M.TECH/BT/3 RD SEM/BIOT 6152/2017
MODELING AND SIMULATION IN BIOPROCESSES
(BIOT 6152)

Time Allotted: 3 hrs **Full Marks: 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and
Any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The convergence of which of the following method is sensitive to starting value?
(a) regular- falsi method
(b) Gauss Siedel method
(c) Newton-Raphson method
(d) bisection method.

(ii) Which of the following statements applies to the bisection method used for finding roots of functions?
(a) It converges within a few iterations
(b) It works for all continuous functions
(c) It is faster than the Newton – Raphson method
(d) It requires that there be no error in determining the sign of the function.

(iii) The Runge-Kutta formula of the fourth order is a method
(a) for numerical differentiation
(b) for numerical integration
(c) for numerical solution of partial differential equations
(d) for numerical solution of ordinary differential equations.

(iv) The Modified Euler's formula is the same as
(a) Runge-Kutta formula of the first order
(b) Runge-Kutta formula of the second order with b=1
(c) Runge-Kutta formula of the second order with b= ½
(d) None of the above.

(v) In solving algebraic and transcendental equations by iterative methods, if I is interval in which the root α of the equation x = φ(x) lies, then the criterion for convergence is
(a) $|\varphi'(x)| = 0$ (b) $|\varphi'(x)| < 1$
(c) $|\varphi'(x)| > 1$ (d) $|\varphi'(x)| > 0$
For all x in the interval I .

(vi) Which of the following is an example of a mathematical model?
(a) Volume of cuboid = length x breadth x height
(b) The Monod Model
(c) The Michaelis Menten Equation
(d) All of the above.

(vii) Which of the following is **not** an assumption for model for determination of concentration of oxygen in liquid phase for metabolic oxygen utilization?
(a) Rate of oxygen utilization= rate of oxygen transfer
(b) For sparingly soluble species the two equilibrated interfacial concentrations are related through linear relationship.
(c) For sparingly soluble species the two equilibrated interfacial concentrations are related through non- linear relationship.
(d) Oxygen transfer into cells from the bulk medium follows two film theory.

(viii) Michaelis-Menten model is
(a) a deterministic model (b) a probabilistic model
(c) an empirical model (d) none of the above.

(ix) Sterilization kinetics follows
(a) a deterministic model (b) a probabilistic model
(c) an empirical model (d) none of the above.

(x) Two compartment model is
(a) a type of structured model
(b) where G component corresponds to cellular enzymes
(c) Overly simplistic
(d) all the above.

Group - B

2. (a) What are the advantages of simulation technology?

(b) Differentiate between a stochastic model and a deterministic model.

(c) Enumerate the possibilities of selection of a model system for interactions in cell population.

4 + 4 + 4 = 12

3. (a) Describe William's two compartment model.

(b) What are the features of a judicious model.

(c) What are the factors that determine cell population kinetic modeling?

4 + 4 + 4 = 12

Group - C

4. A medium containing a vitamin is to be sterilized. Assume that the number of spores initially present is 10^5 spores/L. The values of the Arrhenius constant and E_{0d} for the spores are
E_{0d} = 65kCal/gmol
A = 10^{36}min^{-1}.
For the inactivation of the vitamin, the values of E_{0d} and A are
E_{0d} = 10kCal/gmol
A = 10^{4}min^{-1}.
The initial concentration of the vitamin is 30mg/L. Compare the amount of active vitamin in the sterilized medium for 10L and 10,000L fermenters when both are sterilized at 121°C. We require in both cases that the probability of an unsuccessful fermentation be 0.001. Ignore the effects of the heat-up and cool-down periods.

12

5. *E. Coli* have a maximum respiration rate, q_{O2max}, of about 240mg O_2/gX.h. It is desired to achieve a cell mass of 20g dry weight/L. The k_la is 120h^{-1} in a 1000L reactor (800L working volume). A gas stream enriched in oxygen is used which gives a value of C* = 28mg/L. If oxygen becomes limiting, growth and respiration slow, and oxygen consumption follows Monod model, that is

$$q_{O2} = \frac{q_{O2max} C_L}{\frac{0.2mg}{L} + C_L}$$

where C_L is the dissolved oxygen concentration in the fermenter. What is the value of C_L when the cell mass is 20g/L?

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Group - D

6. Model a system where interaction between two microbes is taking place with competitive assimilation and co-metabolism of substrates. Also model

the system when a growth factor that is excreted by the first organism is required by the second organism. Write down the equations for

(i) substrate consumption rates for both substrates
(ii) biomass production rate of both organisms
(iii) specific growth rate of second organism when it is dependent on the growth factor produced by first organism.

4 + 4 + 4 = 12

7. In a chemostat with recycle, the feed flow rate and the culture volumes are F= 100 ml/hr and V= 1000 ml, respectively. The system is operated under glucose limitation, and yield coefficient Yx/s is 0.5 gdw cells/g substrate. Glucose concentration in the feed is So=10 g glucose /L. The kinetic constant of the organisms are μ_m=0.2 hr^{-1}, Ks = 1 gm glucose /L. The value of C (the ratio of cell concentration in the recycle stream to the cell concentration in the reactor effluent) is1.5. The recycle ratio α = 0.7. The system is at steady state.

(i) Find the substrate concentration in the recycle stream (s).
(ii) Find the specific growth rate (μ_{net})of the organism
(iii) Find the cell (biomass) concentration in the recycle stream.

4 + 4 + 4 = 12

Group E

8. (a) Streptomycin is extracted from the fermentation broth using an organic solvent in a counter-current staged extraction unit. The distribution coefficient of streptomycin at pH = 4 is k = 40 and the flow rate of the aqueous phase is H = 150 l/min. Only 5 extraction units are available to reduce the streptomycin concentration from 10 g/L in the aqueous phase to 0.2 g/L. Determine the required flow rate of the organic phase (L) in the extraction unit if extraction factor (E) is greater than 1 using the Newton-Raphson method.

(b) Write a program to represent the above problem.

8 + 4 = 12

9. (a) Ethanol formation is accomplished in a batch culture of Saccharomyces cerevisiae and the following data were obtained: carrying capacity X(infinity) = 10.8 gm/l; and coefficient k = 0.24 (hr)$^{-1}$. Solve the logistic equation for cell growth in batch mode by the fourth order Runga - Kutta method.

(b) Write a program for the same.

6 + 6 = 12