuum of 475 torr (mm Hg). Find the absolute pressure in kPa.	**03**
	(b)	Define : (a) Selectivity (b) Limiting reactant (c) Heat Capacity (d) Normality	**04**
	(c)	Explain in brief about Recycle, bypass and purge operations with neat sketch.	**07**
Q.2	**(a)**	Convert 88 kg of carbon dioxide into its amount in molar units.	**03**
	(b)	Derive: Pressure%=Mole%=Volume%	**04**
	(c)	Solution of K_2CO_3 is prepared by dissolving 43 kg K_2CO_3 in 100 kg water at 293 K. Find, Molarity, Normality and Molality of the solution. Take density of solution as 1.3 kg/L.	**07**
		OR	
	(c)	Estimate the density of chlorine gas at temperature of 503 K and 15.2 MPa pressure by using (i) the ideal gas law and (ii) the van der Waals equation. Take a = 0.6354 $(m^3)^2$ MPa/$(kmol)^2$ and b = 0.0543 m^3/kmol.	**07**
Q.3	**(a)**	Explain adiabatic reaction with a suitable example.	**03**
	(b)	Write in brief about raoult's law and henry's law.	**04**
	(c)	A makeup of 1000 kg of a solution containing 35% by weight of a substance 'A' is desired. Two solutions are available, one containing 10 weight percent 'A' and other containing 50 weight percent of 'A'. How many kilograms of each solution will be required?	**07**
		OR	
Q.3	**(a)**	Find Nitrogen (N) content of 100 kg urea sample containing 96.43% pure urea.	**03**
	(b)	Write down the general method for solving material balance problems of the systems involving no chemical reactions.	**04**
	(c)	A gas mixture has the following composition by volume: SO_2=8.5%, O_2=10% and N_2=81.5% Find (a) the density of gas mixture at a temperature of 473 K (200℃) and 202.65 kPa g and (b) composition by weight.	**07**

Q.4 **(a)** Explain material balance concept for Liquid-Liquid Extraction process with its diagram. **03**

(b) Give the classification of different forms of energy. **04**

(c) Heat capacity data for gaseous SO_2 is given by the following equation: **07**

$$C°p = 43.458 + 10.634 * 10^{-3}T - \frac{5.945 * 10^5}{T^2}$$

Calculate the heat needed to raise the temperature of 1 kmol pure Sulphur dioxide from 300 K to 1000 K.

OR

Q.4 **(a)** What do you mean by Equivalent weight of an element or compound? Explain in brief with its formula. **03**

(b) Explain the energy balances on closed systems with suitable equations. **04**

(c) The analysis of a refinery gas by volume is: **07**

H_2: 74%, CH_4: 13.5%, C_2H_6: 7.4%, C_3H_8: 3.6%, n-C_4H_{10}: 1.2% and n-C_5H_{12}: 0.3%.

Data:

Component	**$-\Delta H°_C$(gross) , kJ/mol**	**$-\Delta H°_C$(net) , kJ/mol**
CH_4	890.65	802.62
C_2H_6	1560.69	1428.64
C_3H_8	2219.17	2043.11
n-C_4H_{10}	2877.40	2657.32
n-C_5H_{12}	3535.77	3271.67

$\Delta H°_f$ of H_2O (g) = -241.82 kJ/mol at 298 K (25° C)

$\Delta H°_f$ of H_2O (*l*) = -285.83 kJ/mol at 298 K (25° C)

Specific volume at 298 K and 101.3 kPa = 24.465 m^3/kmol.

Calculate the GCV and NCV of the refinery gas in kJ/mol, kJ/kg and kJ/m^3.

Q.5 **(a)** Explain in brief about Stoichiometric coefficient, Stoichiometric ratio and stoichiometric proportion with its example. **03**

(b) Write in brief about Proximate and Ultimate analysis of coal. **04**

(c) The analysis of feed to vacuum crystallizer is given below: **07**

Urea = 82%, water = 17.5% and impurity = 0.5%.

In the crystallizer, 50% of water is evaporated at 323 k. Calculate the yield of urea crystals and percent impurity content of crystals if the mother liquor is found to contain 1.6% impurity.

OR

Q.5 **(a)** Define the following: Molarity , Molality and Normality **03**

(b) In production of Sulphur trioxide, 100 kmol of SO_2 and 100 kmol of O_2 are fed to a reactor. If the percent conversion of SO_2 is 80, calculate the composition of the product stream on mole basis. **04**

(c) A gas mixture containing benzene vapour is saturated at 101.325 kPa and 323 k. Calculate the absolute humidity if the other component of the mixture is (a) nitrogen and (b) carbon dioxide. **07**

Data: Vapour pressure of benzene at 323 K = 36.664 kPa.

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