

2125  
B.E. (Biotechnology) Fifth Semester  
BIO-512: Bio-Process Engineering

Time allowed: 3 Hours

Max. Marks: 50

NOTE: Attempt five questions in all, including Question No. 1 which is compulsory and selecting two questions from each Section. Assume any missing data.

x-x-x

1. Attempt the following:-

- i. What is PPE? Give example.
- ii. What is a HEPA filter?
- iii. What are growth factors?
- iv. Enlist primary and secondary containment barriers.
- v. Point out atleast one important difference in terms of medium design while scaling up a fermentation process.
- vi. Define AMP model in biorisk management and its key components.
- vii. Discuss the significance of Del factor.
- viii. Write down merit and demerit of a batch culture (one each).
- ix. Name the major classes of commercially important fermentation products.
- x. Suggest how a fed-batch culture can be converted to a cyclic fed-batch culture. (10)

SECTION-A

2. A well-mixed fermenter of volume  $V$  contains cells initially at concentration  $x_0$ . A sterile feed enters the fermenter with the volumetric flow rate  $F_i$ , fermentation broth leaves at the same rate. The concentration of the substrate in the feed is  $s_i$ . The equation for rate of cell growth is:  $r_X = k_1 X$  and the expression for rate of substrate consumption is  $r_S = k_2 X$ ; where  $k_1$  and  $k_2$  are rate constants with dimensions  $T^{-1}$ , have dimensions  $L^3MT^{-1}$  and  $x$  is the concentration of cells in the fermenter.
- a) Derive a differential equation for the unsteady state mass balance of cells.
  - b) From this equation, what must be the relationship between  $F$ ,  $k_1$  and the volume of liquid in the fermenter at steady state?
  - c) Solve the differential equation to obtain an expression for cell concentration in the fermenter as a function of time.
  - d) Calculate how long it takes for the cell concentration in the fermenter to reach  $4.0 \text{ g l}^{-1}$ ; if  $F = 2200 \text{ l h}^{-1}$ ;  $V = 10\,000 \text{ l}$ ;  $x_0 = 0.5 \text{ g l}^{-1}$ ;  $k_1 = 0.33 \text{ h}^{-1}$ . (10)

P.T.O.

(2)

3. a) Briefly discuss the effect of dilution rate on cell-mass concentration, substrate concentration and output of cells in a chemostat culture. Also give a schematic representation.
- b) Discuss some of the major problems associated with the scale-up of a bioreactor. (6,4)
4. a) Discuss how fermentation medium may influence oxygen availability during fermentation.
- b) How is medium optimization different from medium formulation? Justify the role of dummy variables in the medium optimization with the help of a suitable illustration. (5,5)

### SECTION-B

5. a) A steam sterilizer is used to sterilize liquid medium for fermentation. The initial concentration of contaminating organisms is  $10^8$  per liter. For design purposes, final acceptable level of contamination is usually taken to be  $10^{-3}$  cells. For how long should  $1 \text{ m}^3$  medium be treated if the temperature is i)  $80^\circ\text{C}$  ii)  $121^\circ\text{C}$ ? To be safe, assume that the contaminants present are the spores of *Bacillus stearothermophilus*, for which the activation energy for thermal death is  $283 \text{ kJ gmol}^{-1}$  and the Arrhenius constant is  $10^{36.2} \text{ s}^{-1}$ .
- b) Discuss the essence of engineering controls for controlling bio risks in laboratory. Contrast merits and demerits of various mitigation measures for controlling bio risks. (6,4)
6. Classify the types of fluids according to their rheological behavior. Draw the flow curves for each classification, providing equations for shear stress and apparent viscosity for each. (10)
7. a) Define critical biomass concentration. Derive an expression to define critical biomass concentration in terms of critical dissolved oxygen concentration.
- b) A strain of *Azobacter vinelandii* is cultured in a  $15\text{-m}^3$  stirred fermenter for alginate production. Under current operating conditions,  $k_{La}$  is  $0.17\text{s}^{-1}$ . The solubility of oxygen in the broth is approximately  $8 \times 10^{-3} \text{ kg m}^{-3}$ . The specific rate of oxygen uptake is  $12.5 \text{ mmol g}^{-1} \text{ h}^{-1}$ .  
What is the maximum cell concentration supported by oxygen transfer in the fermenter?
- c) Giving the salient features of air-lift bioreactors, justify why these are considered as energy efficient bioreactors. (3,4,3)