



ENTER B.E/B.TECH DEGREE EXAMINATIONS: NOV/DEC 2022

(Regulation 2018)

Fifth Semester

BIOTECHNOLOGY

U18BTI5203: Heat and Mass Transport in Bioprocess

COURSE OUTCOMES

- CO1:** Outline the modes of heat of transfer
CO2: Design the heat transfer equipment in bioprocess industries
CO3: Illustrate the principles of diffusion and apply the concepts of interphase mass transfer in bioreactor
CO4: Comprehend the extraction separation in bioprocess
CO5: Interpret the membrane separation in bioprocess

Time: Three Hours

Maximum Marks: 100

Answer all the Questions:-

PART A (10 x 2 = 20 Marks)

(Answer not more than 40 words)

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|--|-----|-------------------|
| 1. Define the modes and the corresponding laws of heat transfer | CO1 | [K ₁] |
| 2. What is overall heat transfer coefficient? Show its components | CO1 | [K ₁] |
| 3. Compare LMTD method with NTU method | CO2 | [K ₃] |
| 4. Write the enthalpy equation of single effect evaporator | CO2 | [K ₁] |
| 5. Prove $D_{AB} = D_{BA}$ | CO3 | [K ₂] |
| 6. Recall the Hirschfelder-sportz empirical relation to find the diffusivity of gas mixtures | CO3 | [K ₁] |
| 7. Illustrate the extraction isotherm | CO4 | [K ₂] |
| 8. Differentiate in-situ leaching from heap leaching | CO4 | [K ₃] |
| 9. Recall the principle of reverse osmosis | CO5 | [K ₁] |
| 10. List out the uses of reverse osmosis in bioprocess | CO5 | [K ₁] |

Answer any FIVE Questions:-

PART B (5 x 16 = 80 Marks)

(Answer not more than 400 words)

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|---|----|-----|-------------------|
| 11. a) Discuss the thermal conductivity and its application in biological materials | 6 | CO1 | [K ₂] |
| b) To maintain the cold chain of COVID 19 vaccine, a special cold room was designed. Its wall made up of 220 mm of brick outside, 90 mm of plastic foam, and finally 16 mm of wood on the inside. The outside and inside air temperature are 25°C and -3°C respectively. If the inside and outside heat transfer coefficients | 10 | CO1 | [K ₅] |

are 30 and 11 W/m²°C respectively., and the thermal conductivities of brick, foam and wood are 0.99, 0.022, and 0.17 W/m°C respectively, determine:

- (i) The rate of heat removal by refrigeration if the total wall area is 85 m².
- (ii) The temperature of the inside surface of the brick

12. a) In a counterflow plate and frame heat exchanger, hot steam is used to heat the milk at the rate of 10500 kg/hr for pasteurization. The steam enters the heat exchanger at 180°C and leaves at 130°C. The inlet and exit temperatures of milk (assume Cp as water) are 30°C and 80°C respectively. If the overall heat transfer coefficient from steam water is 814 W/m²°C, calculate the heat transfer area. What would be the increase in area if the fluid flows parallel? 10 CO2 [K₅]
- b) Classify the feeding types in the evaporators 6 CO2 [K₂]
13. a) A simulated nasal system is used to predict the invitro diffusion of *terpineol* (drug used in inhalers) into air at steady state. Simulated nasal passage is having a cross sectional area of 0.82 cm² and was operated at 273K and 775 mmHg pressure. The average length of diffusion path was 17.1 ccm. If 0.0208 cc of *terpineol* was evaporated in 10 hours of steady state operation, what should be the value of the diffusivity of *terpineol* through air? Assume the *terpineol*'s vapour pressure at 273 K is 33mmHg, density is 1.59 g/cc and has the molecular weight of 154 g/mol. 10 CO3 [K₅]
- b) Discuss the theories of mass transfer in detail 6 CO3 [K₂]
14. a) Explain the drying curve 6 CO4 [K₂]
- b) Sugar cane molasses is fermented using *Zymomonas mobilis* to produce bioethanol (BE). The fermentation broth is clarified, filtered and distilled to obtain pure bioethanol. A fractionating column separates the filtered broth entering at 5000 kmol/hr containing 50 mole % BE and mole % water (W) into an overhead product of 95 mole% BE and a bottom product of 96% W. A reflux ratio of twice the minimum will be used and the feed enters at its boiling point. Determine the number of theoretical stages required and the location of feed point. 10 CO4 [K₅]

x	0.03	0.06	0.11	0.14	0.26	0.39	0.53	0.66	0.76	0.86	1.0
y	0.08	0.16	0.27	0.33	0.50	0.63	0.71	0.83	0.88	0.93	1.0

15.	a)	Outline material and component balance of the single stage leaching	6	CO4	[K ₂]
	b)	Explain any of the two extraction equipments with neat sketch	10	CO4	[K ₂]
16.	a)	Discuss the electro dialysis technique used in water treatment	6	CO5	[K ₂]
	b)	Explain the principle and working of ultrafiltration	10	CO5	[K ₂]
