BIOREACTOR DESIGN AND ANALYSIS
(BIOT 3202)

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) During exponential phase, growth rate is _____
(a) same as generation time (b) reciprocal of generation time
(c) time required for population to double (d) rate of doubling population.

(ii) What is meant by "k_La"?
(a) Volumetric mass transfer coefficient
(b) Henry's law coefficient
(c) Volumetric oxygen transfer coefficient
(d) Volumetric Solute transfer coefficient.

(iii) The cellular productivity in a continuous stirred tank fermenter (CSTR) increases with an increase in the dilution rate and reaches a maximum value. If the dilution rate is increased beyond the maximum point, the productivity will
(a) decrease abruptly (b) increase
(c) increase drastically (d) be zero.

(iv) The approximate doubling time of a microbial culture where specific growth rate is 0.35/hr. is
(a) one hour (b) two hour (c) three hour (d) six hour.

(v) Monod model is an equation of the following types
(a) linear (b) nonlinear (c) hyperbolic (d) parabolic.

(vi) A bubble column used for aerobic fermentation is best modelled by
(a) plug flow (b) stirred tank
(c) dispersion model (d) plug flow with axial dispersion.

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

(viii) A non-ideal reactor is characterized by
(a) Residence time distribution (b) Peclet number
(c) Schmidt number (d) sherwood number.

(ix) The best method to control Bioreactor operating system is
(a) P I control system (b) PID control system
(c) PD control system (d) none of these.

(x) A batch reactor is characterised by
(a) residence time distribution
(b) variation in extent of reaction and properties of the reaction mixture with time
(c) variation in reactor volume
(d) very low conversion.

Group- B

2. The steady state biomass and substrate concentration in a chemostat operation is given below. If So = 700 mg/L, calculate μ_{max} and Ks, growth yield coefficient ($Y'_{x/s}$ growth) and maintenance coefficient (m)

Dilution rate D (hr^{-1})	S (mg/L)	X (mg/L)
0.3	45	326
0.25	41	328
0.20	16	340
0.12	8	342
0.08	3.8	344

[(CO6)(Calculate/HOCQ)]
12

3. Lethal agents are added to a stirred tank to kill organisms in a medium. Do concentration upon addition of lethal agent is recorded and following data obtained.

t (min)	1	2	2.5	3	4	5
DO (gm/m^3)	1	3	4	5	6.5	7.2

If saturation oxygen concentration is 9 gm/m^3, Calculate K_La. [(CO2)(Calculate/IOCQ)]
12

Group - C

4. The reaction of sulphuric acid with diethylsulfate in aqueous solution at 23 ^0C is given below.

$$H_2SO_4 + (C_2H_5)_2SO_4 \rightarrow 2C_2H_5SO_4H$$

Initial conc. of H_2SO_4 and $C_2H_5SO_4$ are each 5.5 mol/L. Find a rate equation for this Reaction with the help of data given below:

Time (min)------ 0 41 55 96 146 194 267 368 410 infinite
$C_2H_5SO_4H$--------0 1.18 1.63 2.75 3.76 4.31 4.86 5.32 5.42 5.8 (mol/L)

[(CO2)(Analyze/IOCQ)]
12

5. (a) Find the overall order of the irreversible reaction $2H_2 + 2NO \rightarrow N_2 + 2H_2O$ from the following data using equimolar amounts of hydrogen and nitric oxide in a closed vessel:

Total pressure, mm Hg	200	240	280	320	360
Half-life, seconds	265	186	115	104	67

[(CO4)(Calculate/IOCQ)]

(b) Derive first order rate equation and explain the result graphically.
[(CO1)(Remember/LOCQ)]

9 + 3 = 12

Group - D

6. (a) Explain axial dispersion. [(CO3)(Analyze/IOCQ)]

(b) Tracer data given below---

t (min) ----	0	1	3	4	7	9	12	14
C (gm/m^3)-----	0	1	8	10	4	2.2	0.6	0.0

Determine the fraction of material leaving the reactor that has spent between 4 to 7 minutes in the vessel. [(CO5)(Analyze/IOCQ)

3 + 9 = 12

6. (a) What do you understand by the term R T D (significance of RTD)?
[(CO5)(Remember/LOCQ)]

(b) The conc. reading given below represent a continuous response of a pulse input into a closed Vessel.

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

This vessel is to be used as a reactor for the decomposition of a liquid "A"

$A \rightarrow$ Products, $-r_A = K C_A$, $K = 0.307\ min^{-1}$

Estimate the fraction of the reactant unconverted in the real reactor.
[(CO5)(Analyse/HOCQ)]

3 + 9 = 12

Group - E

8. A culture of E. Coli was grown on lactose in a Air lift reactor (mixed flow reactor) (V=1 L) using various flow rates of a C_{A0} =160 mg lactose/lot feed. The following results Were obtained:

v, L/hr	C_A, mg/L	Cell conc., arbitrary
0.2	4	15.6
0.4	10	15
0.8	40	12
1.0	100	6

Find a rate equation to represent this growth. [(CO3)(Analyse/HOCQ)]

12

9. With the help of clean diagram explain the operation of Air Lift Reactor (ALR) And Bubble Column Reactor (B C R). [(CO3)(Remember/LOCQ)]

(6 + 6) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	18.75	45.16	35.48

Course Outcome (CO):

After completing the course, the students will be able to:

1. Develop basic concept of reaction engineering.
2. Understand basic concepts of bioreactor design and analysis.
3. Understand the basic operating principles of bioreactors.
4. Interpret batch reactor data with reference to basic reactor design for a single reaction ideal reactor.
5. Analyze non-ideal flow pattern with reference to residence time distribution (RTD) and dispersion numbers (D/UL)
6. Analyze basic cell growth data to verify Monod model.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question