

MASS TRANSFER – II
(CHEN 3202)

Time Allotted : 2½ hrs

Full Marks : 60

Figures out of the right margin indicate full marks.

*Candidates are required to answer Group A and
any 4 (four) from Group B to E, taking one from each group.*

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve:

12 × 1 = 12

Choose the correct alternative for the following

- (i) In adiabatic humidifier
(a) temperature of air increases
(b) enthalpy of air and liquid temperature remains constant
(c) enthalpy of air decreases
(d) temperature increases, humidity decreases.
- (ii) Dew point of an air-water vapour mixture
(a) decreases with decrease in pressure (b) increases with decrease in pressure
(c) may decrease or increase (d) none of these.
- (iii) Algal growth is more prevalent in _____ cooling tower
(a) natural draft (b) cross-flow induced draft
(c) counter flow induced draft (d) forced draft
- (iv) _____ uses centrifugal force for extraction
(a) Kuhni extractor (b) Bollman extractor
(c) Rotating disc contactor (d) Podbielniak extractor
- (v) The sides of the equilateral triangular coordinate (in ternary liquid system) represents a
(a) ternary mixture (b) binary mixture
(c) pure component (d) none of these.
- (vi) If W_s is the wet of dry solid, A the drying surface area, X_1 and X_2 are the initial and final moisture content, and N_c the constant rate of drying, the expression for time of drying during constant rate period in a batch dryer is
(a) $\frac{W_s(X_1 - X_2)}{AN_c}$ (b) $\frac{W_s(X_1 - X_2)N_c}{A}$
(c) $\frac{W_s N_c}{A(X_1 - X_2)}$ (d) $\frac{AN_c(X_1 - X_2)}{W_s}$

- (vii) If the moisture content of a solid on wet basis is 30%, the moisture content on dry basis is
 (a) 30% (b) 70%
 (c) 42.9% (d) 50%
- (viii) Solution-diffusion is the separation mechanism for
 (a) Ultrafiltration (b) Microfiltration
 (c) Reverse osmosis (d) Nanofiltration.
- (ix) The required range of pressure differential for microfiltration is
 (a) less than 2 bar (b) 2-10 bar
 (c) 10-100 bar (d) >100 bar
- (x) Purification of enzyme is carried out by
 (a) Electrodialysis (b) Pervaporation
 (c) Reverse osmosis (d) Ultrafiltration.

Fill in the blanks with the correct word

- (xi) Except 0 and 100 percent humidity, percentage saturation is always _____ than relative saturation.
- (xii) Due to Lewis relation, adiabatic saturation is _____ wet-bulb temperature for water-air vapour mixture.
- (xiii) The moisture content of a solid which exerts a partial pressure less than the normal vapour pressure of water at a given temperature is known as _____.
- (xiv) Pressure differential for reverse osmosis is generally _____.
- (xv) The removal of salts from an aqueous solution by transport through an electrically charged membrane is known as _____.

Group - B

2. (a) What do you understand by wet-bulb temperature? Derive the equation of psychrometric line. [[CO1](Apply/IOCQ)]
 (b) Calculate the humid volume of an air-water vapour mixture (abs. humidity= 0.015 kg water vapour/kg dry air) at 28°C and 1.2 atm. pressure. [[CO1](Evaluate/HOCQ)]
(2 + 7) + 3 = 12
3. (a) Obtain the equation of adiabatic saturation line. [[CO1](Apply/IOCQ)]
 (b) Mention the classification of cooling tower. Compare between forced draft and induced draft cooling tower. Also mention the components of cooling tower. [[CO1](Remember/LOCQ)]
 (c) Why is makeup water required in a cooling tower? [[CO1](Remember/LOCQ)]
4 + 7 + 1 = 12

Group - C

4. (a) Give two examples for each of industrial extraction and leaching processes. Define 'selectivity' and 'distribution coefficient'. [[CO2](Remember/LOCQ)]

- (b) Mention the properties of a suitable solvent for Liquid- liquid extraction? [[CO2](Remember/LOCQ)]
- (c) How do you classify commercial extractors? [[CO2](Remember/LOCQ)]

6 + 3 + 3 = 12

5. (a) Pure isopropyl ether (A) 660 kg/h is being used to extract an aqueous solution of 200 kg/h with 30 wt% acetic acid (C) by counter current multistage extraction at 25°C. The exit acid concentration in the aqueous phase is 10 wt%. Calculate the number of stages required.

Equilibrium data at 25°C is given below:

Water Layer (wt%)			Isopropyl ether layer (wt%)		
Acetic acid	Water	Isopropyl ether	Acetic acid	Water	Isopropyl ether
0.0	98.8	1.2	0	0.6	99.4
2.89	95.5	1.6	0.79	0.8	98.4
6.42	91.7	1.9	1.93	1.0	97.1
13.3	84.4	2.3	4.82	1.9	93.3
25.5	71.1	3.4	11.4	3.9	84.7
36.7	58.9	4.4	21.6	6.9	71.5
44.3	45.1	10.6	31.1	10.8	58.1
46.4	37.1	16.5	36.2	15.1	48.7

[mm graph paper required]

[[CO2](Evaluate/HOCQ)]

- (b) In extraction, define plait point. [[CO2](Remember/LOCQ)]

11 + 1 = 12

Group - D

6. (a) Wet porous catalyst pellets in the form of small cylinders, 14 mm diameter and 13 mm long are to be dried of their water content in a through circulation drier. The pellets are to be arranged in beds 50 mm deep on screens and dried by air flowing at 0.9 kg dry air/(m² bed cross-section).s entering at 82°C dry bulb temperature, humidity 0.01 kg water/kg dry air. Apparent bed density is 600 kg dry solids/m³ and particle surface 280 m²/m³ bed volume. Estimate the rate of drying and humidity and temperature of air leaving the bed during constant rate period. Given: viscosity of air = 1.9×10⁻⁵ kg/m.s and saturation humidity = 0.031 kg water/kg dry air corresponding to wet bulb temperature = 32°C, void fraction ε = 0.237, Sc = 0.6 for air-water vapour. The expression for Colburn j-factor is given as

$$j_D = \frac{2.06}{\varepsilon} \text{Re}^{-0.575}$$

$$k_Y = \frac{j_D G_s}{Sc^{2/3}} \text{ Kg H}_2\text{O/m}^2.\text{s}.\Delta Y$$

(psychrometric chart required)

[[CO3](Evaluate/HOCQ)]

- (b) In a tray dryer with convective heating, derive the expression for drying rate in terms of wet bulb temperature and humidity of air. [[CO3](Apply/IOCQ)]

- (c) Discuss the various mechanisms of moisture removal from a wet solid.
 [[C03](Remember/LOCQ)]
6 + 3 + 3 = 12
7. (a) Distinguish between the working principles of vacuum shelf dryer and vacuum rotary dryer with labelled diagram of both.
 [[C03](Analyse/IOCQ)]
 (b) Discuss the various steps of freeze drying. Sketch and explain the temperature profiles obtained in a freeze dryer. State the applications of freeze drying.
 [[C03](Understand/LOCQ)]
 (c) Explain the process of through circulation drying with a sketch.
 [[C03](Remember/LOCQ)]
5 + 4 + 3 = 12

Group - E

8. (a) Mention membrane pore size range, membrane material, driving force and separation mechanism for reverse osmosis process.
 [[C05](Remember/LOCQ)]
 (b) A liquid containing dilute solute A at a concentration of 3×10^{-2} Kg mol./m³ is flowing rapidly past a membrane of thickness 3.0×10^{-5} m. Distribution coefficient is 1.5 and diffusivity of solute A is 7.0×10^{-11} m²/s in the membrane. The solute diffuses through the membrane and its concentration on the other side of the membrane is 0.50×10^{-2} Kg mol./m³. The mass transfer coefficient in the feed side is large and can be considered as infinite, mass transfer coefficient on the other side of the membrane is 2.02×10^{-5} m/s.
 (i) Obtain the equation to find steady-state flux.
 (ii) Calculate the flux and solute concentrations at the membrane interfaces.
 [[C05](Analyze/HOCQ)]
4 + 8 = 12
9. (a) Explain the working principle of a hollow fibre membrane module with diagram.
 [[C05](Remember/LOCQ)]
 (b) Discuss the models for solvent flux in ultrafiltration.
 [[C05](Understand/LOCQ)]
 (c) With a labelled schematic diagram, describe the process of micellar enhanced ultrafiltration.
 [[C05](Understand/IOCQ)]
4 + 5 + 3 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	45.83	25	29.17