B.TECH/BT/6TH SEM/BIOT 3203 (BACKLOG)/2022

BIOREACTOR DESIGN AND ANALYSIS
(BIOT 3203)

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) Which of the following is the best definition of generation time in a bacterium?
(a) The length of time it takes to reach the log phase
(b) The length of time it takes for a population of cells to double
(c) The time it takes to reach stationary phase
(d) The length of time of the exponential phase.

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

(iii) Which part of fermenter is used for mixing process?
(a) Impeller (b) Shaft (c) Sparger (d) Headspace.

(iv) A non-ideal reactor is characterized by
(a) residence time distribution (b) Peclet number
(c) segregated model (d) dispersion number.

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

(vi) 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 4h?
(a) 4.0×10^4 cells (b) 4.2×10^4 cells
(c) 4.6×10^4 cells (d) 4.8×10^4 cells.

(vii) A packed bed reactor with immobilized cells is modeled as a
(a) PFR (b) MFR
(c) CSTR (d) Plug flow with axial dispersion.

(viii) The exit age distribution of fluid leaving a vessel is used
(a) to study the reaction mechanism
(b) to study the extent of non-ideal flow in the vessel
(c) to know the reaction rate constants
(d) to know the activation energy of a reaction.

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

(x) A chemostat can be operated at dilution rate which is
(a) higher than the specific growth rate
(b) lower than the specific growth rate
(c) equal to the specific growth rate
(d) not related to the specific growth rate.

Group- B

2. (a) What is " washout condition" of chemostat? [(CO6)(Define/LOCQ)]
(b) The batch growth experiment of a pure bacterial culture shows the following growth data.

t (hr)	0	2	4	8	10	12	14	16
X (Kg/m3)	0.2	0.2	0.305	0.98	1.77	3.2	5.6	6.15
S (Kg/m3)	9.23	9.21	9.07	8.03	6.8	4.6	0.92	0.77

Find out
(i) Values of Ks and μ_{max}, if Monod growth model is followed.
(ii) Value of biomass yield (Yx/s). [(CO6)(Calculate/HOCQ)]
2 + (7+3) =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 ^{0}C 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/lit. 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/lit.) [(CO2) (Analyze/IOCQ)]
12

5. Consider a gas phase, isothermal, zero order reaction $A \rightarrow 3B$. Initial concentration of A is 2 mol/L, there are 40% inerts in the feed. Specific rate constant is 0.1 mol/L.min and activation energy is 40 kJ/mol. Final conversion required is 80%. In case of flow reactors, the volumetric flow rate to be used is 2L/min. Calculate the following:
   (i) Time required in a constant volume batch reactor?
   (ii) Time required in a constant pressure batch reactor?
   (iii) Volume required of a CSTR? [(CO4) (Evaluate/HOCQ)]

(4 + 4 + 4) = 12

Group - D

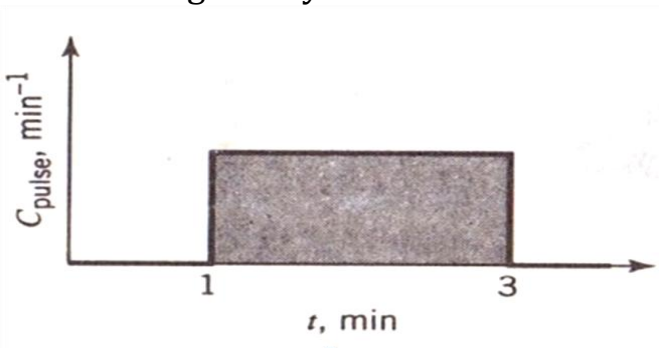
6. (a) Explain axial dispersion. [(CO3) (Analyze/IOCQ)]
   (b) Tracer data given below---

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

7. (a) Derive rate equation for autocatalytic reaction. [(CO1)(Understand/LOCQ)]
   (b) Dispersed non-coalescing droplets (C_{Ao} = 2 mol/liter) reacts as given below ($A \rightarrow R$, $-r_A = K C_A^2$. K = 0.5 liter/ mol. min) as they pass through a contactor. Find the average concentration of A remaining in the droplet leaving the contactor if their RTD is given by the curve below.



[(CO5)(Understand/HOCQ)]

4 + 8 = 12

Group - E

8. At room temperature sucrose is hydrolyzed by the enzyme sucrose as follows
   Sucrose → products
   Starting with sucrose (C_{A0} = 1 mol/m^3) and sucrose (C_{E0} = 0.01 mol/m^3). The following data are obtained in a bubble column reactor. Concentration vs time data as given below.

C_A, mol/m^3	0.68	0.16	0.006
T, hr	2	6	10

   Find a rate equation to represent the kinetics of this reaction. [(CO4)(Understand/IOCQ)]

12

9. (a) With the help of a schematic diagram describe the working principles of Air-lift bioreactor. [(CO3)(Understand/LOCQ)]

   (b) How to find the Monod constants from the batch experiments. [(CO6)(Analyse/LOCQ)]

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	15.63%	48.96%	35.41%

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