M.TECH/BT/3RD SEM /BIOT 6152/2015
2015

Modelling 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 alternatives for the following: 10 x 1=10

(i) An open system in which the growth rate is maintained by adding a nutrient (present in limiting quantities) at the same rate as that medium containing micro-organisms is removed is called
   (a) manostat (b) chemostat
   (c) turbidostat (d) culturostat.

(ii) Unit of specific growth rate is
   (a) time 1 (b) hr (c) kg/m^3 (d) m^3.

(iii) In which of the following methods, proper choice of initial value is very important?
   (a) Bisection method (b) False position
   (c) Newton-Raphson (d) Bairsto method.

(iv) Individuality of cells are the basic assumption of a
   (a) structured model (b) segregated model
   (c) non-segregated model (d) unstructured model.

(v) Continuous sterilization model is a type of
   (a) unstructured model (b) deterministic model
   (c) segregated model (d) probabilistic model.

(vi) 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 these.

(vii) Heat transfer rates (per unit volume) will be lowest in
   (a) stirred tank bioreactor with biomass recycle
   (b) continuous air lift bioreactor
   (c) continuous packed bed reactor
   (d) continuous fluidized bed bioreactor.

(viii) The convergence of which of the following method is sensitive to starting value?
(a) False position (b) Gauss seidal method
(c) Newton-Raphson method (d) Bisection Method.

(ix) 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.

(x) Errors may occur in performing numerical computation on the computer due to
(a) rounding errors (b) power fluctuation
(c) operator fatigue (d) All of these.

Group – B

(a) What are the advantages of simulation technology?

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

6 + 6 = 12

(a) Explain structured model with the help of a case study.

b) What are the disadvantages of compartmental models?

10 + 2 = 12

Group – C

A batch fermentation is conducted at 35º C. Experiments with sodium sulphite oxidation indicate that k_La. $C_i^* = 0.1$mol/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.($C^* = 1.09$mmol/l).
(ii) Calculate the dissolved oxygen level as the cells increase from $X_0 = 10^{-6}$g/ml. Plot C_i vs X. At what biomass level is C_i predicted to be zero?

(6 + 6) =12

a) Establish a model for determination of dissolved oxygen level in metabolic oxygen utilization

b) What is BOD? Why is it determined at 20°C?

10 + (1 + 1) = 12

Group – D

6. In a fed batch culture operating with intermittent addition of glucose solution, values of the following parameter are given at time t = 2 hr, when the system is at quasi-steady state.

   V=1000 litre, F= 200 ml/hr, S_0= 100 gm glucose/litre, μ_m= 0.3 hr^{-1}.
   K_s= 0.1 gm glucose/litre, Y_x/s = 0.5 gdw cells/ g glucose, X_0 t=30 gm
   (i) Find the initial volume of culture
   (ii) Determine the concentration of growth limiting substrate in the vessel at quasi steady-state.
   (iii) Determine the concentration and total amount of biomass in the vessel at t = 2 hr. (at quasi steady state).
   (iv) If q_p= 0.2 gm product /gm cell, P_0= 0, determine the concentration of product in the vessel at t = 2 hr.

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7. Model a two stage chemostat with additional feed stream for their respective substrate concentrations and sludge concentrations in the reactor. Write down the equations how the above mentioned parameters are changing with time.

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Group – E

8. Write the program to simulate three-isothermal openloop CSTR using fourth-order Runge-Kutta method.
   Given: The initial conditions are $C_{A1(0)}$ = 0.8 kg.mol of component A/m^3, $C_{A2(0)}$ = 0.4 kg.mol of component A/m^3, $C_{A3(0)}$ = 0.2 kg.mol of component A/m^3; The forcing function at time zero C_{A0} = 3.6 kg.mol of component A/m^3; The parameter τ = 4 min, k = 1 min^{-1}; the step size = 0.2.

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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 Newton-Raphson method.
   Given: $\mu_{net} = 0.25, \mu_m = 0.35, K_S = 100, K_I = 150$

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