Seat No.: _____ Enrolment No.

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– IV (New) EXAMINATION – WINTER 2019

Subject Code: 2140406 **Date: 12/12/2019**

Subject Name: Stoichiometry

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.**

Q.1 **(a)** Define: Ideal gas law, Raoult's law, Henry's law. **03**

(b) The conductance of a fluid –flow sytem is defined as volumetric flow rate, reffered to a pressure of one torr (133.322 Pa.). For an orifice, the conductance C can be computed from **04**

$$C = 89.2A\sqrt{\frac{T}{M}}\, ft^3/s$$

Where A = area of opening.ft^2, T = Temperature, ^0R, M = Molecular Weight. Convert the empirical equation into SI units.

(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 the flue gases are CO_2 and O_2. **07**

Q.2 **(a)** Iron metal weighs 200 lb & occupies a volume of 117 lit. Find the density in gm/cm^3. **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) Cracked gas from a petroleum refinery has the following composition by vol.; Methane 45%, Ehtane 10%, Ehtylene 25%, Propane 7%, Propylene 8%, n-Butane 5%. Find: a) Average molecular weight of the mixture, and b) the composition by wt%. **07**

OR

(c) An aqueous solution of K_2CO_3 is prepared by dissolving 43 kg K_2CO_3 in 100 kg water at 293 K. Find the molarity, normality and molality of the solution. Take specific gravity of the solution as 1.3 . **07**

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

(b) State recycling and bypassing operations with their importance in the process industries. **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.3 **(a)** Define : Conversion, yield, selectivity. **03**

(b) Formaldehyde is produced from methanol catalytic reactor. The production rate of formaldehyde is 1000 kg/h. If conversion of methanol is 65%, calculate the required feed rate of methanol. **04**

(c) An effluent sample from a formaldehyde plant is found to contain methanol and formaldehyde. The analysis of the solution indicated that TOC and ThOD are 258.3 mg/lit and and 965.5 mg/lit respectively. Find the concentration of each of the compounds in the sample. **07**

Q.4 **(a)** Define: i) Standard Heat of Formation ii) Standard Heat of Combustion iii) Standard Heat of Reaction. **03**

(b) Soyabeen seeds are extracted with n-hexane in batch extractors. The flaked seeds contain 18.6% oil, 69.0% solids and 12.4% moisture. At the end of the extraction process, de-oiled cake (DOC) analysis yields 0.8% oil, 87.7% solids and 11.5% moisture. Find the percentage recovery of oil. All percentages are by mass. **04**

(c) In the Deacon process for manufacturing chlorine, HCl gas is oxidized with air. The reaction taking place is: $4HCl_{(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)} + 2Cl_{2(g)}$
If the air is used in excess of 30% of that theoretically required, and if the oxidation is 80% complete, calculate the composition by volume of dry gases leaving the reaction chamber. **07**

OR

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

(b) Pure methane is heated from 303K to 523K at atmospheric pressure. Calculate the heat added per kmol methane, using data given. $C_p = a + bT + cT^2$
where C_p^o = Ideal gas heat capacity at 101.325 kPa, kJ/(kmol.K)
and T = Absolute temperature, K **04**

Compound	a	b x 10^{-3}	c x 10^{-6}	d x 10^{-9}
Methane (CH_4)	19.2494	52.1135	11.973	-11.3173

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

Q.5 **(a)** Explain material balance of Extractor. **03**

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

(c) Obtain an empirical equation for calculating the heat of reaction at any temperature T (in K) for the reaction $CH_{4(g)} + C_2H_{4(g)} \rightarrow C_3H_{8(g)}$. Data: ΔH_R° at 298 K = -82.66 kJ/mol , $C_p = a + bT + cT^2 + dT^3$, J/kmol.K **07**

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

OR

Q.5 **(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 (Cs). **04**

(c) 10000 kg of an aq sol containing 29.6% by wt anhydrous Na_2SO_4 at 413 K is charged to the crystallizer. During the cooling, 5% of initial water is lost by evaporation. As a result, crystals of $Na_2SO_4H_2O$ crystallize out. If the mother liquor is found to contain 18.3 % (by wt) anhydrous Na_2SO_4. Cal the yield & the quantity of mother liquor. **07**

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