[3 Hours] **[Total Marks: 80]**

Instructions to the candidates if any: -

1. **Question No 1 is compulsory**
2. **Attempt any three questions from the remaining five questions**
3. **Assume suitable data wherever necessary**
4. **The figures to the right indicate full marks**

Q. No. 1

a. As a chemical engineer how will select the solvent to be used in gas absorption? [05]

b. Discuss the diffusion process of various solute through polymers. [05]

c. Discuss the concept of wet-bulb temperature. [05]

d. A thin film of liquid is flowing past a vertical surface, inclined at an angle of 30^O with the vertical. The density of the liquid is $998\ kg/m^3$, viscosity is $8.94 \times 10^{-2}\ kg/ms$. The thickness of the liquid film is $2\ mm$. Find the bulk average velocity with which the film is coming down. [05]

Q. No. 2

a. What do you mean by the unicomponent diffusion of liquid A in its binary mixture with liquid B ? Derive an equation for the steady state mass transfer flux in this case. [08]

b. The solute HCl is diffusing through a thin film of water $2.5\ mm$ thick at $293\ K$. The concentration of HCl at point 1 at one boundary of the film is $13\ wt\ \%\ HCl$ (Density of $1060.7\ kg/m^3$), and at the other boundary at point 2 it is $7\ wt\ \%\ HCl$ (Density of $1030.3\ kg/m^3$). The diffusion coefficient of HCl in water is $2.5 \times 10^{-9}\ m^2/s$. Assume steady state and one boundary impermeable to water, calculate the flux of HCl in $kmole/m^2s$. [12]

Q. No. 3

a. A gas phase is in contact with a liquid and solute A is transferring from the gas phase to the liquid phase. Draw the concentration profile for this interphase phase transfer. Also, derive the relationship between individual and overall mass transfer coefficients. [10]

b. Water is flow down a vertical wall $2.5\ m$ long in the form of a thin film. The flow rate for the falling film is $0.045\ kg/s$ per meter width at 25^OC and $1\ std\ atm$. The water film is in contact with pure carbon dioxide. The solubility of carbon dioxide in water at 25^OC is $0.0336\ kmole/m^3\ of\ solution$ and water is essentially free of carbon dioxide initially. The diffusion coefficient of carbon dioxide in water at the prevailing conditions is $1.96 \times 10^{-9}\ m^2/s$. The density of the solution is $998\ kg/m^3$ and its viscosity is $8.94 \times 10^{-4}\ kg/m.s$. Estimate the rate of absorption of carbon dioxide in water . [10]

Q. No. 4

a. Compare tray columns with packed columns considering the following points. [08]

1. Gas-side pressure drop.
2. Liquid hold-up
3. Liquid to gas ratio
4. Foaming systems
5. Presence of solids
6. Temperature fluctuations.
7. Cleaning
8. Corrosion

b. A plant manufacturing dry ice will burn coke in air to produce a flue gas containing 15 % CO_2, 6 % O_2 and 79 % N_2. The gas is blown into a counter current absorption tower at 1.2 $std\ atm$ and 25^0C, to be scrubbed with 30 % ethanolamine solution containing 0.058 mole fraction of CO_2 in it. The gas leaving the absorption tower is to contain 2 % of CO_2 by volume.

i. Determine the minimum liquid to gas ratio.
ii. Determine $kg\ of\ entering\ liquid/m^3\ of\ the\ entering\ gas$, for liquid to gas ratio which is 20 % more than the minimum ratio.

The equilibrium data is given in the following table. $x^*_{CO_2}$ is the mole fraction of CO_2 in the liquid solution and $P^*_{CO_2}$ is the partial pressure of CO_2 in the gas mixture in $mm\ of\ Hg$

$x^*_{CO_2}$	0.058	0.060	0.062	0.064	0.066	0.068	0.070
$P^*_{CO_2}$	5.6	12.8	29.0	56.0	98.7	155	232

[12]

Q. No. 5

a. Derive the equation for adiabatic saturation curves [08]

b. 220 kg of a wet solid is to be dried from an initial moisture content of 26 % to a final moisture content of 3.5 %. Drying tests show that the rate of drying is constant at $3 \times 10^{-4}\ kg/m^2s$ in the region $0.2 - 0.4\ \frac{kg\ water}{kg\ solid}$. The drying rate falls linearly in the range of $0.01 - 0.2\ \frac{kg\ water}{kg\ solid}$. If the equilibrium moisture content is $0.01\ \frac{kg\ water}{kg\ solid}$, calculate the time of drying. The drying surface is $\frac{1\ m^2}{48\ kg\ dry\ solid}$ [12]

Q. No. 6

Write short notes on the following (Any four)- (20)

a. Packings used in packed columns
b. Minimum liquid to gas ratio in gas-absorption
c. Venturi Scrubber
d. The typical rate of drying curve
e. Operational problems with tray columns

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