M.TECH/BT/3RD SEM/BIOT 6152/2016

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) 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.

(ii) Which of the following is not a cell growth model?
(a) Tessier model (b) Moser model
(c) Monod model (d) Michaelis Menten model.

(iii) Stationary phase is described as
(a) no further increase in the cell population after a maximum value
(b) deceleration of growth and division rate after the growth rate reaches a maximum
(c) acceleration of growth and division rate after the growth rate reaches a maximum
(d) deceleration of growth and division rate after the growth rate reaches a minimum.

(iv) Which of the following is used to calculate mass of substrate in the reactor?
(a) Flow rate x substrate concentration in the reactor
(b) Volume of reactor x substrate concentration in reactor
(c) Flow rate x mass of reactor
(d) Volume of reactor x Flow rate.

(v) Newton-Raphson method of solution of numerical equation is not preferred when
(a) Graph of A(B) is vertical
(b) Graph of x(y) is not parallel
(c) The graph of f(x) is nearly horizontal-where it crosses the x-axis
(d) The graph of f(x) is nearly vertical-where it crosses the y-axis

(vi) Which of the following statements applies to the bisection method used for finding roots of functions?
(a) Converges within a few iterations
(b) Guaranteed to work for all continuous functions
(c) Is faster than the Newton-Raphson method
(d) Requires that there be no error in determining the sign of the function

(vii) What is the basic assumption in Briggs- Haldane model of enzyme substrate reaction?
(a) Rapid equilibrium
(b) Quasi steady state
(c) Substrate and inhibitor should be structurally similar
(d) None of the above.

(viii) Monod model is
(a) a structured, segregated model
(b) an unstructured, segregated model
(c) a deterministic model
(d) an empirical model

(ix) Structured and segregated model solicits
(a) multicomponent average cell description
(b) single component heterogeneous individual cell
(c) multicomponent, heterogeneous cell description
(d) average cell description.

(x) Two compartment model is
(a) a type of structured model
(b) where G component corresponds to cellular enzymes
(c) overtly 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) Explain the three compartment models.

4 + 4 + 4 = 12

3. Explain the kinetic model for product formation in a biochemical system stating all possible assumptions in detail.

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Group – C

4. Establish a model for determination of sludge age in activated sludge process.

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5. A batch fermentation is conducted at 35º C. Experiments with sodium sulfite oxidation indicate that k_la. C_l^* = 0.1mol/l-h. The culture has a doubling time, in exponential growth, of 30min, and an oxygen yield coefficient of 0.6gcells/gO_2.
   (i) Calculate the exponential specific growth rate, μ.(C^* = 1.09mmol/l).
   (ii) Calculate the dissolved oxygen level as the cells increase from $X_0 = 10^{-6}$g/ml. Plot C_l vs X. At what biomass level is C_l predicted to be zero?

(6 + 6) = 12

Group – D

6. Consider a system where a mixed culture consisting of two microbes are growing in a batch reactor. Both the organisms can grow on both substrates Glucose and citrate. But organism 1 has a preference of glucose and organism 2 has preference of citrate as substrate. Two key enzymes E1 and E2 are plying the major role of assimilation of glucose and citrate, respectively. Again, an inhibitor is produced during assimilation of glucose by organism 1, which inhibits the assimilation of citrate by organism 2.
   Considering the above system, model the following equations:
   (i) Specific growth rate of organism 1 for glucose as limiting substrate.
   (ii) Specific growth rate of organism 1 for citrate as limiting substrate.
   (iii) Specific growth rate of organism 2 for glucose as limiting substrate.
   (iv) Specific growth rate of organism 2 for citrate as limiting substrate.
   (v) Glucose degradation rate with respect to time.
   (vi) Citrate degradation rate with respect to time.

6 × 2 = 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/ gm substrate. Glucose concentration in the feed is So = 10 g glucose /litre. The kinetic constant of the organisms are $\mu_m = 0.2\ hr^{-1}$, Ks = 1 gm glucose /litre. 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. Write a program to simulate the gravity-flow tank system using fourth-order Runge-Kutta method. The system equations are $f(h,t) = 0.311 - 0.0624v$ and $f(v,t) = 0.0107h - 2.05 \times 10^{-3}v^2$. Find the velocity of the fluid in the pipe to fill up 7 ft. height of the tank. The initial conditions of physical parameters of the tank: v_0 = 3.4 ft/sec, h_0 = 2.05 ft, t_0 = 0 sec, h = 20.

12

9 Consider steady-state operation of a chemostat. Assume that growth is substrate inhibited and that endogeneous metabolism can be ignored. Determine the effluent glucose by using $\mu_{net} = \frac{\mu_m S}{K_S + S + S^2/K_I}$ with the help of Regular-Falsi method.
Given : $\mu_{net} = 0.125h^{-1}, \mu_m = 0.35h^{-1}, K_S = 100\ g/l\ , K_I = 150\ g/l.$

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