*Seat No.: _____* *Enrolment No._____*

# GUJARAT TECHNOLOGICAL UNIVERSITY

**BE - SEMESTER– IV EXAMINATION – SUMMER 2015**

**Subject Code: 140504** **Date: 08/06/2015**

**Subject Name:** Fundamental of Chemical Engg. Calculations & Stoichiometry

**Time: 10.30am-01.00pm** **Total Marks: 70**

**Instructions:**

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **At wt. Na = 23, O= 16, H=1, N=14, C=12, Cl=35.5, S=32, Ca=40**

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|---|---|---|---|
| **Q.1** | **(a)** | 1 L of alcohol is mixed with l L of water. The densities of alcohol and water are 0.789 and 0.998 g/cm$^3$, respectively. What is the density of the resulting solution in kg/m$^3$? | **04** |
| | **(b)** | Define: (i) Raoult's law and (ii) Dalton's law. | **04** |
| | **(c)** | Differentiate between fundamental units & derived units. | **03** |
| | **(d)** | How many kilograms of $CaCO_3$ are there in:<br>(i) 15 lb-mol of $CaCO_3$<br>(ii) 50 g-mol of $CaCO_3$ ? | **03** |
| **Q.2** | **(a)** | A solution composed of 50% ethanol (EtOH), 10% methanol (MeOH), and 40% water ($H_2O$) is fed at the rate of 100 kg/hr into a separator that produces one stream at the rate of 60 kg/hr with the composition of 80% EtOH, 15% MeOH, and 5% $H_2O$, and a second stream of unknown composition. Calculate the composition (in %) of the three compounds in the unknown stream and its flowrate in kg/hr. | **07** |
| | **(b)** | A solution of sodium chloride in water contains 25% NaCl by mass. The density of the solution is 1.3 kg/L. Find the molarity, normality and molality of the solution. Atomic mass: Na = 23, Cl = 35.5. | **07** |
| | | **OR** | |
| | **(b)** | A natural gas has the following composition by volume: $CH_4$ – 80%, $C_2H_6$ – 15% and $N_2$ – 5%. Calculate (i) the average molecular weight and (ii) density at standard condition. | **07** |
| **Q.3** | **(a)** | Describe the methods of solving material balance problems without chemical reactions. Give proper examples of each method. | **07** |
| | **(b)** | A fuel oil containing 88.2% C and 11.8% $H_2$ is burnt with 20% excess air. 95% of carbon is burnt to $CO_2$ and the rest to CO. All the Hydrogen is converted to water. Determine the composition of the flue gas. | **07** |
| | | **OR** | |
| **Q.3** | **(a)** | Explain recycle stream, bypass stream and purge stream. Draw proper diagrams and give examples. | **07** |
| | **(b)** | 1000 kg of limestone of the following composition: $CaCO_3$ = 91%, $MgCO_3$ = 7.5% and insoluble = 1.5%. is calcined in a lime kiln. Calculate: (i) mass of CaO formed, (ii) mass of $CO_2$ formed. | **07** |

**Q.4** **(a)** (i) Define: (i) Heat of formation and (ii) heat of reaction. **08**
(ii) Differentiate between BOD and COD.

**(b)** Heat capacity for gaseous $SO_2$ is given by the following equation: **06**
$C^0 = 43.458 + 10.634 \times 10^{-3}\ T - 5.945 \times 10^5/T^2$
Calculate the heat required to raise the temperature of 1 kmol pure $SO_2$ from 300K to 1000K.

**OR**

**Q.4** **(a)** Explain the following terms with reference to chemical process **08**
i) Process flow sheet ii) endothermic and exothermic reactions
iii) Degree of freedom iv) Limiting and excess reactant

**(b)** A heat exchanger is used for cooling hot oil at the rate of 5000 kg/hr entering at 430 K and leaving at 350 K. Cooling is achieved by supplying 11000 kg/hr of cooling water, entering the exchanger at 290 K. The average heat capacity of oil is 2.51 KJ/kg K. Calculate the outlet temperature of the water. **06**

**Q.5** **(a)** With a neat sketch show the material balance for the following unit operation: (i) extraction (ii) evaporation. **07**

**(b)** A spent lye sample contains 9% glycerol and 11% NaCl salt. It is concentrated at the rate of 6000 kg/h in a double effect evaporator until the final solution contains 80% glycerol and 6% salt. 4% glycerol is lost by entrainment. All the percentage are by mass. Determine: **07**
(i) the evaporation taken place in the system.
(ii) the amount of salt crystallized out from the evaporator.

**OR**

**Q.5** **(a)** A multiple contact counter-current extractor is employed to extract oil from halibut livers with the help of ethyl ether. The fresh livers are charged to the extractor at the rate of 1000 kg/h and contain 25.7% oil. Pure ether enters the bottom of the extractor. The overflow from the extractor contains 70% oil. The underflow rate is 0.23 kg solution/kg of oil-free solids and is known to contain 12.8% oil. Based on these operating conditions, make the complete material balance and find the flow rate of ether to the extractor. Also compute the percentage recovery of oil. All percentage are by mass. **07**

**(b)** Do a material balance for distillation column operation with a neat diagram. **07**

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