Ref. No.: Ex/FTBE/PC/B/T/324/2024

Name of the Examination:	Subject:	Part:
B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING THIRD YEAR SECOND SEMESTER EXAM 2024	MASS TRANSFER OPERATION - II	Part - I (50)

Time : Three hours **Full Marks : 100**

Part I (50 marks)

Use separate answerscript for each part.

Psychrometric chart and steam tables may be used.

Answer question no. 6 and any three from the rest.

1. (i) What is the difference between absolute humidity and relative humidity of an air-water vapour mixture? Show how heating, cooling and adiabatic cooling of humid air can be followed on a psychrometric chart. 4+6 (CO2)

   (ii) Estimate for air at 75^0C dry bulb temperature and 20% relative humidity and at 1 atmospheric pressure (a) absolute humidity (b) dew point (c) humid heat. 5 (CO2)

2. State how drying or dehydration of food can be considered as a method of preservation. What is water activity and how is it important in dehydration of food? Explain how Liquid diffusion and capillary movement theory account for the variation in the falling rate period drying curves. 3+4+8 (CO3)
3. Show how rate of drying in the constant rate period can be correlated both with heat transfer and mass transfer coefficients. How is heat transfer coefficient of humid air related to its mass velocity? 12+3 (CO3)
4. Air enters a counterflow dryer at 60^0C dry bulb temperature and 25^0C dew point temperature. Air leaves the dryer at 40^0C and 60% relative humidity. The initial moisture content of the food to be dried is 72% (wet basis). The amount of air moving through the dryer is 200 kg dry air /hr. The mass flow rate of the food substance is 1000 kg dry solid /hr. What is the final moisture content of the dried solid on wet basis? 15 (CO2 and CO3)
5. Deduce an expression for time taken to dry a food in a freeze dryer with respect to the fraction of moisture remaining in the solid from x_1 to x_2. 15 (CO3)
6. Justify the statement: (any one) 5 (CO2 and CO3)
   (i) Moisture content of a solid can be bound and free at the same time.
   (ii) Temperature and humidity of air can influence the constant rate drying.
   (iii) Spray dryer can be used to manufacture milk powder.
   (iv) Freeze dried solids are superior than hot air dried solids. (Any 5 points).

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B.E.FOOD TECHNOLOGY AND BIOCHEMICAL ENGINEERING
3rd Year, 2nd Semester EXAMINATION 2024
MASS TRANSFER OPERATIONS II (FTBE/PC/B/T/324)
PART II (50 Marks)

Answer Q.No. 3(compulsory) and any two from the following:

Q.1. (i) In a differential distillation unit, a liquid mixture containing 70% more volatile component A and the rest less volatile component B. If the composition of the residue liquid left behind equals to 30 mole % of A, estimate the fraction of liquid distilled and composition of the distillate. Assume relative volatility $\alpha_{AB} = 2$

(ii) "In a tray distillation column, the slope of the rectifying line is always less than 1 while for stripping line, it is greater than one" Justify the statement mathematically **10+5 = 15**

Q.2. In an ordinary tray distillation column, an equimolar saturated liquid mixture is introduced at the bubble point with a rate of 120 kmol/hr containing n-Hexane (A) and the rest n-Octane (B) with an expectation to achieve A at the top with 94 mole % and 6 mole % at the bottom. The reflux ratio is maintained 1.25 times the minimum reflux ratio assuming the relative volatility between A & B is equal to 2. Estimate (a) The minimum reflux ratio (b) amount of distillate and the bottom product (kmol/hr) (c) Equation of the operating lines in the rectifying and stripping section (d) slope of the operating lines at minimum reflux **4+3+5+3 =15**

Q.3. In a continuous distillation column, 100 kmol/hr of an equimolar saturated Benzene (A)-Toluene (B) liquid mixture is fed at the bubble point with a relative volatility for all the trays to be maintained at 2. The mole % of A in the distillate and the bottom are 90 and 10, respectively. If the equation of the rectifying section is $y = 0.8x+0.18$, where y and x are the mole fraction of A in the vapor and in the liquid phase, respectively. Find out the (i) Minimum reflux ratio (ii) Point of intersection of the operating lines on the feed line (iii) Ratio of actual reflux to minimum reflux (iv) No. of trays required(theoretically) (v) Amount of distillate and bottom product(kmol/hr.) **3+5+10+2= 20**

Q.4 A rectification column is fed with 60-40 mole% saturated liquid mixture of n-Hexane and n-Octane at atmospheric condition to achieve 90 mole% of Hexane at the top and 10 mole% at the bottom. The reflux ratio is 1.2 times the minimum reflux ratio to be maintained. Estimate the following (i) minimum reflux ratio (ii) actual reflux ratio (iii) No. of theoretical trays required (iv) Equation of the operating lines

Mole fraction of n-Hexane in liq., x	**1.00**	**0.69**	**0.4**	**0.2**	**0.05**	**0.00**
Mole fraction of n-Hexane in vap., y	**1.00**	**0.93**	**0.78**	**0.54**	**0.18**	**0.00**

3+2+7+3=15

Q.5 Write short notes on the following: **3×5 =15**
(a) Effect of feed conditions on q-line (b) Reflux ratio (c) Difference between rectifying line and stripping line

Q.6 Justify the following statements mathematically (any three) **3×5 = 15**
(i) "At maximum reflux, both the operating lines (stripping and rectifying) in a tray distillation column merges on the diagonal"
(ii) "For a cold feed to a tray distillation unit, the slope of the q-line is always greater than 1"
(iii) "For superheated vapor feed to a tray distillation unit, the slope of the q-line always lie between 0 and 1"
(iv) "q-line is the locus of intersection of the operating lines in rectifying and stripping section of a tray distillation unit"