National Institute of Technology Hamirpur
Department of Chemical Engineering

Class: B.Tech End Semester Theory Examination 2020 **Semester:** V

Subject: Mass Transfer – I **Code**: CHD-311

Total Marks: 50 **Time: 2 hours**

Note: - The figures in the margin indicate full marks for the question.
- Assume the missing data/information (if any) and state it clearly.
- Answer all questions.

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1. (a) Explain the Knudsen diffusion from kinetic theory of gases. (2)

(b) A gas mixture containing (H_2 = 15%, CO = 30%, CO_2 = 5%, and N_2 = 50%) flows through a tube of 1 inch diameter, at 15 bar total pressure. If the velocities of the respective components are 0.05 m/s, 0.03 m/s, 0.02 m/s, and 0.03 m/s, calculate the mass average and molar average velocities of the mixture? (4)

(c) A sphere of naphthalene having a radius of 5mm is suspended in a large volume of still air at 310 K and 1 atm. The partial pressure at the surface of naphthalene at 310K is 50Pa. Assume dilute gas phase. The D_{AB} of naphthalene in air at 310K is 6×10^{-6} m^2/s. Calculate the rate of evaporation of naphthalene from the surface? (4)

2 (a) Discuss the film theory. State the assumptions and limitations, if any. (4)

(b) In an experimental study of the absorption of certain gas from air stream by water, the value of overall mass transfer coefficient, K_G was found to be 2×10^{-6} $kmol/m^2s\,kPa$. The absorption takes place at 298 K and 1 atm. At a particular location of column, the gas phase concentration is 5 mol% and liquid phase concentration is 0.2 mol%. Only 10% of total resistance lies in the liquid phase. The solution obeys Henry's law and value of m=1.5 at 298K and 1 atm. Calculate the individual film coefficients, flux and the interfacial concentrations. (6)

3. It is desired to absorb 95% of acetone by water from a mixture of acetone and Nitrogen containing 1.5% of the component in a counter-current tray tower. Total gas input is 30 kmol/hr and water enters the tower at a rate of 90 kmol/hr. The tower operates at 27 °C and 1 atm. Pressure. The tower has 12 number of real trays. Equilibrium data for the system is given in the following table: (10)

X	0.0	0.001	0.002	0.003	0.004	0.005
Y	0.0	0.00253	0.00506	0.00759	0.01012	0.01265

i) write down the equation of operating line

ii) Determine the number of ideal stages necessary for the separation using graphical method

iii) Calculate the overall tray efficiency

4. Solute A is to be absorbed from a binary mixture containing 7.5% of A with solvent B in a packed tower. Based on flooding calculation, a tower diameter of 1.2 m is selected. Total gas flow rate is 60 kmol/h. The exit gas must not contain 0.2% of solute A. Solute free liquid B enters from the top of the tower at 40 kmol/h. The gas phase and liquid phase mass transfer coefficients based on mole ratio unit are: $k_X = 2.05\,\text{kmol/m}^2\text{h}\,(\Delta X)$ and $k_Y = 1.75\,\text{kmol/m}^2\text{h}\,(\Delta Y)$. The equilibrium line equation is Y=0.63X. Specific interfacial area of gas-liquid contact is 71 m^2/m^3. (10)

   i) Calculate packing height required for the desired separation.
   ii) For 99.5% solute A removal, what percentage increase in packed height is needed?

5 (a) Explain the drying rate curve. Comment on the removal of different kinds of moisture and major resistances at various stages of drying. (5)

(b) What is an adsorption isotherm? Discuss Langmuir adsorption isotherm and state the assumptions clearly. (5)