MODELLING AND SIMULATION IN BIOPROCESS
(BIOT 6131)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

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

(ii) Growth kinetics of bacterial cells follow
(a) Deterministic Model (b) Michaelis Menten Model
(c) Monod Model (d) Probabilistic 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) Leudeking-Piret model used for
(a) production kinetics (b) substrate utilization kinetics
(c) growth kinetics (d) none of the above.

(v) Wash out in steady state fermentation occurs when
(a) Dilution rate is less than specific growth rate
(b) Dilution rate is higher than specific growth rate
(c) Cell concentration reaches maximum
(d) Specific growth rate is maximum.

(vi) Which is **not** related to the continuous culture?
(a) Substrate concentration and other conditions remain constant
(b) Cells grow at a constant fully acclimatized exponential rate
(c) It has four phase, these are lag, log, stationary and death phase
(d) Specific growth rate = dilution rate.

(vii) A completely mixed continuous stirred-tank reactor for the cultivation of cells
(a) Turbidostat (b) Chemostat
(c) Haemostat (d) Thermostat

(viii) Which of the following equation describes the relationship between μ and residual growth limiting substrate?
(a) Eyring equation (b) Van't Hoff equation
(c) Arrhenius equation (d) Monod equation.

(ix) 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.

(x) The equation f(x) is given as $x^3 - x^2 + 4x - 4 = 0$. Considering the initial approximation at x=2 then the value of **next** approximation correct upto 2 decimal places (Newton-Raphson method) is given as _____
(a) 0.67 (b) 1.33 (c) 1.00 (d) 1.50.

Fill in the blanks with the correct word

(xi) Penicillin is produced in _____ phase of growth.

(xii) At steady state dilution rate is equal to _____.

(xiii) In sterilization process, spores of this organism is considered as control-_____.

(xiv) The unit of Dilution rate "D" in chemostat is given as a ratio of _____.

(xv) The last stage of fed batch culture is known as _____.

Group - B

2. (a) 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 10^5spores/L. At 121°C k_d= $1min^{-1}$ and E_{0d}= 90kCal/gmol. What is the probability that the medium is sterile? *[(CO2)(Apply/IOCQ)]*
(b) What type of mathematical model was used to solve the above problem? *[(CO1)(Remember/LOCQ)]*

10 + 2 = 12

3. (a) What do you understand by terms modelling and simulation? *[(CO1)(Understand/LOCQ)]*
(b) What are compartment models? *[(CO2)(Remember/LOCQ)]*
(c) Describe a three compartment model. *[(CO2)(Remember/LOCQ)]*

4 + 2 + 6 = 12

Group - C

4. A medium containing a vitamin is to be sterilized. Assume that the number of spores initially present is 10^5spores/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 when 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. *[(CO3)(Analyse/IOCQ)]*

12

5. (a) Establish a model for determination of sludge age in activated sludge process. *[(CO3)(Derive/IOCQ)]*

(b) What is BOD? *[(CO1)(Remember/LOCQ)]*

10 + 2 = 12

Group - D

6. Consider a 1000 lit chemostat in which biomass being produced with glucose as substrate. Microbial system follows Monod equation. μ_{max} =0.4hr-1, Ks= 1.5 gm/lit, Yx/s = 0.5. If normal operation is with sterile feed containing 10 gm/lit glucose at a rate of 100lit/hr, find
   (i) What is the specific biomass production rate (g/lit.hr) at steady state.
   (ii) If recycle is used with a recycle stream of 10 lit/hr and recycle biomass concentration five times as large as that in the reactor exit, what would be the new specific biomass production rate. *[(CO4)(Apply/HOCQ)]*

12

7. Ethanol formation from glucose is accomplished in a batch culture of *S. cerevisea* and the following data were obtained.

Time (hr)	Glucose (gm/lit)	Biomass(gm/lit)	Ethanol(gm/lit)
0	100	0.5	0.0
2	95	1.0	2.5
5	85	2.1	7.5
10	58	4.8	20.0
15	30	7.7	34.0
20	12	9.6	43.0
25	5	10.4	47.5
30	2	10.7	49.0

Determine yield coefficient Yx/s, Yp/s, $Y_{P/X,}$ μ_{max}, and identify graphically what type of product is ethanol. *[(CO3)(Analyse/HOCQ)]*

12

Group - E

8. 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 gm/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.

[(CO6)(Solve/HOCQ)]

12

9. In a process of Lactic acid fermentation, the production of lactic acid inhibits the microbial growth in a non-competitive manner, for which the following data were obtained. Find the kinetic constants of the microbial growth.

S=200mg		S=2000 mg	
μ (hr_{-1})	I (mg)	μ (hr_{-1})	I (mg)
0.045	0	0.015	0
0.030	12	0.0098	12
0.019	27	0.0067	27

[(CO6)(Evaluate/HOCQ)]

12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	16.7	33.3	50