Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–III(New) • EXAMINATION – WINTER 2016

Subject Code:2133606 Date:09/01/2017

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		Define the following terms	
	1	Mole	1
	2	Yield	1
	3	Selectivity	1
	4	Conversion	1
	5	Calorific value of fuel	1
	6	Morality	1
	7	Molality	1
	8	Degree of completion of a reaction	1
	9	Boiling point	1
	10	Heat capacity	1
	11	Latent heat	1
	12	Specific gravity	1
	13	Molar % composition of air	1
	14	STP and NTP conditions	1

Q.2 (a) What is Fundamental quantity and Derived quantities? **03**

(b) Give units of following in terms of fundamental quantity: Area, Volume, Work, Power, Mass flow rate and Specific heat **04**

(c) A weight of 1.20 kg of Carbon dioxide occupies a volume of 33 liter at 300 K. Using the Van der Waals equation of state, calculate the pressure. Data: For CO_2 , take a = 3.60 $[(m^3)^2\text{-kPa}]/(\text{kmol})^2$ and b = 4.3 x 10^{-2} m^3/kmol **07**

OR

(c) The Antoine equation predicts the effect of temperature on vapour pressure by the relation **07**

$$\ln P^S = A - \frac{B}{(T - C)}$$

Where A, B, and C are the Antoine constants, for water the values of the constant when vapour pressure is in kPa and temperature is in K are found to be A=16.261, B= 3799.887 and C= 46.854. What are the values, when vapour pressure is in psi and temp in ^oF.

Q.3 (a) Write short notes on vapour pressure and partial pressure. **03**

(b) Explain: Dalton's law , Raoult's law, Henry's law and Ideal gas law **04**

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

Components	Vapour pressure at 100 ^oC	Mol. weight
Benzene	1340 mm Hg	78
Toluene	560 mm Hg	92
Xylene	210 mm Hg	106

OR

Q.3 **(a)** Explain: Limiting Reactant, Excess reactant and percent excess reactant. **03**

(b) Explain: mass fraction, mass%, and mole fraction and mole %. **04**

(c) A petroleum gas has the following composition by volume expressed as: CH_4 =78%, C_2H_6 = 12% and C_3H_8 =10%. Calculate the gas density in kg/m^3 under 585 psig and 310 K. **07**

Q.4 **(a)** Write short notes on recycling, bypassing and purging operations. **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 is the excess reactant and what is the percent excess?

b) How much ammonium sulphate is obtained

(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 **07**

OR

Q.4 **(a)** Discuss methods of solving material balance problems without chemical reaction **03**

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

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

(1) The stoichiometric 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) It is required to make 1000 kg mixed acid containing 60% H_2SO_4, 32% HNO_3 and 8% water by blending (1) the spent acid containing 11.3% HNO_3, 43.4% H_2SO_4 and 45.3% water, (2) aqueous 90% **07**

HNO_3 and (3) Aqueous 98% H_2SO_4 all percentages by weight. Calculate the quantities of each of three acids required for blending

Q.5 **(a)** Define adiabatic reactions and adiabatic flame temperature. **03**

(b) Define the following terms with reference to air-water humidification operation: **04**
(1) Dry-bulb temperature (2) Absolute humidity
(3) Percentage humidity (4)Humid volume

(c) Combustion of solid wastes produces a flue gas of the following analysis: CO_2 = 9.0 %, CO = 2.0 % ,O_2 = 7.0 % and N_2 = 82.0 %. Find the difference in enthalpies (or heat available) for this gas between the bottom and top of the stack. If the temperature of the gas at the bottom and top are 600 and 375 K respectively. The heat capacities (kJ/kmol K) of the gas are: **07**

No.	Gases	Heat capacities, C_P
1	CO	$26.586 + 7.5820 \times 10^{-3} T - 1.1200 \times 10^{-6} T^2$
2	CO_2	$26.540 + 42.454 \times 10^{-3} T - 14.298 \times 10^{-6} T^2$
3	O_2	$25.740 + 12.987 \times 10^{-3} T - 3.8640 \times 10^{-6} T^2$
4	N_2	$27.030 + 5.8150 \times 10^{-3} T - 0.2890 \times 10^{-6} T^2$

OR

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

(b) Explain in details about Proximate and Ultimate analysis of coal **04**

(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.

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