

GUJARAT TECHNOLOGICAL UNIVERSITY**BE- SEMESTER– III EXAMINATION – SUMMER 2026****Subject Code:3130508****Date:02-07-2026****Subject Name:Material & Energy Balance Computation****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) Explain i) Boyle's law and ii) Dalton's law.	03
	(b) The diameter and height of a vertical cylindrical tank are 5 ft and 6 ft 6 in respectively. It is full up to 75% height with carbon tetrachloride (CCl ₄), the density of which is 1600 kg/m ³ . Find the mass in kilograms.	04
	(c) Cracked gas from a petroleum refinery has the following composition by volume: 45% methane, 10% ethane, 25% ethylene, 7% propane, 8% propylene, 5% n-butane. Find: a) the average molar mass of the gas mixture, and b) the composition by mass, and c) density of the gas mixture at 273 K and 101.325 KPa.	07
Q.2	(a) In a double effect evaporator plant, the second effect is maintained under vacuum of 475 torr. Find the absolute pressure in kPa and bar.	03
	(b) Differentiate between intensive property and extensive property.	04
	(c) The conductance of a fluid flow system is defined as the volumetric flow rate, to a pressure of one torr (133.233 Pa). For an orifice, the conductance C can be computed from $C = 89.2A \sqrt{\frac{T}{M}} \text{ ft}^3/\text{s}$ where, A = area of opening, ft ² , T = temperature, °R, M = Molar mass Convert the empirical equation in SI units.	07
	OR	
	(c) An aqueous solution of K ₂ CO ₃ is prepared by dissolving 43 kg of K ₂ CO ₃ in 100 kg of water at 293 K. Calculate the normality, molarity and molality of the solution. Density of the solution is 1.3 kg/L. Atomic mass of K is 39.	07
Q.3	(a) Define Fundamental and Derived Units with example.	03
	(b) Using Watson equation, calculate latent heat of vaporization of acetone at 353 K. Data: Latent heat of acetone at 329.4 K = 29121 kJ/kmol Critical temperature of acetone = 508.1 K.	04
	(c) Vapor phase oxidation of ethyl alcohol using copper catalyst at 550 °C produces acetaldehyde by the following reaction: $\text{C}_2\text{H}_5\text{OH} + 0.5 \text{O}_2 \rightarrow \text{CH}_3\text{CHO} + \text{H}_2\text{O}$ Conversion of reaction is 30% and excess air supplied is 10%. Calculate composition of product stream if 100 kg of C ₂ H ₅ OH per hr is fed to the reactor.	07
	OR	
Q.3	(a) Define Standard heat of reaction, Standard heat of formation and Standard heat of combustion.	03
	(b) Pure methane is heated from 303.15 K to 523.15 K at atmospheric pressure. Calculate the heat added per kmole methane using C _p data. $C_p = a + bT + cT^2 + dT^3$ Data for methane:	04

- $a = 19.2494$, $b \times 10^3 = 52.1135$, $c \times 10^6 = 11.973$, $d \times 10^9 = -11.3173$
- (c) In the Deacon process for manufacturing chlorine, hydrochloric acid gas is oxidized with air. The reaction taking place is: 07
 $4\text{HCl} + \text{O}_2 \rightarrow 2\text{Cl}_2 + 2\text{H}_2\text{O}$
 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.
- Q.4** (a) Explain classification of material balance problems. 03
 (b) If 10 kg of C_7H_{16} reacts completely with stoichiometric quantity of O_2 , how many kg of CO_2 will be found as product? 04
 (c) The spent acid from nitrating process contains 21% HNO_3 , 55% H_2SO_4 and 24% H_2O by weight. This acid is to be concentrated to contain 28% HNO_3 and 62% H_2SO_4 by addition of concentrated sulphuric acid containing 93% H_2SO_4 (by wt) and concentrated nitric acid containing 90% HNO_3 (by wt). Calculate the weights of spent acid, concentrated acids- HNO_3 and H_2SO_4 that must be combined to obtain 1000 kg of the desired mixture. 07
- OR**
- Q.4** (a) Discuss uses of recycling and bypassing operation. 03
 (b) A sample of coal is found to contain 63% carbon and 24% ash on weight basis. The analysis of refuse after combustion shows 7% carbon and rest ash. Calculate the percentage of the original carbon unburnt in the refuse. 04
 (c) 2000 kg of wet solids containing 70% solids by wt. are fed to a tray dryer and dried by air. The product finally obtained is found to contain 1% moisture by weight, calculate: a) kg of water removed from wet solids b) kg of product obtained. 07
- Q.5** (a) Define percentage conversion, percentage yield and selectivity. 03
 (b) Discuss Proximate analysis of coal. 04
 (c) An Orsat analysis of the flue gases from a boiler house chimney gives CO_2 : 11.4%, O_2 : 4.2% and N_2 : 84.4% (mole %). Assuming that complete combustion takes place, (a) Calculate the % excess air, and b). Find C:H ratio in the fuel. 07
- OR**
- Q.5** (a) Explain Gross calorific value, Net calorific value. 03
 (b) The GHV(gross heating value) of gaseous n- butane is 2877.40 kJ/ mol at 298 K. calculate its NHV (net heating value) in kJ/kg 04
 (c) An Orsat analysis of the combustion products of a hydrocarbon liquid fuel gave the following results CO_2 : 10 %, CO : 0.6%, O_2 : 5.7%. N_2 : 79% (by volume). Calculate the C/H ratio (by wt) of liquid fuel. 07
