Enrolment No./Seat No_____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE- SEMESTER–III EXAMINATION – WINTER 2025

Subject Code:3130508 Date:22-12-2025

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 quantity and derived quantity.	**03**
	(b)	The flow rate of water through a pipe is reported as 20 ft^3/min. Convert the volumetric flow rate into the mass flow rate in kg/sec. Density of water is 1 gm/cc.	**04**
	(c)	A solution of ethyl alcohol containing 8.6% alcohol is fed at the rate of 1000 kg/h to a continuous distillation column. The product (distillate) is a solution containing 95.5% alcohol. The waste solution from the column carries 0.1% of alcohol. All percentages are by mass. Calculate (a) the mass flow rates of top and bottom products in kg/h (b) the percentage loss of alcohol.	**07**
Q.2	**(a)**	Define Raoult's law. What are the applications and limitations of Raoult's law?	**03**
	(b)	A liquid has a specific gravity of 0.90 at 25°C. What is its (i) Density at 25°C in kg/m^3? (ii) Specific volume at 25°C in ft^3/lb_m? (iii) If the liquid is placed in a 1.5 L bottle that has a mass of 232 g, how much will the full bottle weigh?	**04**
	(c)	A solution of NaCl in water contains 15 % NaCl (by mass) at 335 K. The density of the solution is 1.127 kg/lit. Determine the molarity, normality and molality of the solution.	**07**
		OR	
	(c)	Pure water and alcohol are mixed to get a 60% (weight) alcohol solution. The densities (kg/m^3) of water, alcohol and the solution may be taken to be 998, 798 and 895 respectively at 293 K. Calculate the following: (i) The volume percent of ethanol in the solution at 293 K (ii) The molarity (iii) The molality	**07**
Q.3	**(a)**	In a textile mill, a double-effect evaporator system concentrates weak liquor containing 4% (by mass) caustic soda to produce a lye containing 25 % solids (by mass), Calculate the evaporation of water per 100 kg feed in the evaporator	**03**
	(b)	Discuss methods of solving material balance problems with chemical reaction.	**04**
	(c)	Oxidation of ethylene to produce ethylene oxide is given by reaction: $C_2H_4 + 0.5O_2 \rightarrow C_2H_4O$ If air is used 20% in excess of that theoretically required, calculate the quantity of air supplied based on 100 kmol of ethylene fed to the reactor.	**07**
		OR	
Q.3	**(a)**	Determine the weight of water removed while drying 1,000 kg of wet substance from 35% to 5%.	**03**
	(b)	Define terms: Excess Reactant, Conversion, Yield, and Selectivity.	**04**
	(c)	A combustion reactor is fed with 50 kmol/h of butane and 2000 kmol/h of air. Calculate the % excess air used and composition of the gases leaving combustion reactor assuming complete combustion of butane	**07**

Q.4 **(a)** Define the following terms: **03**
(i) Heat of formation (ii) Heat of combustion (iii) Heat of reaction

(b) Describe the reasons for performing purging, bypassing and recycling operations in unit operations. **04**

(c) Calculate the standard heat of formation of n-propanol liquid using the following data: **07**
Standard heat of formation of CO_2 (g) = -393.51 KJ/mol
Standard heat of formation of H_2O (l) = -285.83 KJ/mol
Standard heat of combustion of n-propanol liquid = -2028.19KJ/mol

OR

Q.4 **(a)** Define the following terms: **03**
(i) Latent heat (ii) Sensible heat (iii) Heat capacity

(b) With a neat sketch show the material balance for the following unit operations: **04**
(i) Crystallization (ii) Liquid Liquid extraction

(c) A natural gas has the following composition on mole basis: CH_4=84%, C_2H_6=13%, and N_2 = 3%. Calculate the heat to be added to heat 2 kmol of natural gas from 311 K to 533 K using heat capacity data given below: **07**
$C_{pm}°$ (kJ/kmol·K)

Gas	$C_{pm}°$ (311-298 K)	$C_{pm}°$ (533-298K)
CH_4	36.0483	41.7800
C_2H_6	53.5240	67.4954
N_2	29.1317	29.3578

Q.5 **(a)** Give detailed classification of fuels **03**

(b) Define and explain the following terms: (i) Heat of formation (ii) Heat of combustion (iii) Heat of reaction (iv) Heat of solution **04**

(c) Define GCV and NCV for fuels. Give its importance. Also give the names of the equipment used for measuring CV of solid, liquid and gases **07**

OR

Q.5 **(a)** Describe proximate analysis of coal **03**

(b) Explain: (i) Watson equation (ii) Riedel Equation. **04**

(c) Discuss Ultimate analysis of coal. Give Dulong formula and Calderwood equation with nomenclature. **07**

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Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE –SEMESTER 3(NEW SYLLABUS)EXAMINATION- SUMMER 2024

Subject Code:3130508 Date:

Subject Name: Material and energy balance computation

Time: Total Marks: 70

Instructions:

5. **Attempt all questions.**
6. **Make suitable assumptions wherever necessary.**
7. **Figures to the right indicate full marks.**

			Marks	CO (Course Outcome)	Cognitive Level (As per Revised Bloom's Taxonomy)
Q.1	**(a)**	Define fundamental quantity and derived quantity.	**03**	**CO1**	**R**
	(b)	The flow rate of water through a pipe is reported as 20 ft^3/min. Convert the volumetric flow rate into the mass flow rate in kg/sec. Density of water is 1 gm/cc	**04**	**CO1**	**A**
	(c)	A solution of ethyl alcohol containing 8.6% alcohol is fed at the rate of 1000 kg/h to a continuous distillation column. The product (distillate) is a solution containing 95.5% alcohol. The waste solution from the column carries 0.1% of alcohol. All percentages are by mass. Calculate (a) the mass flow rates of top and bottom products in kg/h (b) the percentage loss of alcohol.	**07**	**CO3**	**A**
Q.2	**(a)**	Define Raoult's law. What are the applications and limitations of Raoult's law?	**03**	**CO2**	**R**
	(b)	A liquid has a specific gravity of 0.90 at 25°C. What is its (i) Density at 25°C in kg/m^3? (ii) Specific volume at 25°C in ft^3/lb_m? (iii) If the liquid is placed in a 1.5 L bottle that has a mass of 232 g, how much will the full bottle weigh?	**04**	**CO2**	**U**
	(c)	A solution of NaCl in water contains 15 % NaCl (by mass) at 335 K. The density of the solution is 1.127 kg/lit. Determine the molarity, normality and molality of the solution.	**07**	**CO2**	**U**
		OR			
	(c)	Pure water and alcohol are mixed to get a 60% (weight) alcohol solution. The densities (kg/m^3) of water, alcohol and the solution may be taken to be 998, 798 and 895 respectively at 293 K. Calculate the following: (i) The volume percent of ethanol in the solution at 293 K (ii) The molarity (iii) The molality	**07**	**CO2**	**U**
Q.3	**(a)**	In a textile mill, a double-effect evaporator system concentrates weak liquor containing 4% (by mass) caustic	**03**	**CO3**	**U**

		soda to produce a lye containing 25 % solids (by mass), Calculate the evaporation of water per 100 kg feed in the evaporator			
	(b)	Discuss methods of solving material balance problems with chemical reaction.	**04**	**CO4**	**U**
	(c)	Oxidation of ethylene to produce ethylene oxide is given by reaction: $C_2H_4 + 0.5O_2 \rightarrow C_2H_4O$ If air is used 20% in excess of that theoretically required, calculate the quantity of air supplied based on 100 kmol of ethylene fed to the reactor.	**07**	**CO4**	**A**
		OR			
Q.3	**(a)**	Determine the weight of water removed while drying 1,000 kg of wet substance from 35% to 5%.	**03**	**CO3**	**U**
	(b)	Define terms: Excess Reactant, Conversion, Yield, and Selectivity.	**04**	**CO4**	**R**
	(c)	A combustion reactor is fed with 50 kmol/h of butane and 2000 kmol/h of air. Calculate the % excess air used and composition of the gases leaving combustion reactor assuming complete combustion of butane	**07**	**CO4**	**A**
Q.4	**(a)**	Define the following terms: (i) Heat of formation (ii) Heat of combustion (iii) Heat of reaction	**03**	**CO5**	**R**
	(b)	Describe the reasons for performing purging, bypassing and recycling operations in unit operations.	**04**	**CO3**	
	(c)	Calculate the standard heat of formation of n-propanol liquid using the following data: Standard heat of formation of CO_2 (g) = -393.51 KJ/mol Standard heat of formation of H_2O (l) = -285.83 KJ/mol Standard heat of combustion of n-propanol liquid = -2028.19KJ/mol	**07**	**CO5**	**N**
		OR			
Q.4	**(a)**	Define the following terms: (i) Latent heat (ii) Sensible heat (iii) Heat capacity	**03**	**CO5**	**R**
	(b)	With a neat sketch show the material balance for the following unit operations: (i) Crystallization (ii) Liquid Liquid extraction	**04**	**CO3**	**U**
	(c)	A natural gas has the following composition on mole basis: CH_4=84%, C_2H_6=13%, and N_2 = 3%. Calculate the heat to be added to heat 2 kmol of natural gas from 311 K to 533 K using heat capacity data given below: $C_{pm}°$ (kJ/kmol·K) Gas | $C_{pm}°$ (311-298 K) | $C_{pm}°$ (533-298K) CH_4 | 36.0483 | 41.7800 C_2H_6 | 53.5240 | 67.4954 N_2 | 29.1317 | 29.3578	**07**	**CO5**	**N**
Q.5	**(a)**	Give detailed classification of fuels	**03**	**CO6**	**U**
	(b)	Define and explain the following terms: (i) Heat of formation (ii) Heat of combustion (iii) Heat of reaction (iv) Heat of solution	**04**	**CO6**	**U**

	(c)	Define GCV and NCV for fuels. Give its importance. Also give the names of the equipment used for measuring CV of solid, liquid and gases	**07**	**CO5**	**U**
		OR			
Q.5	**(a)**	Describe proximate analysis of coal	**03**	**CO6**	**U**
	(b)	Explain: (i) Watson equation (ii) Riedel Equation.	**04**	**CO6**	**U**
	(c)	Discuss Ultimate analysis of coal. Give Dulong formula and Calderwood equation with nomenclature.	**07**	**CO5**	**U**

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