**Name:**

**Enrolment No:**

**UPES, DEHRADUN.**

**End semester Examination, April-May- 2024**

**Programme Name: B. Tech. (CERP)** **Semester : I I**

**Course Name : Material and Energy Balance Calculations** **Time : 3 hrs**

**Course Code : CHCE 2029** **Max. Marks : 100**

**Nos. of page(s) : 02**

Instructions : Assume any missing data. Draw the diagrams, wherever necessary.

**SECTION A**
**(5X4=20 marks)**

| S. No. | | Marks | CO |
|---|---|---|---|
| **1** | A liquefied mixture of methane, butane and propane has the compositions of 20, 35 and 45 percent respectively by volume. Find mol%, weight %, and average molecular weight of the mixture and density at STP. | **4** | **CO1** |
| **2** | Sulfur trioxide is obtained by the combustion of iron pyrites FeS2 according to the reaction<br>$4FeS_2 + 15\ O_2 \text{ -------} \rightarrow 2Fe_2O_3 + 8SO_3$<br>How many kilograms of pyrites are burned to obtain 100 Kg of sulfur trioxide. How many kilograms of oxygen is consumed during the production of 50 Kg of sulfur trioxide. | **4** | **CO2** |
| **3** | A wet stock of ammonium sulfate containing 20% water is sent to a drier. The material leaving the drier contains 2.44% moisture. Determine how many kgs of water removed per kg of wet cake charged. Also find the percentage of original water in the feed that is removed. | **4** | **CO2** |
| **4** | The solubility of sodium chloride in water at 298K is 35.8 kg/100 kg of water. Express the solubility as 1. Mass (Weight) % of NaCl 2. Mole % of NaCl 3. Kmol of NaCl/100 kg of water | **4** | **CO2** |
| **5** | If Cp of a gas is $Cp = a + bT + cT^{-2}$ , T in K and Cp in KJ/kmol K.<br>a) **Derive** is the average heat capacity between the temperatures $T_1$ to $T_2$.<br>What will be the heat required to heat one kmol of gas from $T_1$ to $T_2$. | **4** | **CO4** |

**SECTION B**
**(4 X 10=40 marks)**

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|---|---|---|---|
| **6** | 10,000 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<br>a. The mass flow rate of distillation and bottom product.<br>b. The percentage loss by methyl alcohol. | **10** | **CO1** |
| **7** | A producer gas made from coke has the following composition by volume.<br>**Item** \| **CO** \| **$O_2$** \| **$CO_2$** \| **$N_2$**<br>**Composition** \| **28** \| **0.5** \| **3.5** \| **68**<br>This gas is burned with 20% excess air(Assuming complete combustion). If the combustion is 98% complete, calculate the weight and composition of the stack gases formed per 100 moles of gas burned. | **10** | **CO3** |

| | | | |
|---|---|---|---|
| **8** | A solution of sodium chloride is available at 343 K which is saturated. This solution when cooled to 298 K, releases 100 g of crystals of NaCl.<br>a) What is the weight of the initial solution at 343K.<br>b) What is the weight and composition of the residual mother liquor.<br>The solubility of NaCl in water at 343 and 298 K are 6.39 and 6.14 kmol /1000 kg water respectively. | **10** | **CO3** |
| **9** | 1000 kg /h of thermic fluid to be used as a heat transfer medium is being heated using a heater from 380 to 550 K. Calculate the heat load on the heater in KW. The heat capacity of the fluid is given by the equation $Cp=1.436+2.18x10^{-3}T$ where T in K and Cp in kJ/kg K. | **10** | **CO4** |
| **SECTION C**<br>**(2 X 20=40 marks)** | | | |
| **10** | **a.** In the process of production of $PCl_5$, 4.25 g of $Cl_2$ with 2.20 g of $P_4$ produces 4.28 g of $PCl_5$. According to the following reaction. **Detail** the following.<br>$P_4 + 10Cl_2 \dashrightarrow 4PCl_5$<br>1. Limiting reactant 2. % excess reactant 3. Extent of reaction 4. What is the yield of $PCl_5$ with respect to $P_4$.<br>**b.** The drag coefficient $C_D$ is known to be function of diameter of the sphere, velocity and the fluid properties of the medium like its viscosity and density in a flow past immersed medium. Using Buckingham's π-theorem, **write** an expression for discharge $C_D$ (dimensionless) dimeter of the sphere, d (m), speed u (m/s), density of medium ρ ($kg/m^3$), viscosity of medium μ (kg/m-s). | **10**<br><br>**10** | **CO2** |
| **11** | One kg of water is heated from 250 K to 400 K at one standard atmospheric pressure. **Estimate**, how much heat is required for this?<br>Data: The mean heat capacity of ice Cp=2.03 KJ/kmol K (between 250 and 273 K)<br>The heat capacity of water between 273 K and 373 K is 1 btu/lb $^oF$.<br>The heat capacity of water vapor from 373 to 400 K is<br>$Cp=30.475+9.652x10^{-3}\ T + 1.189x10^{-6}\ T^2$.<br>The latent heat of fusion of water is 144 btu/lb and that of vaporization is 40608 KJ/Kmol.<br>**OR**<br>The heat capacity of benzene at two different temperatures is<br>T (K) \| 293 \| 323<br>Cp (J/gmol K) \| 131.05 \| 138.04<br>Fit the data into an equation of the form Cp=a+bT.<br>**Calcualte** the heat required to convert 100 kg of liquid benzene from 293.15 K to saturated vapor at the boiling point of 353.25 K. The latent heat of vaporization may be calculated using the Kistyakowsky equation $\frac{\Delta H}{T_b} = 36.63 + 8.31\ lnT_b$ where Tb is the boiling point of benzene and ΔH is the heat of vaporization. | **20** | **CO4** |