BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(MID SEMESTER EXAMINATION)

CLASS: BE **SEMESTER: V**
BRANCH: CHEMICAL/CHEMICAL (P&P) **SESSION : MO/2018**

SUBJECT : CL5001 MASS TRANSFER OPERATIONS

TIME: 1.5 HOURS **FULL MARKS: 25**

INSTRUCTIONS:
1. The total marks of the questions are 30.
2. Candidates may attempt for all 30 marks.
3. In those cases where the marks obtained exceed 25 marks, the excess will be ignored.
4. Before attempting the question paper, be sure that you have got the correct question paper.
5. The missing data, if any, may be assumed suitably.

Q1 (a) Describe Fick's law of diffusion. Derive the equation for molar flux of steady-state counter-current diffusion. [2]

(b) Ammonia is being absorbed from a stagnant mixture of nitrogen and hydrogen by contact with a 2 N sulfuric acid solution. At one place in the apparatus where the pressure is 1 bar and the temperature 300 K, the analysis of the gas is (1) 40% NH_3, (2) 20% N_2 and (3) 40% H_2 by volume. Estimate the effective diffusivity of ammonia in the gaseous mixture. [3]
Given: $D_{12} = 0.237$ cm^2/s and $D_{13} = 0.728$ cm^2/s at 1bar and 300 K.

Q2 (a) The Knudsen diffusivity of hydrogen at 20°C is 1.684×10^{-4} m^2/s. Find the Knudsen diffusivity of oxygen at same temperature. [2]

(b) In an experimental study of the absorption of ammonia by water in a wetted-wall column, the value of K_G was found to be 2.75×10^{-6} kmol/m^2-s-kPa. The total pressure was 1 atm. Eighty five percent of the total resistance to mass transfer was found to be in the gas phase. Assume Henry's is applicable with m=1.64. Calculate the individual film coefficients. [3]

Q3 (a) Describe Raoult's law. Write the assumptions for ideal liquid solutions. [2]

(b) A gas contains 2% ammonia by volume and is washed using water (contains 0.1% ammonia) as solvent. The water inlet rate is 2 mole/s. It is aimed to remove 98% ammonia from the gas. If the gas flow rate at the inlet of absorber is 0.25 m^3/s at 300 K and 1 std atm pressure. Calculate the mole fraction of ammonia in exit liquid. [3]

Q4 (a) Describe the material balance for absorption in the case of one component transferred in co-current and counter-current flow. Also, show the operating line and equilibrium lines for both cases. [2]

(b) Describe flooding and loading phenomena in detail for a tower operation. [3]

Q5 (a) Describe constant-pressure vapor-liquid equilibria for a binary system with a neat diagram. [2]

(b) A binary liquid mixture of A (more volatile) and B containing 60% mole A, at 30°C is to be continuously flash-vaporized at 1 std atm pressure to get a distillate fraction of 0.6. what will be the composition of vapor and liquid in the flash drum at equilibrium? (Given: $\alpha_{AB} = 2.16$). [3]

Q6 (a) Describe the minimum boiling azeotrope. Draw a neat diagram for the minimum boiling azeotropism at constant temperature, at constant pressure including equilibrium distribution curve. [2]

(b) An equimolar liquid mixture of species 1 and 2 is in equilibrium with its vapor at 400 K. At this temperature, the vapor pressures of species are $P_1^{sat} = 180$ kPa and $P_2^{sat} = 120$ kPa. Assuming the Raoults law is valid, calculate the value of y_2. [3]

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