

KATHMANDU UNIVERSITY  
End Semester Examination [C]  
December, 2024

Marks Scored:

Level : B.E.

Year : III

Exam Roll No. :

Time: 30 mins.

Registration No.:

Course : CHEG 313

Semester : II

F. M. : 10

Date 24 DEC 2024

SECTION "A"

[20 Q. × 0.5 = 10 marks]

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

- 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  $3 \text{ m}$ ?  
a. 2.5                      b. 5.5                      c. 7.5                      d. 10.5
- 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
- The absorption factor is defined as  
a.  $L/mG$                       b.  $G/mL$                       c.  $mL/G$                       d.  $LG/m$
- 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
- 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
- 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
- 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.  $D_{AB}$
- Flooding in a column results due to  
a. High pressure drop                      b. Low pressure drop  
c. Low velocity of the liquid                      d. High temperature
- 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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24 DEC 2024

Course : CHEG 313  
Semester : II  
F. M. : 40

SECTION "B"

[5 Q × 8 = 40 marks]

Attempt ALL questions. A graph paper and psychrometric chart should be provided.

1.
  - a. A thin liquid film of ammonia, which has formed on the inner surface of a tube diameter  $D=10$  mm and length 1 m is removed by passing dry air through the tube at a flow rate of  $3 \cdot 10^{-4}$  kg/sec. The tube and the air are at  $25^\circ\text{C}$ . What is the average mass transfer coefficient? Properties of air at  $25^\circ\text{C}$ :  $\nu = 15.7 \cdot 10^{-6}$  m<sup>2</sup>/s;  $\mu = 183.6 \cdot 10^{-7}$  Ns/m<sup>2</sup> and  $D_{AB} = 0.28 \cdot 10^{-4}$  m<sup>2</sup>/s. Show that the flow is laminar ( $Re < 2300$ ) and use  $Sh = A \left( \frac{Re \cdot Sc}{L/D} \right)^n$  where  $A = 1.86$  and  $n=1/3$  for pipe flow cases.  $Sc = \nu / D_{AB}$  and  $k_c = (Sh \cdot D_{AB}) / D$ . [4]
  - 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?  $[S = \frac{mV}{L}] [N = \frac{\ln[(x_a - x_a^*) / (x_b - x_b^*)]}{\ln S}]$  [4]
2. 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]
  - 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.

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

3. Hydrogen gas is maintained at 3 bars and 1 bar on opposite sides of a plastic membrane, which is 0.3 mm thick. The temperature is  $25^\circ\text{C}$ , and the binary diffusion coefficient of hydrogen in the plastic is  $8.7 \times 10^{-8}$  m<sup>2</sup>/s. The solubility of hydrogen in the membrane is  $1.5 \times 10^{-3}$  kmol/m<sup>3</sup> bar. What is the mass diffusive flux of hydrogen through the membrane? [8]

P.T.O.

4. A gas stream containing 90 mol %  $N_2$  and 10 %  $CO_2$  is passed through an absorber, in which pure and cool water at 5 °C is used as a solvent. The operation is assumed to be isothermal at 5 °C and isobaric at 10 atm. The liquid flow rate is 1.5 times the minimum liquid flow rate  $(L/G)_{min}$ . Determine the number of equilibrium stages required to absorb 92 % of  $CO_2$ . Given Henry's constant of  $CO_2$  in water at 5 °C of 876 atm/mole fraction. Basis: 1.0 mol/h of the gas mixture. Hint: Make sure you know the difference between  $x$  and  $X$  ( $y$  and  $Y$ ). (If graph paper is not provided, plot the graph roughly to solve the problem) [8]
5. Assume that the outside temperature is 32 °C with a relative humidity = 60 %. Use the psychrometric chart to determine the specific humidity, the enthalpy  $h$ , the wet bulb temperature  $T_{wb}$ , the dew-point temperature  $T_{dp}$ , and the specific volume of the dry air,  $v$ . (Please submit your psychrometric chart along with your answer sheet with marked lines and values) [8]

24 DEC 2024



Universal Industrial Gases, Inc.

### PSYCHROMETRIC CHART

BAROMETRIC PRESSURE 760 mm of Mercury



