

10. The solubility of oxygen from air in pure water between 0 °C - 36 °C can be correlated using the equation:
 14.161 - 0.3943T + 0.007714T² + 0.0000646T³
 14.161 - 0.3943T + 0.007714T² - 0.0000646T³
 14.161 - 0.3943T - 0.007714T² - 0.0000646T³
 14.161 - 0.3943T - 0.007714T² - 0.0000646T³
11. The method of K_{LA} measurement best suited for small lab scale fermenters is
 Dynamic method Oxygen balance method
 Sulphite oxidation method Unsteady state method
12. If dissolved oxygen concentration is above the critical oxygen concentration, specific oxygen uptake rate is
 Constant Minimum
 Dependent of C_{AL} All of the mentioned
13. Volumetric oxygen transfer coefficient (k_{LA}) has the unit
 ms⁻² s⁻¹ m²s⁻¹ m²s²
14. The most appropriate target level of contamination in terms of cell number during sterilization can be
 0 0.001 1 1.5
15. The residence time is important in
 Batch process Fed Batch process
 Plug flow process Continuous process
16. Dilution rate is defined as
 F/V V/F F/T T/F
17. In the equation Q = UAΔT; ΔT is
 Geometric mean temperature difference.
 Arithmetic mean temperature difference.
 Logarithmic mean temperature difference.
 The difference of average bulk temperatures of hot and cold fluids
18. Enzyme reactions are rarely carried out in
 Batch Fed batch Continuous Plug flow
19. For large scale sterilization, the method preferentially used is
 Heat treatment UV radiation
 Chemical treatments Gamma radiation
20. In bubble column reactor the aspect ratio is
 1:1 3:1 1:3 2:3

SECTION "B"
[10Q. × 1 = 10 marks]

Fill in the blanks.

21. An expression for rate of oxygen transfer from gas to liquid is given by _____.
22. _____ are used in stirred reactors to reduce vortexing.
23. _____ culture is used extensively in production of baker's yeast to overcome catabolite repression.
24. The _____ systems are unsteady during start-up and shut-down.
25. In bioprocessing, heat exchange occurs most frequently between _____.
26. The heat exchanger that is independent of reactor is _____.
27. The _____ method is the most reliable procedure for estimating $k_L a$, and allows determination from a single-point measurement
28. The specific death constant (K_d) is evaluated as a function of _____.
29. Residence time is defined as the ratio of _____.
30. In _____ operation, intermittent or continuous feeding of nutrients is used to supplement the reactor.

KATHMANDU UNIVERSITY

End Semester Examination

January/February, 2024

Level : B.Tech.

Year : II

Time : 2 hrs. 30 mins.

Course : BIOT 210

Semester : II

F.M. : 55

07 FEB 2024

SECTION "C"

[3Q × 8 = 24 marks]

Attempt *ANY THREE* questions.

1. Explain unsteady state process with examples relevant to bioprocess technology
2. Explain the simple dynamic method for the measurement of K_{La} .
3. In an amino acid fermentation factory, molasses solution must be heated from 12 °C to 30 °C in a double-pipe heat exchanger at a rate of at least 19 kg min⁻¹. The heat is supplied by water at 63 °C; an outlet water temperature of 33 °C is desired. The overall heat transfer coefficient is 12 kW m⁻² °C⁻¹ and the exchanger is operated with countercurrent flow. The specific heat capacities of water and molasses solution are 4.2 kJ kg⁻¹ °C⁻¹ and 3.7 kJ kg⁻¹ °C⁻¹, respectively.
 - a. Each stackable unit of a commercially available double-pipe assembly contains 0.02 m² of heat transfer surface. How many units need to be purchased and connected together for this process?
 - b. For the number of units determined in (a), what flow rate of molasses can be treated?
4. Diafiltration is carried out to exchange the buffers used to suspend a globular protein. Initially, the protein is contained in 3000 liters of solution containing 45 g L⁻¹ salt. The aim is to remove 99.9 % of the salt and suspend the protein in new, salt-depleted buffer. A microporous ultrafiltration membrane is applied to separate the salt from the protein. The membrane retains the protein but allows passage of all smaller molecules such as salt and water into the permeate stream. The permeate flow rate is 750 Lh⁻¹. The total volume of protein solution is kept constant by addition of new buffer. Estimate the time required to complete this process.
5. A strain of *Escherichia coli* has been genetically engineered to produce human protein. A batch culture is started by inoculating 12 g of cells into a 100-liter bubble column fermenter containing 10 g L⁻¹ glucose. The culture does not exhibit a lag phase. The maximum specific growth rate of the cells is 0.9 h⁻¹; the biomass yield from glucose is 0.575 g g⁻¹.
 - a. Estimate the time required to reach stationary phase.
 - b. What will be the final cell density if the fermentation is stopped after only 80% of the substrate is consumed?

SECTION "D"

Attempt *ANY SIX* questions. (Question No. 6 is Compulsory)

6. Write a short note on ANY TWO
 - a. Continuous operation
 - b. Critical oxygen concentration
 - c. Bubble column reactor

[3 + 3 = 6]

7. During the exponential phase of batch culture, the growth rate of a culture is proportional to the concentration of cells present. When *Streptococcus lactis* bacteria are cultured in milk, the concentration of cells doubles every 45 min. If this rate of growth is maintained for 12 h, what is the final concentration of cells relative to the inoculum level? [5]
8. *Serratia marcescens* bacteria are used for the production of threonine. The maximum specific oxygen uptake rate of *S. marcescens* in batch culture is $5 \text{ mmol O}_2 \text{ g}^{-1} \text{ h}^{-1}$. It is planned to operate the fermenter to achieve a maximum cell density of 40 g l^{-1} . At the fermentation temperature and pressure, the solubility of oxygen in the culture liquid is $8 \times 10^{-3} \text{ kg m}^{-3}$. At a particular stirrer speed, k_{LA} is 0.15 s^{-1} . Under these conditions, will the rate of cell metabolism be limited by mass transfer or depend solely on metabolic kinetics? [5]
9. Explain briefly the different types of heat transfer equipment in bioprocess technology with suitable diagram. [5]
10. Draw a well labeled typical temperature-time profile for batch sterilization. [5]
11. Explain the oxygen balance method for measurement of K_{LA} . [5]
12. Explain the gas liquid mass transfer using film theory with a suitable diagram [5]
13. Derive the batch time (t_b) in terms of initial and final substrate concentration for a batch enzyme reactor [5]