Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE- SEMESTER–III (NEW) EXAMINATION – WINTER 2020

Subject Code:3133606 Date:09/03/2021

Subject Name:Fundamentals of Material & Energy Balance Calculations

Time:10:30 AM TO 12:30 PM Total Marks:56

Instructions:

1. **Attempt any FOUR questions out of EIGHT questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

			Marks
Q.1	**(a)**	Define following terms (a) Yield (b) limiting reactant and (c) Molality	**03**
	(b)	What are the methods of expressing the composition of mixtures and solutions?	**04**
	(c)	The waste acid from a nitrating process containing 20% HNO_3, 55% H_2SO_4 and 25% H_2O by weight is to be concentrated by addition of concentrated sulphuric acid containing 90% HNO_3 to get desired mixed acid containing 26% HNO_3 and 60% H_2SO_4. Calculate the quantities of waste and concentrated acids required for 1000 kg of desired mixed acid.	**07**
Q.2	**(a)**	2000 kg of wet solids by weight are fed to a tray dryer where it is dried by hot air. The product finally obtained is found to contain 1 % moisture by weight, calculate: (a) The kg of water removed from solids, (b) The kg of product obtained.	**03**
	(b)	Explain Recycle, Purge, bypass with suitable diagram and also define the overall and single pass fraction conversion.	**04**
	(c)	A mixture of benzene vapour and nitrogen gas at 297 K and 100 kPa has a relative humidity of 60%. It is desired to recover 80% of benzene by cooling a mixture to 283 K and compressing to a suitable pressure. Find out the pressure required for above duty. Data: Vapour pressure of benzene at 297 K = 12.2 kPa	**07**
Q.3	**(a)**	Write down the steps to be followed for the calculation of material balance problem.	**03**
	(b)	Brief about raoult's law and henry's law for gas-liquid system.	**04**
	(c)	A mixture of acetone vapour and nitrogen contains 14.8% acetone by volume. Calculate the following at 293 K and a pressure of 99.33 kPa. (a) Partial pressure of acetone. (b) Moles of acetone per mole of nitrogen. (c) Relative saturation of mixture at 293 K. (d) Percentage saturation of mixture at 293 K. Data: Vapour pressure of acetone at 293 K = 24.638 kPa	**07**
Q.4	**(a)**	Define NCV and GCV.	**03**
	(b)	A tank holds 100 m3 of a water-salt solution in which 4 kg of salt is dissolved. Water runs into tank at the rate of 5 m3/min and salt solution overflows at the same rate. If the mixing in the tank is adequate to keep the concentration of salt in the tank uniform at all times, how much salt is in the tank at the end of 50 min. Assume that the density of the salt solution is essentially the same as that of water.	**04**
	(c)	A natural gas has the following composition on mole basis: CH_4= 84%, C_2H_4=13% and N_2= 3%	**07**

Calculate the heat added to heat 10 kmol of natural gas from 298 K to 523 K using heat capacity dat given below:

$Cp = a + bT + cT^2 + dT^3$ kJ/(kmol.K)

Gas	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
CH_4	19.2494	52.1135	11.973	-11.3173
C_2H_6	5.4129	178.0872	-67.3749	8.7147
N_2	29.5909	-5.141	13.1829	-4.968

Q.5 **(a)** Define (a) Adiabatic saturation temperature (b) Wet bulb Temperature (c) Molal humidity **03**

(b) Give Classification of material balance problems with and without chemical reaction and explain it briefly. **04**

(c) The gaseous reaction A = 2B + C takes place isothermally in a constant pressure reactor. Starting with a mixture of 75 % A and 25 % inerts (by volume), in a specified time the volume double. Calculate the conversion achieved. **07**

Q.6 **(a)** Discuss Proximate and Ultimate analysis of coal. **03**

(b) Calculate the heat of reaction at 298.15 K of the following reaction: **04**

$3CaSO_{4(s)} + SiO_{2(s)} \longrightarrow 3\,CaO.SiO_{2(s)} + SO_{2(g)} + 3/2\,O_{2(g)}$

Component	**ΔH^0_f, kJ/mol at 298.15 K (25^0 C)**
$CaSO_{4(s)}$	-1432.7
$SiO_{2(s)}$	-903.5
$3\,CaO.SiO_{2(s)}$	-2879
$SO_{2(g)}$	-296.81
$O_{2(g)}$	0.0

(c) 1 kg nitrogen is mixed with 3.5 m3 of hydrogen at 300 K and 101.3 kPa and sent to the ammonia converter. The product leaving the converter analyzed 13.7 % ammonia, 70.32 % hydrogen and 15.98 % nitrogen. **07**

i. Identity the limiting reactant.

ii. What is the present excess of excess reactant?

iii. What is the present conversion of the limiting reactant?

Q.7 **(a)** 98 grams of sulphuric acid are dissolved in water to prepare one litre of solution. Find normality and molarity of solution. **03**

(b) Explain orsat analysis with diagram. **04**

(c) Acetone is recovered from an acetone-air mixture containing 25% (volume) acetone by scrubbing with water. Assuming that air is insoluble in water, determine the percent of acetone in the entering gas that is absorbed if the gas leaving the scrubber analyzes 5% acetone. **07**

Q.8 **(a)** Write in brief about selectivity. **03**

(b) Write down statement of Amagat's law with mathematical expression. **04**

(c) A continuous distillation column is used to regenerate solvent for use in a solvent extraction unit. The column treats 200 kmol/hr of a feed containing 10 % mole ethyl alcohol and the rest is water. The overhead product is 89% mole alcohol and the bottom product is 0.3% mole alcohol. The overhead product is sent to the extraction unit and the bottom is wasted. What is the daily requirement of make-up alcohol in the solvent extraction unit? **07**

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