

# CBCS SCHEME

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18BT732

## Seventh Semester B.E. Degree Examination, Dec.2023/Jan.2024 Bioreactor Design Concepts

Time: 3 hrs.

Max. Marks: 100

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

### Module-1

- 1 a. Explain with a neat schematic diagram about continuous stirred - tank reactor (CSTR) and derive the material balance equation for evaluating residence time, dilution rate for irreversible first-order reaction. (12 Marks)
- b. Explain about the microbial growth and product formation kinetics with an equation and a diagram in detail. (08 Marks)

OR

- 2 a. Explain the assumption to be considered for internal mass transfer reaction in a heterogeneous reaction. (10 Marks)
- b. Explain the process of batch and continuous heat sterilization of culture media with the help of equation for each. (10 Marks)

### Module-2

- 3 a. Explain about various types of flow measuring devices used in the fermentation process in detail. (15 Marks)
- b. Explain about the importance of thermodynamic aspects in the designing of non-isothermal reactors. (05 Marks)

OR

- 4 a. Explain about the bioreactor design consideration for plant and animal cell culture. Also mention the effect of media on reactor design. (12 Marks)
- b. Explain the optimum temperature progression for Irreversible, Reversible endothermic and Reversible exothermic reactions with the graphical representation. (08 Marks)

### Module-3

- 5 a. Explain about external mass transfer limitations and correlation in packed bed reactor. (12 Marks)
- b. A gas component A in air is absorbed into water at 1 atm and 20°C. The Henry's law constant  $H_m$  of A for this system is  $1.67 \times 10^3 \text{ Pa m}^3 \text{ Kmol}^{-1}$ . The liquid film mass-transfer co-efficient  $K_L$  and gas-film co-efficient  $K_G$  are  $2.50 \times 10^{-6} \text{ ms}^{-1}$  and  $3.00 \times 10^{-3} \text{ ms}^{-1}$  respectively.
  - (i) Determine the overall co-efficient of gas liquid mass transfer  $K_L(\text{ms}^{-1})$
  - (ii) When the bulk concentration of A in the gas phase and liquid phase are  $1.013 \times 10^4 \text{ Pa}$  and  $2.00 \text{ Kmol m}^{-3}$  respectively, calculate the molar flux of A. (08 Marks)

OR

- 6 a. Explain about the mass transfer correlations and limitations in a fluidized bed reactor. (12 Marks)

- b. To measure  $K_{La}$ , a fermentor was filled with 10L of 0.5M sodium sulfite solution containing  $0.003M$   $Cu^{++}$  ion and the air sparger was turned on. After exactly 10 minutes, the air flow was stopped and a 10 ml sample was taken and titrated. The concentration of the sodium sulfite in the sample was found to be  $0.21$  mol/L. The experiment was carried out at  $25^{\circ}C$  and  $1$  atm. Calculate the oxygen uptake and  $K_{La}$ . (08 Marks)

#### Module-4

- 7 a. Explain about the correlation between power number and Reynolds number for Rushton turbine, paddle and marine propeller without sparging. (12 Marks)
- b. Calculate the power requirements with and without aeration of a  $1.5m$  dia stirred tank, containing water  $1.5m$  deep equipped with a rise blade Rushton turbine that is  $0.5m$  is diameter  $d$ , with blades  $0.25d$  long and  $0.2d$  wide, operating at a rotational speed of  $180$  rpm,. Air is supplied from the tank bottom at a rate of  $0.6m^3 min^{-1}$ . Operation is at room temperature. Values of water viscosity  $\mu = 0.001 kg m^{-1} s^{-1}$  and water density  $\rho = 1000 kg m^{-3}$ ; hence  $\mu/\rho = \nu = 10^{-6} m^2 s^{-1}$  can be used. (08 Marks)

OR

- 8 a. Explain about the design and operation of spargers, agitator, valves with a neat diagram carried out in design of fermentor. (10 Marks)
- b. A stirred fermentor of a diameter  $5m$  contains an internal helical coil for heat transfer. The fermentor is mixed using a turbine impeller  $1.8m$  in diameter, operated at  $60$  rpm. The fermentation broth has the following properties :  $\mu_n = 5 \times 10^{-3} Pa S$ ,  $\rho = 1000 kg/m^3$ ,  $C_p = 4.2 KJkg^{-1} ^{\circ}C^{-1}$ ;  $k_b = 0.70 W/m^{\circ}C$ ; Neglecting viscosity change at the wall of the coil. Calculate the heat transfer co-efficient. (10 Marks)

#### Module-5

- 9 a. Explain about the design aspects of packed bed reactor. (10 Marks)
- b. Explain about the design aspects of airlift and slurry reactors. (10 Marks)

OR

- 10 a. Explain the waste treatment process carried out using bioreactors. (10 Marks)
- b. Explain in detail about the criteria to be considered in scale-up of bioreactors. (10 Marks)

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