

**GUJARAT TECHNOLOGICAL UNIVERSITY****BE - SEMESTER-III (NEW) EXAMINATION – SUMMER 2021****Subject Code:3133606****Date:06/09/2021****Subject Name:Fundamentals of Material & Energy Balance Calculations****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.

		<b>Marks</b>
<b>Q.1</b>	(a) Define: (a) Stoichiometric Ratio (b) Humid heat (c) Heat capacity	<b>03</b>
	(b) What is the difference between fundamental units and derived units?	<b>04</b>
	(c) A heat exchanger for cooling a hot hydrocarbon liquid uses 10000 kg/h of cooling water, which enters the exchanger at 294 K. The hot oil at the rate of 5000 kg/h enters at 423 K and leaves at 338 K and has an average heat capacity of 2.5 kJ/kg K. Calculate the outlet temperature of water.	<b>07</b>
<b>Q.2</b>	(a) Convert 2 atm to mm Hg.	<b>03</b>
	(b) Write in brief about heat of reaction ( $\Delta H_R$ ).	<b>04</b>
	(c) An aqueous solution of $K_2CO_3$ is prepared by dissolving 44 g $K_2CO_3$ in 100 g water at 293 K. Find, Molarity, Normality and Molality of the solution. Take density of solution as 1.3 kg/L.	<b>07</b>
<b>OR</b>		
	(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 $a = 0.6354 \text{ (m}^3)^2 \text{ MPa/(kmol)}^2$ and $b = 0.0543 \text{ m}^3/\text{kmol}$ .	<b>07</b>
<b>Q.3</b>	(a) How many grams of carbon are present in 264 g of $CO_2$ ?	<b>03</b>
	(b) Differentiate between sensible heat and latent heat	<b>04</b>
	(c) What are the methods of expressing the composition of mixtures and solutions?	<b>07</b>
<b>OR</b>		
<b>Q.3</b>	(a) Write in brief about Amagat's law with its expression.	<b>03</b>
	(b) $H_2SO_4$ solution has a molarity of 11.24 and molality of 94. Calculate the density of solution.	<b>04</b>
	(c) It is desired to make up 1000 kg of a solution containing 35% by weight of a substance 'A'. 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?	<b>07</b>
<b>Q.4</b>	(a) Write short note on recycling, bypassing and purging operations.	<b>03</b>
	(b) Give classification of material balance problems.	<b>04</b>
	(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 °C) and 202.65 kPa g and (b) composition by weight.	<b>07</b>

**OR**

- Q.4** (a) Define: (1) standard heat of formation (2) standard heat of reaction (3) adiabatic flame temperature **03**  
 (b) Explain: Limiting Reactant, Excess reactant and percent excess reactant. **04**  
 (c) Write a short note on Hess's law of constant heat summation. **07**

- Q.5** (a) Define: i) Dry-bulb temperature ii) Wet-bulb temperature. **03**  
 (b) Write a short note on proximate and ultimate analysis of coal. **04**  
 (c) Heat capacity data for gaseous SO<sub>2</sub> is given by the following equation:

$$C^{\circ}p = 43.458 + 10.634 * 10^{-3}T - \frac{5.945 * 10^5}{T^2} \quad \mathbf{07}$$

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

**OR**

- Q.5** (a) Explain adiabatic reaction with a suitable example. **03**  
 (b) Write in detail about calorific values of fuels. **04**  
 (c) The analysis of a refinery gas by volume is:  
 H<sub>2</sub>: 74%, CH<sub>4</sub>: 13.5%, C<sub>2</sub>H<sub>6</sub>: 7.4%, C<sub>3</sub>H<sub>8</sub>: 3.6%, n-C<sub>4</sub>H<sub>10</sub>: 1.2% and n-C<sub>5</sub>H<sub>12</sub>: 0.3%.

Data:

Component	$-\Delta H^{\circ}c(\text{gross})$ , kJ/mol	$-\Delta H^{\circ}c(\text{net})$ , kJ/mol
CH <sub>4</sub>	890.65	802.62
C <sub>2</sub> H <sub>6</sub>	1560.69	1428.64
C <sub>3</sub> H <sub>8</sub>	2219.17	2043.11
n-C <sub>4</sub> H <sub>10</sub>	2877.40	2657.32
n-C <sub>5</sub> H <sub>12</sub>	3535.77	3271.67

$\Delta H^{\circ}f$  of H<sub>2</sub>O (g) = -241.82 kJ/mol at 298 K (25° C)

$\Delta H^{\circ}f$  of H<sub>2</sub>O (l) = -285.83 kJ/mol at 298 K (25° C)

Specific volume at 298 K and 101.3 kPa = 24.465 m<sup>3</sup>/kmol.

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

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