


VIT

Vellore Institute of Technology

Final Assessment Test – November 2024

Course: BBIT301L - Principles of Bioprocess Engineering

Class NBR(s): 1218 / 1221

Time: Three Hours

Slot: E2+TE2

Max. Marks: 100

- KEEPING MOBILE PHONE/ANY ELECTRONIC GADGETS, EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE
- DON'T WRITE ANYTHING ON THE QUESTION PAPER

 Answer ALL Questions

(10 X 10 = 100 Marks)

2. a) Elaborate on the design of a stirred tank bioreactor with illustration. [7]
 b) Enlist its advantages and disadvantages. [3]
3. a) Compare Feedback and Cascade control system. [4]
 b) How the temperature and oxygen are monitored and controlled in the bioreactor? [6]
3. You have been tasked with producing a bio product in a stirred tank reactor using the batch mode of operation. Propose a process flow chart and devise the equations for the batch culture time for biomass, product production, and substrate utilization.
4. *Bacillus Subtilis* cells are used for chemostat culture in a 60 m^3 fermenter. The feed contains 12 g/L glucose: K_s for the organism is 0.2 g/L . Given: $Y_{x/s} = 0.0 \text{ g/g}$; $Y_{p/x} = 7.7 \text{ g/g}$; $Y_{p/s} = 0.46 \text{ g/g}$; $\mu_{\max} = 0.3/\text{h}$; $m_s = 2.2 \text{ g/g.h}$; $s_i = 12 \text{ g/L}$; $V = 60 \text{ m}^3$; $q_p = 3.4/\text{h}$. (a) What flowrate is required for a steady-state substrate concentration of 1.5 g/L ? (b) At a flow rate of (a), what is the cell density? (c) At a Flow rate of (a), What concentration of ethanol is produced?
5. "Microbial conversions are autocatalytic, and maintaining a higher cell concentration in a chemostat with cell recycle system increases conversion rates." Support the statement with mass balance.
6. An Antibiotic is produced by *P.chrysogenum* in a fed batch culture with the intermittent addition of glucose solution to the culture medium. The initial culture volume at quasi- steady is $V_0 = 500 \text{ ml}$, and glucose – containing nutrient solution is added with the flow rate of $F = 50 \text{ L/h}$. Glucose concentration in the feed solution and initial cell concentration are $S_0 = 300 \text{ g/L}$ and $X_0 = 20 \text{ g/L}$, respectively. The kinetic and yield coefficients of the organism are $\mu_{\max} = 0.2/\text{h}$, $K_s = 0.5 \text{ g/L}$, and $Y_{x/s} = 0.3 \text{ gdw/g glucose}$. (a) Determine the culture volume at $t = 10 \text{ h}$. (b) Determine the concentration of glucose at $t = 10 \text{ h}$ at quasi-steady state. (c) Determine the concentration at quasi steady state when $t = 10 \text{ h}$.

⑤ A bacteria is cultured in a bioreactor for production of industrially important protein. The maximum specific oxygen uptake rate for this strain in batch culture is $5 \text{ mmol O}_2 \text{ g}^{-1} \text{ h}^{-1}$. The strain is grown in a stirred fermenter to a cell density of 40 g l^{-1} ; $k_L a$ under these circumstances is 0.15 s^{-1} . At the fermenter operating temperature and pressure, the solubility of oxygen in the culture liquid is $8 \times 10^{-3} \text{ kg m}^{-3}$. Is the rate of cell metabolism limited by mass-transfer, or dependent solely on metabolic kinetics?

- 8.a) Elaborate on the diffusion process and discuss two film theories related to oxygen transfer in a bioreactor.

OR

- 8.b) Write about the oxygen uptake by cells in aerobic culture from the liquid.

9. a) Compare scale up and scale down of fermenters [3]

- b) Discuss the approaches adopted for scale-up of a fermenter. [7]

- ✓ 10.a) Classify three major category of product formation with examples and illustrate the growth patterns linking with product formation. Assume that Luedeking – piret equation is applied for all the category of product, calculate the productivity. Assume the process is steady state chemostat process and Monod kinetics applies. Given : $D=0.8 \mu\text{m}$; $\mu_{\text{max}}=1.0 \text{ h}^{-1}$; $k_s=10 \text{ mg/l}$; $\alpha=0.4 \text{ mgP/gX}$; $Y_{x/s}=0.5 \text{ gX/gS}$; $S_0=1000 \text{ mg/l}$; $\beta=0.5 \text{ h}^{-1} \text{ mgP/gX}$.

OR

- 10.b) A strain of *Bacillus* sp. has been used to produce an industrially important enzyme. A batch culture is started by inoculating 12 g cells into a 100 litres bubble column fermenter containing 10 g/l glucose. The maximum specific growth rate of the culture is $0.9/\text{h}$; the biomass yield from glucose is 0.575 g/g . Estimate the time required to reach stationary phase and what will be the cell density if the fermentation is stopped after only 70% of the substrate is consumed.

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