Seat No.: _____ Enrolment No.

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–III (NEW) EXAMINATION – SUMMER 2019

Subject Code: 2133606 **Date: 18/06/2019**

Subject Name: 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.**

			Marks
Q.1	**(a)**	Define the quantities with SI units: i) Density ii) Pressure iii) Volume.	**03**
	(b)	The mass velocity of a gas through a duct is 1000 $Kg/m^2.h$. Express the velocity in to $lb/ft^2.s$	**04**
	(c)	A chemist is interested in preparing 500 ml of 1 normal, 1 molar and 1 molal solution of H_2SO_4. Assuming the density of H_2SO_4 solution to be 1.075 g/cm^3, calculate the quantities of H_2SO_4 to be taken to prepare these solutions.	**07**
Q.2	**(a)**	Define the following: Molarity , Molality and Normality	**03**
	(b)	The average molar mass of a flue gas sample is calculated by two different engineers. One engineer uses the correct molar mass of 28 for N_2 and determines the average molar mass to be 30.08, the other engineer, using an incorrect value of 14, calculates the average molar mass to be 18.74. (i) Calculate the volume % of nitrogen in the flue gases, (ii) If the remaining components of the flue gases are CO_2 and O_2, calculate the volume % each of them	**04**
	(c)	Cracked gas from a petroleum refinery has the following composition by volume, methane 45%, Ethane10%, ethylene 25%, Propane 7%, Propylene 8%, n-Butane 5% . Find (a) Average mol. wt. of gas mixture. (b) the composition by weight % and (c) Specific gravity of the gas mixture at STP.	**07**
		OR	
	(c)	A weight of 1.10 kg of Carbon dioxide occupies a volume of 0.033 m^3 at 300 K. Using the Van der Waals equation of state, calculate the pressure. Data: For CO_2 gas, take a = 3.60 $[(m^3)^2.kPa] / (kmol)^2$ and b = 4.3 x 10^{-2} m^3 /kmol.	**07**
Q.3	**(a)**	State : Dalton's law and Raoult's law	**03**
	(b)	The spent acid from a nitrating process contains 33% H_2SO_4, 36% HNO_3 and 31% water by weight. This acid is to be strengthened by the addition of concentrated sulphuric acid containing 95% H_2SO_4 and concentrated nitric acid containing 78% HNO_3. The strengthened mixed acid is to contain 40% H_2SO_4 and 43% HNO_3. Calculate the quantities spent and concentrated acids that should be mixed together to yield 1500 kg of the desired mixed acid	**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.3 **(a)** Define the terms: (a) Conversion (b) Yield (c) Selectivity **03**

(b) 2000 kg of wet solids containing 70% solids by weight are fed to tray dyer where it is dried by hot air. The product finally obtained is found to contain 1% moisture by weight, calculate: (1) kg of water removed from wet solids (2) kg of the product obtained. **04**

(c) A solution contains 50% Benzene, 30% Toluene and 20% Xylene by weight at a temperature of 100 °C. The vapors are in contact with solution. Calculate the total pressure and molar % compositions of liquid and the vapor. The vapor pressures and the molecular weights are as follows: **07**

Components	vapor pressure at 100 °C	Mol. weight
Benzene	1340 mm Hg	78
Toluene	560 mm Hg	92
Xylene	210 mm Hg	106

Q.4 **(a)** Explain: Limiting reactant, Excess reactant and Percent excess reactant **03**

(b) Ammonia reacts with sulphuric acid giving ammonium sulphate: **04**

$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

a) 20 m^3 of ammonia at 1.2 bar and 300 k reacts with 40 kg of sulphuric acid. Which one is the excess reactant and what is the percent excess?

b) How much ammonium sulphate is obtained

(c) 1 kg nitrogen is mixed with 3.5 m^3 of hydrogen at 300 K and 101.3 kPa and sent to the ammonia converter. The product leaving the converter analysed 13.7 % ammonia, 70.32 % hydrogen and 15.98 % nitrogen. **07**

(a) Identity the limiting reactant.

(b) What is the present excess of excess reactant?

(c) What is the present conversion of the limiting reactant?

OR

Q.4 **(a)** State the basic principle of material balance **03**

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

$$C_2H_4 + 2Cl_2 \rightarrow C_2HCl_3 + H_2 + HCl$$

(1) The stoichiometry ratio of Cl_2 to C_2H_4

(2) If 4 kmol Cl_2 is used per kmol of C_2H_4, find the % excess Cl_2

(3) The amount of HCl produced from 50 kg C_2H_4 assuming reaction goes to completion

(c) A coal containing C=67.9%, H=4.4%, S=0.8%, N=1.6%, O=7.9%, ash =4.5% and water =12.9 % is burnt in a furnace. The product of combustion dry gas , analyses, CO_2 =14.5%, O_2 =4.7 and rest N_2.Calculate **07**

1). The theoretical volume of air used for the complete combustion of 100 kg of coal.

2). The percent excess air used.

Q.5 **(a)** Define: i) Heat capacity ii) Sensible heat and iii) Latent heat **03**

(b) A heat exchanger for cooling hot oil uses 10000 kg/hr of cooling water, which enters the exchanger at 294 K. The hot oil at the rate of 5000 kg/hr enters at 423 K and leaves at 338 K and has an average heat capacity of 2.51 KJ/kg K. Calculate the outlet temperature of the water **04**

(c) Calculate the theoretical flame temperature for CO when it is burnt with 100 % excess air. Both the reactants are at 373K. The heat capacities (J/mol.K) (may be assumed constant) are 29.23 for CO, 34.83 for O_2 ,33.03 for N_2 and 53.59 for CO_2. The standard heat of combustion at 298K is -282.99 kJ/mol CO **07**

OR

Q.5 **(a)** Define : Heat of formation and Heat of combustion **03**

(b) Pure methane is heated from 303 K to 523 K at atmospheric pressure. Calculate the heat added per kmol methane using the following data: $Cp= 26.586 + 7.5820 \times 10^{-3} T - 1.1200 \times 10^{-6} T^2$, kJ/(kmol-K) **04**

(c) Calculate the change in enthalpy between reactants and products if both are at 298 K (25^0C) and if 5 mole of ethylene oxide is produced as per the following reaction: **07**

$$C_2H_{4(g)} + 1/2\ O_{2(g)} = C_2H_4O_{(g)}$$

Data:

Component	ΔH^0_f, kJ/mol at 298.15 K(25^0C)
C_2H_4(g)	52.50
C_2H_4O(g)	-52.63

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