Seat No.: _____ Enrolment No.

GUJARAT TECHNOLOGICAL UNIVERSITY

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

Subject Code:2140406 **Date:15/05/2019**

Subject Name: 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)** In a double effect evaporator plant, the second effect is maintained under vacuum of 475 torr (mm Hg). Find the absolute pressure in kPa, bar and psi. **03**

(b) A solution of sodium chloride in water contains 30% NaCl (by mass) at 333K. The density of the solution is 1.2 kg/L. Find the molarity, normality and molality of the solution. Atomic mass: Na = 23, Cl = 35.5. **04**

(c) Obtain an empirical equation for calculating the heat of reaction at any temperature T (in K) for the reaction: $CH_{4\,(g)} + C_2H_5(g) \rightarrow C_3H_8$ **07**

Data: ΔH°_R at 298 K = -82660 J/mol ,$C^\circ_P = a + bT + cT^2 + dT^3$, J/(mol.K).

Component	a	b × 10^3	c × 10^6	d × 10^9
$CH_{4(g)}$	19.2494	52.1135	11.973	-11.3173
$C_2H_{4(g)}$	4.1261	155.0213	-81.5455	16.9755
$C_3H_{8(g)}$	-4.2227	306.264	-158.6316	32.1455

Q.2 **(a)** A weight of 1.10 kg of carbon dioxide occupies a volume of 33 litre at 300 K. Using the Van der Waals equation of state, calculate the pressure. **03**

(b) The diameter and height of a vertical cylindrical tank are 5 ft and 6 ft 6 inch respectively. It is full up to 75% height with carbon tetrachloride (CCl_4), the density of which is 1.6 kg/lit. Find the mass in kg. **04**

(c) A gas mixture has the following composition by volume. **07**
Ethylene: 30.6%, Benzene: 24.5%, Oxygen: 1.3%, Methane: 15.5%, Ethane: 25.0%, Nitrogen: 3.1%. Find a) the average molecular weight of the gas mixture, b) the composition by weight, and c) the density of the mixture in kg/m^3 at STP.

OR

(c) In case of liquids, the local heat-transfer coefficient for long tubes and using bulk-temperature properties is expressed by the empirical equation **07**

$$h = 0.023\, G^{0.8} k^{0.67} c_p^{\,0.33} / (D^{0.2} \mu^{0.47})$$

where h = heat-transfer coefficient, $Btu/(h.ft^2.{}^0F)$
G = mass velocity of liquid, $lb/(ft^2.s)$
c_p = heat capacity, $Btu/(lb.{}^0F)$
k = thermal conductivity, $Btu/(h.ft.{}^0F)$
D = diameter of tube, ft and
μ= viscosity of liquid, lb/(ft.s)
Is the given equation dimensionally consistent? If yes, convert the equation into SI units.

Q.3 **(a)** Explain Material balance of Extractor. **03**

(b) Define Ideal gas law, Raoult's Law, Henry's Law and Dalton's Law. **04**

(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, calculate the average molar mass to be 18.74. Calculate i) the volume % of N_2 in the flue gases, and ii) if the remaining components of **07**

the flue gases are CO_2 and O_2, calculate the volume % of each of them.

OR

Q.3 **(a)** Discuss methods of solving material balance problems without chemical reaction. **03**

(b) A single effect evaporator is fed with 1000 kg/h of weak liquor containing 15% caustic by weight and is concentrated to get thick liquor containing 40% by weight caustic (NaOH). Calculate: a) kg/h of water evaporated, and b) kg/h of thick liquor obtained **04**

(c) Heat capacity for gaseous SO_2 is given by the following equation: **07**

$C_p = 43.458 + 10.634 \times 10^{-3}\ T - \frac{5.945 \times 10^5}{T^2}$. Calculate the heat required to raise the temperature of 1 kmol pure SO_2 from 300 K to 1000 K.

Q.4 **(a)** Explain Material balance of Crystallizer. **03**

(b) Define & explain following terms: i) absolute humidity (H) ii) % humidity iii) wet-bulb temp (WB) iv) humid heat. **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 95% H_2SO_4 and concentrated nitric acid containing 90% HNO_3 to get desired mixed acid containing 26% HNO_3 and 60% H_2SO_4. Calculate the quantities of waste acid and concentrated acids required for 1000 kg of desired acid. **07**

OR

Q.4 **(a)** State Hess's Law of constant heat summation with example. **03**

(b) With a near sketch show the material balance for the following unit operations: Distillation and Evaporation. **04**

(c) A solution of ethyl alcohol containing 8.6% alcohol is fed at rate of 1000 kg/h to a continuous distillation column. The product is a solution containing 95.5% alcohol. The waste solution from the column carries 0.1% alcohol. All % are by weight. Calculate i) the mass flow rate of top & bottom product in kg/h ii) the % loss of alcohol. **07**

Q.5 **(a)** Define: (i) Standard Heat of formation (ii) Standard Heat of combustion (iii) Standard Heat of reaction. **03**

(b) Write a short note on recycling and bypassing operations. **04**

(c) A pilot plant reactor was charged with 50 kg naphthalene and 200 kg (98% by mass) H_2SO_4. The reaction was carried out for 3 hours at 433 K. The reaction goes near to completion. The product distribution was found to be 18.6% monosulphonate naphthalene and 81.4% disulphonate naphthalene. Calculate (a) the quantities of monosulphonate naphthalene (MSN) and disulphonate naphthalene (DSN) products, and (b) the complete analysis of the product. **07**

OR

Q.5 **(a)** Define Conversion, Yield, and Selectivity. **03**

(b) For o-xylene, calculate (a) latent heatof vaporization at T_B using Riedel equation, and (b) latent heat of vaporization at 25^0C using Watson equation. Data given: For o-xylene: Pc = 3732 kPa, Tc = 630.3 K, T_B = 417.6 K **04**

(c) In the Deacon process for manufacture of Chlorine, hydrochloric gas is oxidized with air. The reaction taking place is: $4\ HCl + O_2 \rightarrow 2\ Cl_2 + 2\ H_2O$. The air used is in excess of 30% of that theoretically required and the oxidation is 80% complete. Calculate the composition by volume of dry gases leaving the reaction chamber. **07**

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