BIOREACTOR DESIGN AND ANALYSIS
(BIOT 3202)

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) Yield coefficient represents
(a) total biomass or product produced
(b) conversion efficiency of a substrate into product
(c) conversion rate of a substrate into biomass or product
(d) production time of biomass or product

(ii) What do you mean by "k_La"?
(a) Volumetric mass transfer coefficient (b) Henry's law coefficient
(c) oxygen transfer coefficient (d) Solute transfer coefficient

(iii) If the rate equation is given by $--r_A = K C_A^{0.6} C_B^{0.4}$ then the molecularity and order of the reaction will be
(a) 1 and 1 (b) 1 and 2
(c) 2 and 1 (d) 2 and 2

(iv) Dispersion number is given by
(a) D/UL (b) DU/L
(c) DL/U (d) L/DU

(v) The parameter D, which we call axial dispersion coefficient, uniquely characterize
(a) the degree of backing during flow
(b) the degree of mixing during the flow
(c) the degree of mixing during laminar flow
(d) the degree of mixing during turbulent flow

(vi) The kinetics of monoclonal antibodies are described by the type
(a) growth associated (b) non-growth associated
(c) Monod model (d) combination of (a) and (b).

(vii) The units of second order rate constant is
(a) mole/ lit. sec (b) mole/sec
(c) lit/mole sec (d) 1/mole

(viii) Airlift fermenter may be design on the basis of
(a) plug flow (b) plug flow with dispersion
(c) completely mixed system (d) segregated model

(ix) Perfusion reactor is used for
(a) vaccine formation (b) animal cell culture
(c) alcohol production (d) biomass production

(x) Damkohler number (Da) is a measure of
(a) pore diffusion (b) film diffusion
(c) combination of (a) and (b) (d) none of these

Fill in the blanks with the correct word

(xi) The ratio of tank diameter to impeller diameter in bioreactor is _____.

(xii) D = 0 (dispersion coefficient) means_____ of the tracer curve

(xiii) In non-ideal reactors the parameter D, which we call axial dispersion coefficient, uniquely characterized the degree of _____ during flow.

(xiv) The concentration of A in a first order reaction, A → R, decreases _____ with time.

(xv) Example of axial flow impeller is _____.

Group - B

2. *Pseudomonas sp* has minimum doubling time of 2.4 hrs when grown on acetate (in a chemostat operation that follows the Monod model). Given, Ks=1.3 g/L, Yx/s=0.46 g cell/g acetate, and So= 38g/L.
(i) Find S and X when D=1/2 of Dmax.
(ii) Find cell mass productivity at 0.8 Dmax.
(iii) Find $D_{washout}$. *[(CO1)(Evaluate/HOCQ)]*

(4 + 4 + 4) = 12

3. (a) Differentiate between axial flow impeller and radial flow impeller. *[(CO1)(Analyse/LOCQ)]*

(b) A fermentation broth with viscosity 10^{-2} Pa- s and density 1000 kg m^{-3} is agitated in a 2.7 m^3 baffled tank using a Rushton turbine with diameter 0.5 m and stirrer speed 1 s^{-1}. Estimate the mixing time. *[(CO2)(Evaluate/HOCQ)]*

6 + 6 = 12

Group - C

4. A plug flow reactor (PFR) (2 m^3) processes an aqueous feed (100liters/min.) containing reactant A (C_{A0} = 100 m mol/lit.). This reaction is ***reversible*** and represented by A → R, $-r_A$ = (0.04 min^{-1}) C_A -- (0.01 min^{-1}) C_R.
First find the equilibrium conversion and then find the actual conversion of reactant A in the reactor. *[(CO2)(Apply/IOCQ)*

(2 + 10) = 12

5. (a) The first-order reversible reaction $A \rightarrow R$, C_{A0} = 0.5 moles/lit. , C_{R0} = 0 takes place in a batch reactor. After 8 minutes, conversion of A is 33.3 %while equilibrium conversion is 66.75 % . Find the rate equation for this reaction.

[(CO1)(Understand/IOCQ)]

(b) Find the first-order rate constant for the disappearance of A in the gas phase reaction $2A \rightarrow R$ if, on holding the pressure constant, the volume of the reaction mixture, starting with 80 % A , decreases by 20% in three minutes.

[(CO2)(Calculate/IOCQ)]

8 + 4 = 12

Group - D

6. (a) Explain the significance of C – curve. *[(CO2)(Remember/LOCQ)]*

(b) The concentration reading given below represent a continuous response to a pulse input into a closed vessel which is to be used as a chemical reactor. Calculate the mean residence time of fluid in the vessel. Generate C –curve and E –Curve for the same.

time (t) min	0	5	10	15	20	25	30	35	infinite
C_{pulse} (gm/lit.)	0	3	5	5	4	3	2	1	0.0

[(CO5)(Analyse/HOCQ)]

4 + (4 + 4) = 12

7. (a) Explain the significance of R T D. *[(CO5)(Analyse/HOCQ)]*

(b) Experimental tracer data given below:

t(min)	0	1	3	4	7	9	12	14	infinite
C_{pulse} (gm/m^3)	0	1	8	10	4	2.2	0.6	0.01	0.0

Determine the fraction of material leaving the reactor that has spent Between 4 to 7 minutes in the vessel. *[(CO5)(Understand/IOCQ)]*

3 + 9 = 12

Group - E

8. (a) What do you understand by membrane bioreactor? *[(CO3)(Analyse/HOCQ)]*

(b) What are the major consideration of membrane bioreactor? *[(CO4)(Remember/LOCQ)]*

(c) What are the application of membrane bioreactor? *[(CO2)(Apply/IOCQ)]*

(d) With the help of a clean diagram explain the operation of membrane bioreactor. *[(CO3)(Apply/IOCQ)]*

2 + 4 + 2 + 4 = 12

9. (a) Explain the relation between C_A and C_M in Michaelis-Menten enzyme kinetics for the first order behaviour and zero order behaviour.

$-r_A = [K C_{E0} C_A] / [C_M + C_A]$ *[(CO3)(Analyse/HOCQ)]*

(b) For the operation of immobilized enzyme reactor [M F R, V = 6 lit. reactor volume] following data were obtained. Substrate A pass through enzyme.

C_{E0} (mol/lit)	C_{A0} (mol/lit)	C_A (mol/lit)	v(lit/min) flow rate
0.02	0.2	0.04	3.0
0.01	0.3	0.15	4.0
0.001	0.69	0.60	1.2

From the entering (C_{A0}) and leaving (C_A) concentration and flow rate find a rate equation to represent the action of enzyme on substrate. *[(CO3)(Analyse/HOCQ)]*

4 + 8 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	14.58	40.63	44.79