

Seat No.: \_\_\_\_\_

Enrolment No. \_\_\_\_\_

## GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER-III (New) EXAMINATION – WINTER 2018

**Subject Code: 2133606**
**Date: 12/12/2018**
**Subject Name: Material & Energy Balance Calculations**
**Time: 10:30 AM TO 01:00 PM**
**Total Marks: 70**
**Instructions:**

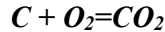
1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.

		Marks
Q.1	(a) Define the quantities with SI units: i) Force ii) Pressure iii) Work.	03
	(b) A force of 20 kgf is applied on a piston of diameter 5 cm. Find the pressure exerted on a piston in KPa.	04
	(c) A chemist is interested in preparing 500 ml of 1 normal, 1 molar and 1 molal solution of H <sub>2</sub> SO <sub>4</sub> . Assuming the density of H <sub>2</sub> SO <sub>4</sub> solution to be 1.075 g/cm <sup>3</sup> , calculate the quantities of H <sub>2</sub> SO <sub>4</sub> to be taken to prepare these solutions.	07
Q.2	(a) Define the laws with their equations: i) Ideal Gas Law ii) Raoult's Law iii) Henry's Law	03
	(b) A certain quantity of a gas contained in a closed vessel of volume 1 m <sup>3</sup> at a temperature of 298 K (25°C) and pressure of 131.7 KPa is to be heated such that the pressure should not exceed 303.98 KPa. Calculate the temperature of gas attained.	04
	(c) Derive: Pressure% = Mole% = Volume%	07
<b>OR</b>		
	(c) A weight of 1.10 kg of Carbon dioxide occupies a volume of 0.033 m <sup>3</sup> at 300 K. Using the Van der Waals equation of state, calculate the pressure. Data: For CO <sub>2</sub> gas, take $a = 3.60 [(m^3)^2 \cdot kPa] / (kmol)^2$ and $b = 4.3 \times 10^{-2} m^3 / kmol$ .	07
Q.3	(a) Derive: $\rho_{mix} = (PM_{avg}) / RT$	03
	(b) A gas mixture contains 0.274 kmol of HCl, 0.337 kmol of N <sub>2</sub> and 0.089 kmol of O <sub>2</sub> . Calculate: (a) Average molecular weight of gas.	04
	(c) A solution containing 55% benzene, 28% toluene and 17% xylene by weight is in contact with its vapour at 373 K. Calculate the total pressure and molar composition of the liquid & vapour. Data: Vapour Press. Data at 373 K: Benzene: 178.60KPa, Toluene: 74.60KPa, Xylene: 28KPa.	07
<b>OR</b>		
Q.3	(a) Define the terms: (a) % Conversion (b) % Yield (c) % Excess	03
	(b) In the production of sulphur trioxide, 100 kmol of SO <sub>2</sub> , 200 kmol O <sub>2</sub> are fed to reactor. The product stream is found to contain 80 kmol SO <sub>3</sub> . Find the % conversion of SO <sub>2</sub> .	04
	(c) In the manufacture of acetic acid by oxidation of acetaldehyde, 100 kmol of acetaldehyde is fed to the reactor per hour. The product leaving the reactor contains 14.81% acetaldehyde, 59.26% acetic acid, and the rest oxygen (on mole basis). Find the percentage conversion of acetaldehyde. $CH_3CHO + 1/2O_2 = CH_3COOH$	07
Q.4	(a) Define the following terms: i) Limiting Reactant ii) Excess Reactant iii) Stoichiometric Ratio	03

- (b) Calculate the following for the reaction: 04



- (i) The stoichiometric ratio of  $Cl_2$  to  $C_2H_4$   
 (ii) If 4 kmol  $Cl_2$  is used per kmol of  $C_2H_4$ , find the % excess  $Cl_2$ .  
 (c) A coke is known to contain 90% carbon and 10% non-combustible ash (by weight): 07



- i) Find the moles of oxygen theoretically required to burn 100 kg of coke completely.  
 ii) If 50% excess air is supplied, find the analysis of the gases at the end of the combustion?

OR

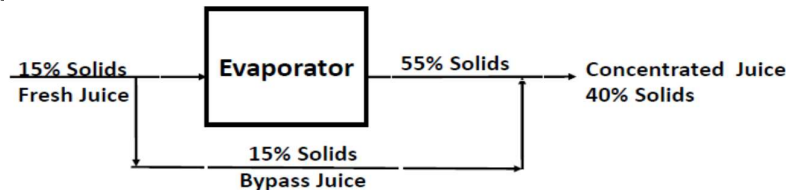
- Q.4 (a) Define the following terms: 03

i) Law of Conservation of Mass ii) Heat Capacity iii) recycling

- (b) Explain the following unit operations with their block diagram and material balances: i) Distillation ii) Evaporation. 04

- (c) Fresh juice contains 15% solids and 85% water by weight and is to be concentrated to contain 40% solids by weight. 07

In a single stage evaporation system, it is found that volatile constituents of juice escape with water leaving the concentrated juice with a flat taste. In order to overcome this problem, part of the fresh juice bypasses the evaporator. The operation is shown schematically:



Calculate:

- i) The fraction of juice that bypasses the evaporator.  
 ii) The concentrated juice produced (containing 40% solids) per 100 kg of fresh juice fed to the process.

- Q.5 (a) Explain standard heat of reaction and standard heat of combustion. 03

- (b) Explain the significance of bypass operation with neat flow diagram. 04

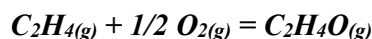
- (c) Soyabean seeds are extracted with the hexane in batch extractors. The flaked seeds are found to contain 18.6% oil, 69% solids, 12.4% moisture (by weight). At the end of the extraction process, cake is separated from hexane-oil mixture. The cake is analyzed to contain 0.8% oil, 87.7% solids and 11.5% moisture (by weight). Find the percent recovery of oil. 07

OR

- Q.5 (a) Define: i) Dry-bulb temperature ii) Wet-bulb temperature. 03

- (b) Chlorinated diphenyl is heated from 313 K (40°C) to 533 K (260°C) in an indirectly fired heater at the rate of 4000 kg/h. Calculate the heat required to be added to the fluid in the heater. The heat capacity of the fluid in this temperature range is given by the equation:  $C = 0.7511 + 1.465 \times 10^{-3} T$ , kJ/(kg.K) where T is in K. 04

- (c) Calculate the change in enthalpy between reactants and products if both are at 298 K (25°C) and if 5 mole of ethylene oxide is produced as per the following reaction: 07



Data:

Component	$\Delta H_f^0$ , kJ/mol at 298.15 K(250C)
$C_2H_4(g)$	52.50
$C_2H_4O(g)$	-52.63

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