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CBCS SCHEME

USN | | | | | | | | | | 15CH/PC52

Fifth Semester B.E. Degree Examination, Dec.2019/Jan.2020
Mass Transfer Operations – I

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. State ficks first and second law of diffusion giving equations. **(08 Marks)**
b. Write brief note on Molecular and Eddy diffusion. **(08 Marks)**

OR

2 a. Derive an expression for the molar flux when a gas is diffusing through another stagnant gas. State the assumptions. **(08 Marks)**
b. Explain the two resistance theory for interphase mass transfer. **(08 Marks)**

Module-2

3 a. The relative humidity of air at 30°C is 70%. Find its i) absolute humidity ii) saturated humidity and iii) Humid volume. **(08 Marks)**
b. Describe a psychometric chart. **(08 Marks)**

OR

4 a. Explain the method of dehumidification of air. **(08 Marks)**
b. Describe: i) Wet Bulb Temperature ii) Dry Bulb Temperature. **(08 Marks)**

Module-3

5 a. Describe briefly the principles of drying. **(08 Marks)**
b. What is a drying curve? How do you evaluate the rate of drying from drying data? **(08 Marks)**

OR

6 a. What are the different types of dryers? Explain anyone with a neat sketch. **(08 Marks)**
b. Discuss various mechanisms of drying. **(08 Marks)**

Module-4

7 a. Explain the various theories of adsorption and adsorption isotherms. **(08 Marks)**
b. List the various industrial adsorbents and their applications. **(08 Marks)**

OR

8 a. What are the various equipments used in adsorption? **(08 Marks)**
b. Briefly explain the method of multistage adsorption. **(08 Marks)**

Module-5

9 a. What are the factors governing Nucleation and crystal growth grates? Explain. **(08 Marks)**
b. What are the various types of crystallizers available Industrially? **(08 Marks)**

OR

10 a. Briefly explain the working principle of reverse osmosis with a neat sketch. **(08 Marks)**
b. Write briefly on: i) Ion exchange ii) Super critical fluid extraction. **(08 Marks)**

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17CH/PC52

Fifth Semester B.E. Degree Examination, Dec.2019/Jan.2020
Mass Transfer Operations – I

Time: 3 hrs. Max. Marks: 100

Note: **1.** ***Answer any FIVE full questions, choosing ONE full question from each module.***
2. ***Use of Humidity chart is allowed.***

Module-1

1 a. Develop a model for a steady state diffusion of A through non diffusing B. State assumptions. **(08 Marks)**

b. Calculate the rate of diffusion of water vapour from a thin layer of water at the bottom of wall 6 m in height to dry air flowing over the top of the well. Assume the entire system is at 298 K and atmosphere pressure. If the well diameter is 3m. Find out the total weight of water diffused per second from the surface of water in the well. Diffusion coefficient of water vapour in dry air at 298 K is 0.256×10^{-4} m^2/sec. The partial pressure of water vapour at 298 K is 0.0323×10^{-4} kg/m^2. **(08 Marks)**

c. Write an equation for estimation of diffusivity of gases and liquids. **(04 Marks)**

OR

2 a. Explain Danckwert's and Higbie's theories and also give its merits and demerits. **(08 Marks)**

b. Develop an equation to relate between individual and overall mass transfer coefficients. **(06 Marks)**

c. Explain steady state co-current and counter current processes with material balance. **(06 Marks)**

Module-2

3 a. Derive an equation for adiabatic saturation temperature. **(06 Marks)**

b. Define the following terms:
(i) Relative humidity (ii) Humid volume
(iii) Humid heat (iv) Relative enthalpy **(06 Marks)**

c. The DBT and Dew Point of air is 30°C and 20°C respectively. The air is cooled to 12°C, calculate the amount of water condensed from 150 m^3 of original air. **(08 Marks)**

OR

4 a. Define dehumidification and brief about the applications of it in industries with relevant examples. **(04 Marks)**

b. Classify cooling towers used in chemical industries. **(04 Marks)**

c. Derive an equation for height of cooling tower. **(12 Marks)**

Module-3

5 a. Develop the time and moisture content relation for constant rate period and falling rate period. **(10 Marks)**

b. A rotary counter current dryer is fed with ammonium nitrate containing 6% moisture at the rate of 100 kg/min and discharges the nitrate with 0.2% moisture. The air enters at 135°C and leaves at 80°C. The humidity of entering air being 0.007 kg H_2O per kg of dry air. The nitrate enter at 21°C and leaves at 65°C. Neglecting radiation losses. Calculate the kg of dry air passing through the dryer and the humidity of the air leaving the dryer.
Special heat of ammonium nitrate = 0.45
Special heat of dry air = 0.238
Special heat of water-vapour = 0.48 **(10 Marks)**

OR

6 Discuss briefly on the following type dryers:
a. Rotary dryer
b. Fluidalized bed dryer
c. Spray dryer
d. Drum dryer

(20 Marks)

Module-4

7 a. What are the characteristics of adsorbents and briefly explain with industrial examples. **(08 Marks)**

b. Estimate the integral heat of adsorption of acetone upon activated carbon at 30°C as a function of adsorbate concentration.
Latent heat of vaporization of acetone = 551 kJ/kg

X, $\frac{\text{kg acetone}}{\text{kg carbon}}$	Slope of isostere	Differential heat of adsorption $\overline{H}$ kJ/kg acetone
0.05	1.170	-640
0.10	1.245	-686
0.15	1.300	-716
0.20	1.310	-721
0.25	1.340	-740
0.30	1.327	-730

(12 Marks)

OR

8 a. Explain adsorption isotherms for dilute solutions. **(05 Marks)**
b. Explain the Freundhich equation. Discuss its application for two stage cross current and counter current adsorption. **(10 Marks)**
c. Explain rotating fixed bed adsorber with neat sketch. **(05 Marks)**

Module-5

9 a. Discuss different methods employed in super saturation. **(05 Marks)**
b. A solution of sodium nitrate in water contains 48% $NaNO_3$ by weight at 313 K. Calculate the percentage yield of $NaNO_3$ crystals that may be obtained when temperature is reduced to 283 K. Solubility of $NaNO_3$ at 283 K is 80.18 kg/100 kg water. **(10 Marks)**
c. Explain Swenson-Walker crystallizer with neat sketch. **(05 Marks)**

OR

10 Write short notes on the following:
a. Reverse osmosis
b. Micro-filtration
c. Ion exchange
d. Super critical fluid extraction

(20 Marks)

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15CH/PC52

Fifth Semester B.E. Degree Examination, June/July 2019
Mass Transfer Operations – I

Time: 3 hrs. Max. Marks: 80

Note: **1.** ***Answer any FIVE full questions, choosing ONE full question from each module.***
2. ***Use of humidity chart is permitted.***

Module-1

1 a. Derive an expression for steady state diffusion of A through non-diffusing B. **(08 Marks)**

b. Oxygen (A) is diffusing through carbon monoxide (B) under steady state conditions, with the carbon monoxide non-diffusing. The total pressure is 1×10^5 N/m^2 and the temperature is 0°C. The partial pressure of oxygen at two planes 2.0 mm apart is respectively 13000 and 6500 N/m^2. The diffusivity of the mixture is 1.87×10^{-5} m^2/s. Calculate the rate of diffusion of oxygen in Kmol/s through each square meter of the two planes. **(08 Marks)**

OR

2 a. Explain the film theory of mass transfer. **(08 Marks)**

b. Explain material balance for steady state counter current process. **(08 Marks)**

Module-2

3 a. Explain the following:
i) Absolute humidity ii) Molal absolute humidity
iii) Dry bulb temperature iv) Dew point **(08 Marks)**

b. An air (B) water vapor (A) sample has a dry-bulb temperature 55°C and an absolute humidity 0.03 kg water/kg dry air at 1 std atm pressure. Tabulate molal absolute humidity, the partial pressure of water vapor in the sample, relative humidity and dew point.
Data: Vapor pressure of water at 55°C = 15730 N/m^2. **(08 Marks)**

OR

4 a. Define humid heat, humid volume, wet bulb temperature and adiabatic saturation temperature. **(08 Marks)**

b. Explain cooling tower arrangement. **(08 Marks)**

Module-3

5 a. Explain the drying rate curve. **(08 Marks)**

b. Define the following:
i) Moisture content wet basis ii) Moisture content dry basis
iii) Bound moisture iv) Free moisture **(08 Marks)**

OR

6 a. Explain the working of rotary drier with sketches. **(08 Marks)**

b. Discuss briefly the classification of driers. **(08 Marks)**

Module-4

7 a. Discuss the types of adsorption. **(08 Marks)**

b. List and explain industrial adsorbents. **(08 Marks)**

OR

8 a. Explain with sketch breakthrough curve. **(06 Marks)**

b. A solvent recovery plant is to recover 0.1 kg/s of ethyl acetate vapor from a mixture with air at a concentration of 3 kg vapor/100 m^3, 1 std atm pressure. The adsorbent will be activated carbon (2.8 mm average particle diameter), apparent density of individual particles 720 kg/m^3. Apparent density of the packed bed = 480 kg/m^3. The carbon will be capable of adsorbing 0.45 kg vapor/kg carbon upto break point. The adsorption cycle will be set at 3h. Determine the amount of carbon required, choose suitable dimensions for the carbon beds and estimate pressure drop.
Data: At 35°C, viscosity of air = 0.0182 kg/ms, density of air = 1.148 kg/m^3. **(10 Marks)**

Module-5

9 a. Derive an expression for crystal growth rate. **(08 Marks)**

b. Discuss an vacuum crystallizer with sketch. **(08 Marks)**

OR

10 a. Explain principle and operation of supercritical fluid extraction. **(10 Marks)**

b. Write a note on ionexchange process. **(06 Marks)**

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CBCS SCHEME

USN | | | | | | | | | | |

15CH52

Fifth Semester B.E. Degree Examination, Dec.2018/Jan.2019
Mass Transfer Operations – I

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. Explain the classification of mass transfer operation based on phases in contact. **(06 Marks)**

b. If an $O_2 - N_2$ gas mixture at 1 atm and 25°C, the concentration of O_2 at two planes, 2 mm part are 10 and 20% (V/V) respectively. Calculate the flux of diffusion of O_2 for the case where

1. The N_2 is non-diffusing
2. There is equimolar counter-diffusion of the gas.

Data: $D_{O_2-N_2}$ at 0°C = 1.86×10^{-5} m^2/s **(10 Marks)**

OR

2 a. Derive an expression from basic concepts from molar flux when a gas is diffusing through a stagnant gas B. State required assumptions. **(06 Marks)**

b. Calculate the amount of diffusion of acetic acid (A) in 2 hrs across a film on non-diffusing water (B), solution 1 mm thick at 17°C when the concentration on opposite side of a film are 9 and 3 weight 3% acid respectively. The diffusivity of acetic acid in solution is 0.95×10^{-9} m^2/s.

Data : At 17°C

Density of 9% solution = 1012 kg/m^3

Density of 3% solution = 1003 kg/m^3 **(10 Marks)**

Module-2

3 a. Define (i) Humidity (ii) Relative humidity (iii) Humid heat (iv) Saturated absolute humidity (v) Dew point. **(06 Marks)**

b. The Dry Bulb temperature and dew point of ambient air were found to be 303 K (30°C) and 289 (16°C) respectively. Barometer reads 100 kPa. Calculate

(i) Absolute molar humidity (ii) Absolute humidity (iii) %RH (iv) % Saturation

(v) Humid heat.

Data: Vapour pressure of water at 289 K = 1.818 kPa

Vapour pressure of water at 303 K = 4.243 kPa. **(10 Marks)**

OR

4 a. With a neat diagram, explain the working of various cooling towers. **(08 Marks)**

b. The DB and WB temperatures on a particular day in Bangalore to be 308 K (35°C) and 299 (26°C) respectively. Use the psychrometric chart.

(i) Absolute humidity (H) (ii) % Relative humidity (iii) Dew Point

(iv) Humid Heat (v) Humid volume **(08 Marks)**

Module-3

5 a. Define : (i) Equilibrium Moisture (ii) Bound Moisture (iii) Critical Moisture content

(iv) Unbound Moisture **(06 Marks)**

b. A batch of solids for which the following table of data applies is to be dried from 25 - 6% moisture. Under conditions identical to those for which the data were tabulated. The initial weight of wet solid is 350 kg and the drying surface is 1 m^2/ 8 kg Dry wt. Determine the time of drying. **(10 Marks)**

X	0.35	0.25	0.20	0.18	0.16	0.14	0.12	0.10	0.09	0.08	0.07	0.064
N	0.3	0.3	0.3	0.266	0.239	0.203	0.180	0.150	0.097	0.07	0.043	0.025

OR

6 a. Derive an equation for the calculation of drying time required for constant rate period and falling rate period. **(06 Marks)**

b. A 100 kg bath of granular solids containing 30% moisture is to be dried in a tray dryer to 16% moisture by passing a current of air at 350 K tangentially across its surface at a velocity 2 m/s. If the constant rate of drying under conditions is 0.7×10^{-3} kg/m^2-s and critical moisture content is 15%. Calculate the time required for drying. Drying surface = 0.03 m^2/kg dry wt. **(10 Marks)**

Module-4

7 A solution of washed raw cane sugar is colored by the presence of small amounts of an impurity. The solution is to be decolourised by treatment with adsorption carbon. The original color concentration of 9.6 measured on an arbitrary scale and it is desired to reduce color is 10% of its original value. The data for an equilibrium isotherm is as follows:

$\frac{\text{kg carbon}}{\text{kg solution}}$	0	0.001	0.004	0.008	0.02	0.04
$\frac{\text{color units}}{\text{kg solution}}$	9.6	8.6	6.3	4.3	1.7	0.7

Determine the minimum total amount of fresh carbon required for single stage cross current per 1000 kg of solution. **(16 Marks)**

OR

8 A solid adsorbent is used to remove colour impurity from an aqueous solution. The original value on an arbitrary scale is 48. It is required to reduce this to 10% of the original value. Using the following data. Find the quantity of fresh adsorbent used for 1000 kg solution for (a) A single stage and (b) Two stage cross current operation when the intermediate colour is 24. Equilibrium data: **(16 Marks)**

$\frac{\text{kg Adsorbent}}{\text{kg solution}}$	0	0.001	0.004	0.008	0.02	0.04
Equilibrium colour (Y)	48	43	31.5	21.5	8.5	3.5

Module-5

9 a. What is meant by supersaturation? What are the methods of supersaturation. **(08 Marks)**

b. A saturated solution of $MgSO_4$ at 353 K is cooled to 303 K in a crystallizer. During cooling, 4% solution is lost by evaporation of water. Estimate the quantity of the original saturated solution to be fed to the crystallizer per 1000 kg of $MgSO_4.7H_2O$ crystals.

Data :

Solubility of $MgSO_4$ at 303 K = $\frac{40.8\text{ kg}}{100\text{ kg water}}$; Solubility of $MgSO_4$ at 353 K = $\frac{64.2\text{ kg}}{100\text{ kg water}}$

(08 Marks)

OR

10 a. Write different membrane separation techniques modules. Write their application. **(08 Marks)**

b. What is the basic principle of super critical extraction technique? Give two industrial applications. **(08 Marks)**