

KATHMANDU UNIVERSITY
End Semester Examination
February, 2025

Marks Scored:

Level : B.E.

Year : III

Exam Roll No. :

Time: 30 mins.

Registration No.:

Course : CHEG 313

Semester : II

F. M. : 10

Date : 27 FEB 2025

SECTION "A"

[20 Q. × 0.5 = 10 marks]

Choose and encircle the most appropriate option from each set of choices

1. Find the diffusivity of AB in m^2/s if $J_A = 5 \text{ mol}/m^2 \cdot \text{sec}$, concentration difference is $2 \text{ mol}/m^3$ and distance is 3 m?
a. 2.5 b. 5.5 c. 7.5 d. 10.5
2. Henry's law states that the
a. Partial pressure of a component over a solution is proportional to its mole fraction in the liquid
b. Partial pressure of a component over a solution is proportional to its mole fraction in the vapor
c. Vapor pressure is equal to the product of the mole fraction and the total pressure
d. Partial pressure is equal to the product of the mole fraction and the total pressure
3. The absorption factor is defined as
a. L/mG b. G/mL c. mL/G d. LG/m
4. The substance on the surface of which adsorption takes place is called _____ and the substance adsorbed is known as _____?
a. Adsorbate and adsorbent b. Adsorbent and adsorbate
c. Absorbent and absorbate d. Absorbate and absorbent
5. The term "approach" in a cooling tower refers to the difference in the temperature of the
a. Cold water leaving the tower and wet bulb temperature of the surrounding air
b. Hot water entering the tower and wet bulb temperature of the surrounding air
c. Hot water entering the tower and cooled water leaving the tower
d. Cold air entering the tower and heated air leaving the tower
6. The number of transfer units (NTU) is equal to the number of theoretical plates (NTP) only when the operating line
a. Lies above the equilibrium line b. Lies below the equilibrium line
c. And the equilibrium line are parallel d. Is far from the equilibrium line
7. According to the penetration theory, the mass-transfer coefficient is directly proportional to
a. D_{AB}^2 b. $D_{AB}^{0.5}$ c. $D_{AB}^{1.5}$ d. D_{AB}
8. Flooding in a column results due to
a. High pressure drop b. Low pressure drop
c. Low velocity of the liquid d. High temperature
9. The psychrometric ratio is defined as _____ where, h_G convective heat transfer coefficient, k_y is convective mass transfer coefficient and c_s is humid heat.
a. h_G / k_y b. k_y / h_G c. $h_G / k_y \cdot c_s$ d. $k_y \cdot c_s / h_G$

10. Reboiler is considered as one theoretical plate, because
- Of the assumption that vapor and liquid leaving the reboiler are in equilibrium
 - Vapor is recycled to the column
 - Reboiler itself contains one plate
 - Vapor is pure
11. Binary distillation involves the mass transfer by _____ at the gas-liquid interface.
- Unidirectional diffusion from liquid to gas phase
 - Unidirectional diffusion from gas to liquid phase
 - Non directional diffusion in either gas to liquid or liquid to gas phase
 - A counter diffusion at an almost equal molar rate
12. What is the humid heat of a mixture of air ($C_p = 10$ J) with water vapor ($C_p = 20$ J), if the humidity is 25%?
- 10
 - 15
 - 20
 - 25
13. Minimum reflux ratio in a distillation column results in?
- Optimum number of trays
 - Maximum condenser size
 - Minimum reboiler size
 - Minimum number of trays
14. At total reflux
- Distillate is nil
 - Reflux is nil
 - Residue is nil
 - Maximum number of stages required
15. Distillation used in the laboratories when the amount of required product is small
- Steam
 - Fractional
 - Azeotropic
 - Batch
16. A binary distillation column is to be designed using McCabe Thiele Method. The distillate contains 90 mol% of the more volatile component. The point of intersection of the q-line with the equilibrium curve is (0.5,0.7). The maximum reflux ration for this operation is _____?
- 2
 - 1.5
 - 0.5
 - 1
17. For stripping of a gas in a countercurrent stripper, the oprating line
- Lies above the equilibrium curve
 - Lies below the equilibrium curve
 - Can lie above or below the equilibrium curve
 - Is always parallel to the equilibrium curve
18. The dimensionless group in mass transfer that is equivalent to Prandtl number in heat transfer is
- Nusset number
 - Sherwood number
 - Schmidt number
 - Stanton number
19. In a batch adsorption process, 5 g of fresh adsorbent is used to beat 1 liter on an aqueous phenol solution. The initial phenol concentration is 100 mg/L. The equilibrium relation is given by $q = 1.3C$, where q is the amount of phenol adsorbed in mg of phenol per gram of adsorbent and C is the concentration of phenol in mg/L in the aqueous solution. When equilibrium is attained between the adsorbent and the solution, the concentration of phenol in the solution is _____ mg/L.
- 13.33
 - 7.5
 - 0.5
 - 11.11
20. Unsaturated air with dry and wet bulb temperatures of 35 °C and 25 °C respectively is passed through water spray chamber maintained at 35 °C. The air will be
- Cooled
 - Humidified
 - Dehumidified
 - Heated

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Semester : II
F. M. : 40

SECTION "B"

[5 Q. × 8 = 40 marks]

Attempt ALL questions. A graph paper should be provided.

1.

- a. A large volume of pure gas B at 2 atm pressure is flowing over a surface from which pure A is vaporizing. The liquid A completely wets the surface, which is a blotting paper. Hence, the partial pressure of A at the surface is the vapor pressure of A at 298 K, which is 0.20 atm. The k'_y has been estimated to be $6.78 \cdot 10^{-5}$ kg mol/s·m²·mol fraction. Calculate N_A , the vaporization rate and also the value of k_y and k_G . If needed, $k'_y = k_y y_{BM}$. [2+1+1]
- b. Ammonia is stripped from a dilute aqueous solution by countercurrent contact with air in a column containing seven sieve trays. The equilibrium relationship is $y_e = 0.8x_e$, and when the molar flow of air is 1.5 times that of the solution, 90 percent of the ammonia is removed. How many ideal stages does the column have, and what is the stage efficiency? $[S = \frac{mV}{L}] [N = \frac{\ln [(x_a - x_a^*) / (x_b - x_b^*)]}{\ln S}]$ [2+2]

2. An adsorbate in vapor is adsorbed in an experimental packed bed. The inlet contains $C_{A,F} = 600$ ppm of adsorbate. Assume 95% removal. Data measuring the outlet concentration over time from the bed are plotted below:

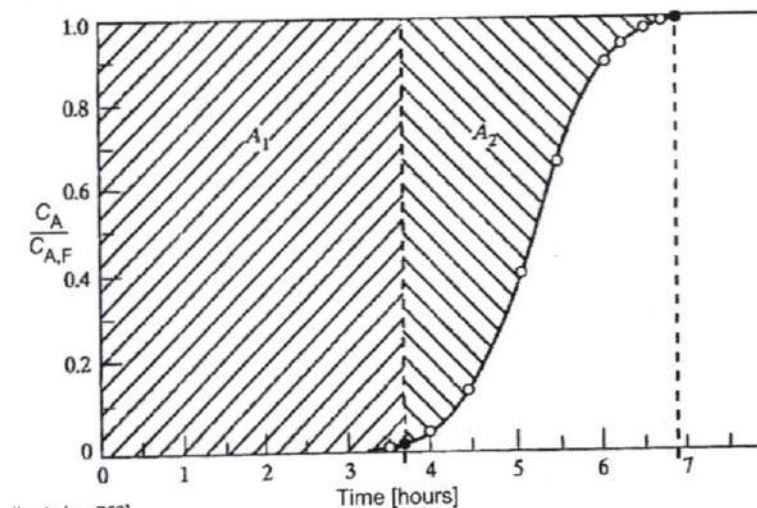


Figure for Problem 2

- a. Determine the breakthrough time, t_b . [1]
- b. What actual fraction of the bed's capacity is used at t_b ? [1]
- c. If the lab scale bed was originally 14 cm long, what equivalent length is unused at time t_b ? [2]
- d. If we wanted a breakthrough time of 7.5 hr instead, how much longer should the bed be (keeping the diameter and flow profile fixed)? [4]
- $[t_b = t^*(1 - LUB/L)] [t^* \propto L]$

3. Ammonia (NH_3) will be absorbed from an air mixture at 293 K and 1.0 atm pressure in a countercurrent packed tower, using water as the absorption solvent. The total inlet gas molar flow rate is $5.03 \cdot 10^{-4}$ kmole/s, and the NH_3 composition in the inlet gas is 3.52% by volume. Ammonia-free water at a mass flow rate of $9.46 \cdot 10^{-3}$ kg/s will be used as the absorption solvent. If the ammonia concentration in the outlet gas is reduced to 1.29% by volume, determine the ratio of the operating solvent molar flow rate to the minimum molar solvent flow rate, equilibrium distribution data for the NH_3 -water-air system at 293K and 1.0 atm are given in the figure below. [8]

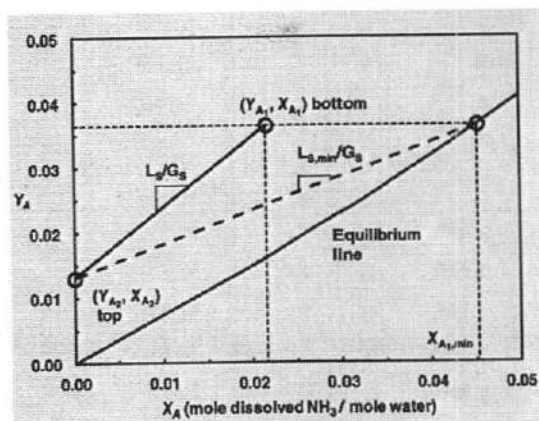


Figure for Problem 3

4. A laboratory apparatus to measure the diffusion coefficient of vapor-gas mixtures consists of a vertical, small-diameter column containing the liquid phase that evaporates into the gas flowing over the mouth of the column. The gas flow rate is sufficient to maintain a negligible vapor concentration at the exit plane. The column is 150 mm high, and the pressure and temperature in the chamber are maintained at 0.25 atm and 320 K respectively? For calibration purposes, you've been asked to calculate the expected evaporation rate ($\text{kg/h}\cdot\text{m}^2$) for a test with water and air under the foregoing conditions, using the known value of D_{AB} for the vapor-air mixture. Water ($T = 320$ K): $p_{\text{sat}} = 0.1053$ bar and D_{AB} at 320 K and 0.25 atm is $1.157 \cdot 10^{-4}$ m^2/s . Also write four assumptions you make while solving this problem. [6+2]

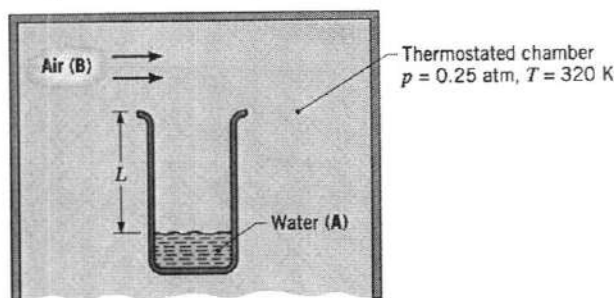


Figure for Problem 4.

5. A continuous fractionating column is to be designed for separating 10000 kg/hr for a liquid mixture containing 40 mole % methanol and 60 mole % water in to an overhead product containing 97 mole % methanol and a bottom product having 98 mole % water. A molar reflux ratio of 3 is used. Calculate
 a. Moles of overhead product obtained per hour [3] and
 b. Number of ideal plates and location of the feed plate, if the feed is at its bubble point [5]

Equilibrium data:

x	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
y	0.417	0.579	0.669	0.729	0.78	0.825	0.871	0.915	0.959

Where, x and y are mole fraction of methanol in liquid and vapor phase respectively.

$$\left(y = \frac{\alpha x}{1 + (\alpha - 1)x}\right) \left(y = \left(\frac{R}{R+1}\right)x + \frac{x_D}{R+1}\right) \text{ for rectifying section} \quad \left(y = \left(-\frac{q}{1-q}\right)x + \frac{x_F}{1-q}\right) \text{ for feed}$$