Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–IV • EXAMINATION – WINTER 2013

Subject Code: 140504 Date: 30-12-2013

Subject Name: Fundamental of Chemical Engineering Calculations And 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.**
4. **Atomic Weights: C-12, H-1, O-16, S-32, Zn-65, K-39, Mg-24, N-14, Cu-63.5, Fe-55.8, Ca-40, Na-23, Cl-35.5**

Q.1 **(a)** H_2SO_4 solution has a molarity of 11.24 and molality of 94. Calculate the density of the solution. **04**

(b) The analysis of the gas sample is given below (on volume basis): **10**
CH_4=66%, CO_2=30%, NH_3=4%
Find (1) The average molecular weight of the gas and (2) Density of the gas at 202.65 kPa g pressure and 303^0 K.

Q.2 **(a)** (1) The diameter and height of a vertical cylindrical tank are 5 ft and 6 ft 6 inch respectively. It is full up to 50% height with water, the density of which is 1 kg/liter. Find the mass of water in kilograms and pounds. **05**
(2) Iron metal weighing 500 lb occupies a volume of 29.25 liter. Calculate the density of iron in kg/m^3. **02**

(b) The average molecular weight of a flue gas sample is calculated by two different engineers. One engineer uses the correct molecular weight of 28 for N_2 and determines the average molecular weight to be 30.08; the other engineer uses an incorrect value of 14, and calculates the average molecular weight to be 18.74. Calculate: **07**
(1)Find the volume % of N_2 in the flue gas.
(2)If the remaining components of the flue gas are CO_2 and O_2; find the volume % of each of them.

OR

(b) The gas phase reaction A → 2B + C takes place isothermally in a constant pressure reactor. Starting with a mixture of 75% A and 25% inert (both on volume basis), in a specified time the volume doubles [i.e. final volume = 2(initial volume)]. Compute the percent conversion of A achieved. **07**

Q.3 **(a)** It is desired to have a mixed acid containing 40% HNO_3, 43% H_2SO_4 and 17% H_2O by weight. Sulfuric acid of 98% by weight is available. Calculate (1) The strength of nitric acid and (2) the weight ratio of sulfuric acid to nitric acid. **07**

(b) 10000 kg/h of solution containing 20% methanol is continuously fed to a distillation column. Distillate (product) is found to contain 98% methanol and waste solution from the column carries 1% methanol. All percentages are by weight. Calculate (1) the mass flow rates of distillate and bottom product and (2) the percent loss of methanol. **07**

OR

Q.3 **(a)** A single effect evaporator is fed with 10000 kg/h of weak liquor containing 15% caustic by weight and is concentrated to get thick liquor containing 40% by weight caustic (NaOH). Calculate: (1) kg/h of water evaporated and (2) kg/h of thick liquor obtained. **04**

(b) 2000 kg of wet solids containing 70% solids by weight are fed to a tray drier where it is dried by hot air. The product finally obtained is found to contain 1% moisture by weight, calculate: (1) the kg of water removed from wet solids, (2) the kg of product obtained. **06**

(c) Define following with respect to Humidification operation: **04**
(1)Absolute humidity (2)Molar humidity
(3)Relative humidity (4)Dry bulb temperature

Q.4 **(a)** Define following with respect to material balance with chemical reaction: **06**
(1)Stoichiometric coefficient (2)Limiting Reactant
(3)Excess Reactant (4)Percent Excess
(5)Conversion (6)Yield

(b) A combustion chamber is fed with butane and excess air. Combustion of butane is complete. The composition of combustion gases on volume basis is given below: **08**
CO_2=9.39%, H_2O=11.73%, O_2=4.70% and N_2=74.18%
Find percent excess air used and mole ratio of air to butane used.

OR

Q.4 **(a)** In the Deacon process for the manufacture of chlorine, a dry mixture of hydrochloric acid gas and air is passed over a heated catalyst which promotes oxidation of acid. Air is used 30% in excess of that theoretically required. Calculate the weight of air supplied per kg of the acid. The reaction taking place is $4HCl + O_2 \rightarrow 2Cl_2 + 2H_2O$ **08**

(b) Calculate the consumption of 96% NaCl and 93% H_2SO_4 to produce 500 kg of HCl if the conversion is 92%. HCl is produced according to the reaction: **06**
$2NaCl + H_2SO_4 \rightarrow Na_2SO_4 + 2HCl$

Q.5 **(a)** Define following with respect to energy balance: **04**
(1)Heat Capacity (2)Standard heat of reaction
(3)Heat of Combustion (4)Standard heat of formation

(b) Discuss the importance of recycle and bypassing operation. **04**

(c) Methane gas is heated from 303^0 K to 523^0 K at atmospheric pressure. Calculate the heat added per kmol methane using C_p^0 data given below. **06**
$C_p^0 = a+bT+cT^2+dT^3$, kJ/kmol-K
For Methane, a=19.2494, $b\times10^3$=52.1135, $c\times10^6$=11.973,
$d\times10^9$= - 11.3173.

OR

Q.5 **(a)** Calculate the energy required to dissociate 1 kg of sodium bicarbonate at 298 K. The dissociation reaction is: **05**
$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$
ΔH_f^0 in kJ/mol at 298^0 K for components is given below.
$NaHCO_3(s)$ = - 950.81, $Na_2CO_3(s)$ = - 1130.68,
$CO_2(g)$ = - 393.51, $H_2O(g)$ = - 241.82

(b) A heat exchanger for cooling hot oil uses 10000 kg/hr of cooling water, which enters the exchanger at 294^0 K. The hot oil at the rate of 5000 kg/hr enters at 423^0 K and leaves at 338^0 K and has an average heat capacity of 2.51 kJ/kg-^{0}K. Calculate the outlet temperature of the water. **04**

(c) A gas mixture has the following composition by volume: **05**
SO_2 = 8.5%, O_2 = 10%, N_2 = 81.5%.
Find out the composition of gas mixture by weight.

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