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| **Name:**<br>**Enrolment No:** | UPES |

**Course: CHEG 235 – Chemical Process Calculations**

**Programme: B.Tech (APE)Gas & B.Tech CE+RP** **Semester: ODD-2017-18 (III Semester)**

**Time: 03 hrs.** **Max. Marks:100**

**Instructions:**

Attempt all questions from **Section A** (each carrying 12 marks)*;* and all questions from **Section B** (each carrying 20 marks)**;**

**Section A ( attempt all)**

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| 1. | A gaseous mixture of 1500 L/s has the following composition :$CH_4$-15% , $C_2H_6$-25% and $H_2$-60% ( all by volume) at 35$^o$C and 2300 mm Hg gauge, calculate,<br>a) the moles of each component<br>b) the concentration of each component in gm mol/cc<br>c) the partial pressure of each component<br>d) the molar density of the mixture<br>e) the mass flow rate of the mixture<br>f) the average molecular weight of the gas | **[12]** | **CO2** |
| 2. | A feed mixture consisting of 60% ethylene, 3% inerts and 37% water is sent to the reactor. The products analyzed 53.89% ethylene, 14.37 % ethanol, 1.80% ether, 26.35% water and 3.59% inerts. Calculate the conversion of ethylene, yield of ethanol and ether based on ethylene. | **[12]** | **CO3** |
| 3. | The dry bulb temperature and dew point of ambient air were found to be 302 K and 291 K respectively. The barometer reads 100.0 kPa absolute. The vapor pressure of water at dew point is 2.0624 kPa. Compute (a) the absolute molar humidity (b) the absolute humidity (c) the % RH, (d) the % saturation, (e) the humid heat, (f) the humid volume. | **[12]** | **CO4** |
| 4. | The following data were obtained in a test on coal fired steam generator. The ultimate analysis of coal: C, 80.5; H, 4.6%; O, 5.0%; N, 1.1. %; ash, 8.8%. No carbon is lost in the refuse. The Orsat analysis of flue gas: $CO_2$, 16.4%; $O_2$, 2.3%; CO, 0.4%; $N_2$, 80.9%. Calculate:<br>a)The weight of dry gaseous products formed per 100 kg of coal fired<br>b) The percent excess air supplied for combustion | **[12]** | **CO5** |
| 5. | Pure naphthalene is fed to a jacketed heater at 32$^o$C and is vaporized at atmospheric pressure by condensing Dowtherm-A vapors in a jacket at 1.15 kg/m$^2$ ($T_{sat}$=260$^o$C and latent heat of vaporization is 68.6 kcal/kg). Assume no subcooling of vapors. Calculate the quantity of Dowtherm-A condensed per 10 kg of naphthalene evaporated.<br>Boiling point: 218$^o$C<br>Melting point: 80$^o$C<br>Latent Heat of Vaporization: 75.5 kcal/kg | **[12]** | **CO6** |

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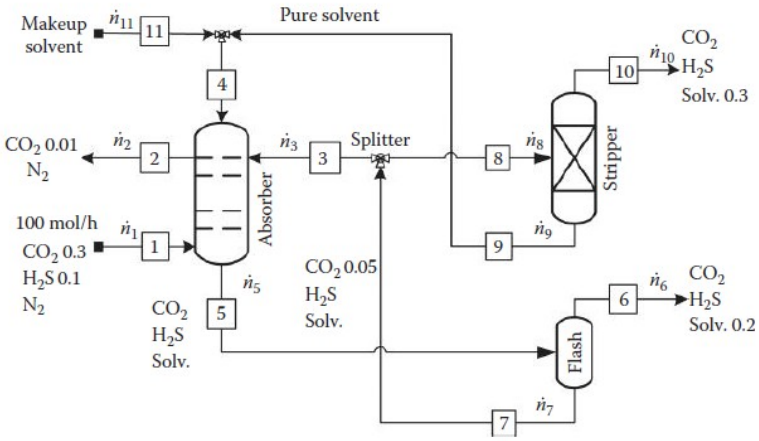
| | Latent Heat of Fusion: 36 kcal/kg<br>Use the average $C_p$ of solid is given by : $C_s$=0.28+0.0011T kcal/kg $^oC$<br>Use the average $C_p$ of liquid is given by: $C_l$=0.35+0.0008T kcal/kg $^oC$ where T is in $^oC$. | | |
| | **SECTION B (**Attempt all**)** | | |
| 6. | The absorber–stripper system shown below is used to remove carbon dioxide and hydrogen sulfide from a feed consisting of 30% $CO_2$ and 10% $H_2S$ in nitrogen. In the absorber, a solvent selectively absorbs hydrogen sulfide and carbon dioxide. The absorber overhead contains only 1% $CO_2$ and no $H_2S$. $N_2$ is insoluble in the solvent. The rich solvent stream leaving the absorber is flashed, and the overhead stream consists of 20% solvent, and contains 25% of the $CO_2$ and 15% of the $H_2S$ from the raw feed to the absorber. The liquid stream leaving the flash unit is split into equal portions, one being returned to the absorber. The other portion, which contains 5% $CO_2$, is fed to the stripper. The liquid stream leaving the stripper consists of pure solvent and is returned to the absorber along with *makeup* solvent. The stripper overhead contains 30% solvent. Calculate all flow rates and compositions of unknown streams. The gas feed rate is 100 mol/h.<br>  <br> | **[20]** | **CO5** |
| 7. | Ammonia is synthesized as per the following reaction:<br>The standard heat of reaction at 298 K for this reaction is -46.222 kJ. The specific heats of the reaction participants are represented by<br>Where Cpo is in J/mol K and the constants are :<br>Obtain an expression relating the heat of reaction and the temperature of the reaction.<br>Pyrites fines are roasted in a chamber plant for making sulphuric acid . The gases leaving the roaster are at 775 Kand have molar composition SO2 7.09%,O2 10.55%, SO3 0.45%, and N2 81.91%. Calculate the heat content of 1 kmol gas mixture over 298.15 K using the heat capacity data provided in the given table.<br>SO2: 24.7706+62.9481 x10-3T-44.2582 x10-6T2+11.122 x10-9 T3<br>O2:26.2057+11.7551x 10-3T-2.3426X10-6T2-0.5623 x 10-9T3<br>SO3: 22.0376+121.624 x 10-3T-91.8673 x10-6T2+24.3691 x 10-9T3 | **[20]** | **CO6** |

| Component | a | b | c |
|---|---|---|---|
| Ammonia | 25.48 | 36.89 x10-3 | -6.305 x 10-6 |
| Nitrogen | 27.31 | 5.2335x1.-3 | -4.1868 x10-9 |
| Hydrogen | 29.09 | -8.374x 10-4 | 2.0139 x10-6 |

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| | N2: 29.5909-5.141 x 10-3T+13.1829 x10-6T2-4.968 x 10-9T3<br>**or**<br>A continuous fractionating column at 1 atm is to be used to separate 15000 kg/h of a solution of benzene and toluene containing 50 weight % benzene into an overhead product containing 96 weight % benzene and a bottom product containing 97 weight % toluene. The feed will be at its boiling point and a reflux ratio of 2.5 kg of reflux per kg of distillate or product is to be used. Calculate the condenser and reboiler heat load.<br>Enthalpy of feed=170.8 kJ/kg<br>Enthalpy of reflux liquid=67 kJ/kg<br>Enthalpy of vapor leaving the column and entering the condenser=540 kJ/kg<br>Enthalpy of liquid leaving the reboiler=201.8 kJ/kg | | |