Seat No.: ________ Enrolment No. ________

GUJARAT TECHNOLOGICAL UNIVERSITY

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

Subject Code:2143507 Date:25/05/2019

Subject Name: Fundamentals of Stoichiometry

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.**

Q.1 **(a)** Define the following : (i) Selectivity (ii) Single pass conversion (iii) Molarity **03**

(b) The effective heat capacity of a mixture of gases is given by **04**

$C_p = 7.13 + 0.577 \times 10^{-3}\, t + 0.0248 \times 10^{-6}\, t^2$ Where C_p is in Btu /(lb-mol °F) and t is in °F. Change the equation in to the form in which C_p is given in kJ/(kmol K) and temperature is in K.

(c) 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 **07**

Q.2 **(a)** Prove mole fraction = Volume fraction = Pressure fraction. **03**

(b) 150 L oxygen cylinder contains gas at 300 K & 10 bar. Calculate the mass of oxygen in the cylinder. **04**

(c) The analysis of a sewage gas sample from a municipal sewage treatment plant is given below on a volume basis: Methane - 68 % Carbon dioxide - 30 % Ammonia - 2 %, and H_2S, SO_2, are in traces. **07**

Find i) The avg. molar mass of gas; ii) The density of gas at NTP

OR

(c) In a gas mixture consisting of hydrogen, nitrogen and carbon dioxide. The partial pressures are 25 kPa for hydrogen, 35 kPa for nitrogen and 140 kPa for CO_2. For 50 m^3 of the gas mixture at 400 K, Determine **07**

i) The number of moles of gas moisture.
ii) The number moles and mole fraction of hydrogen.
iii) The mass and the mass fraction of hydrogen.
iv) The pure component volume of hydrogen.
v) The average molecular weight of mixture.

Q.3 **(a)** Define : Dalton's law and Raoult's law **03**

(b) 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. **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 vapour. 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

Assume Raoult's law is applicable

OR

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

(b) Iron pyrite is burned in 50 % excess air. The following reaction occurs: **04**

$$4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$$

For 100 kg of iron pyrite charged, calculate following:

a) The amount of air supplied in kg.

b) The composition of exit gases if the percent conversion of iron pyrite is 70 %

(c) Calculate the following for the reaction: **07**

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

(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.

Q.4 (a) Explain Recycle, Bypass and Purge operations with example. **03**

(b) A saturated solution of $MgSO_4$ at 353 K is cooled to 303 K in Crystallizer. During cooling mass equivalent to 4% solution is lost by evaporation of water. Calculate the quantity of the original saturated solution to be fed to the crystallizer per 1000 kg of crystals of $MgSO_4.7H_2O$. **04**

Solubilities of $MgSO_4$ at 303 K and 353 K are 40.8 and 64.2 kg per 100 kg water respectively.

Data: Take Molecular mass of $MgSO_4$ is equivalent to 120.3 kg/kmol

(c) A distillation column separates 10000 kg/hr of a 50% benzene-50% toluene mixture. The product D recovered from the condenser at the top of the column contains 95% benzene, and the bottom W from the column contains 96% toluene. The vapour stream V entering the condenser from the top of the column is 8000 kg/hr. A portion of the product from the condenser is returned to the column as reflux, and the rest is withdrawn for use elsewhere. Assume that the compositions of the streams at the top **07**

of the column (V), the product withdrawn (D), and the reflux (R) are identical because the V stream is condensed completely. Find the ratio of the amount refluxed (R) to the product withdrawn (D).

OR

Q.4	**(a)**	Define: Solubility, Vapour pressure and Boiling point	**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 feed containing 50% benzene and 50 % toluene is fed to a distillation column at the rate of 5000 kg/h. The top product contains 95 % benzene and the bottom product contains 92 % toluene by weight. Calculate; i) The mass flow rate of top and bottom products. ii) The percent recovery of benzene.	**07**
Q.5	**(a)**	State Hess's law	**03**
	(b)	The heat capacity of carbon monoxide is given by the following equation, $C_P = 6.395 + 6.77 \times 10^{-4}T + 1.3 \times 10^{-7}T^2$ Where T is in K. What is the enthalpy change associated with heating of 28 grams of carbon monoxide from 500 K to 1000 K?	**04**
	(c)	Calculate the standard heat of formation of liquid methanol, given the standard heat of combustion of liquid methanol is – 726.55 kJ/mol and the standard heat of formation of gaseous CO_2 and liquid water are respectively, -393.51 and – 285.84 kJ/mol	**07**

OR

Q.5	**(a)**	Define the following terms with respect to humidification operation (1) Absolute humidity (2) Dry bulb temperature (3)) Dew point temperature	**03**
	(b)	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.	**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**

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