7. Derive the equation to determine the volume of a mixing tank in activated sludge process in terms of solid retention time, considering endogenous metabolism.

12

Group E

8. Use the R-K method of order 4 to solve the solve the following equation with a step size of h=1, for 1<t<3, $\frac{dx}{dt}$= 1+$\frac{x}{t}$ with initial condition x(1)=1

12

9. 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 gms/l in the aqueous phase to 0.2 gms/l. Determine the required flow rate of the organic phase (L) in the extraction unit if extraction factor (E) is greater than 1 by using the Newton-Raphson method.

12

MODELING AND SIMULATION IN BIOPROCESS
(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) Individuality of cells are the basic assumption of a
(a) structured model (b) segregated model
(c) non-segregated model (d) unstructured model.

(ii) 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.

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

(iv) Which of the following is used to grow bacterial cultures continuously?
(a) Haemostat
(b) Chemostat
(c) Bacteria cannot be grown in continuous culture
(d) Thermostat

(v) 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.

(vi) What do you mean by "quasi steady state"?
(a) Cell concentration remains virtually constant
(b) Cell concentration is virtually variable
(c) Total biomass remains constant with time
(d) Total biomass decreases with time.

(vii) In a fixed-volume fed batch culture μ declines when_____.
(a) biomass increases (b) biomass decreases
(c) biomass remains constant (d) biomass is equal to zero.

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

(ix) Under continuous culture which of the following condition is applicable?
(a) $\mu_{max} < D$ (b) $\mu_{max} > D$
(c) $\mu_{max} = D$ (d) $\mu_{max}=0$.

(x) If one starts with 10,000 (10^4) cells in a culture that has a generation time of 2 h, how many cells will be in the culture after 4 and 48 h?
(a) 4.0×10^4 cells, 1.7×10^{11} cells
(b) 4.2×10^4 cells, 1.1×10^{11} cells
(c) 4.6×10^4 cells, 1.5×10^{11} cells
(d) 4.8×10^4 cells, 1.3×10^{11} cells.

Group - B

2. Establish a mechanistic model for action of an enzyme on a substrate in the cellular system with suitable premises.

12

3. Create a structured kinetic model for product formation in a bioprocess.

12

Group - C

4. An autoclave malfunctions, and the temperature reaches only 119.5°C. The sterilization time at the maximum temperature was 20min. The jar contains 10L of complex medium that has 10^5 spores/L. At 121°C $k_d=1.0min^{-1}$ and $E_{0d}=90kCal/gmol$. What is the probability that the medium was sterile?

12

5. The number of viable spores of a new strain of *Bacillus subtilis* is measured as a function of time at various temperatures.

Time (min)	Number of spores (N) at:			
	T=85°C	T=90°C	T=110°C	T=120°C
0	2.4×10^9	2.4×10^9	2.4×10^9	2.4×10^9
0.5	2.39×10^9	2.38×10^9	1.08×10^9	2.05×10^7
1.0	2.37×10^9	2.3×10^9	4.8×10^8	1.75×10^5
1.5	-	2.29×10^9	2.2×10^8	1.3×10^3
2	2.33×10^9	2.21×10^9	9.85×10^7	-
3	2.32×10^9	2.17×10^9	2.01×10^7	-
4	2.28×10^9	2.12×10^9	4.41×10^6	-
6	2.2×10^9	1.95×10^9	1.62×10^5	-
8	2.19×10^9	1.87×10^9	6.88×10^3	-
9	2.16×10^9	1.79×10^9	-	-

i. Determine the activation energy for thermal death of *Bacillus subtilis* spores.
ii. What is the specific death rate constant at 100°C?
iii. Estimate the time required to kill 99% spores in a sample at 100°C using a deterministic model for sterilization.

12

Group - D

6. In a fed batch culture operating with intermittent addition of glucose solution, values of the following parameters are given at time t = 2 hr, when the system is at quasi-steady state.
V =1000 litre, F = 200 ml/hr, So= 100 gm glucose/litre, $\mu_m= 0.3\ hr^{-1}$.
Ks = 0.1 gm glucose/litre, $Y_{x/s}$= 0.5 gdw cells/ g glucose, Xo^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, Po= 0, determine the concentration of product in the vessel at t= 2 hr.

3 + 3 + 3 + 3 = 12