

Name :

Roll No. :

Invigilator's Signature :

**CS/B.Tech(BT)/SEM-5/BT-502/2009-10
2009**

BIOREACTOR DESIGN & ANALYSIS

Time Allotted : 3 Hours

Full Marks : 70

The figures in the margin indicate full marks.

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

**GROUP – A
(Multiple Choice Type Questions)**

1. Choose the correct alternatives for any *ten* of the following :

10 ∞ 1 = 10

- i) The molecularity of any reaction will be
 - a) integral number b) fractional number
 - c) both (a) & (b) d) constant.
- ii) The order of any reaction will be
 - a) integral number b) fractional number
 - c) both (a) & (b) d) constant.
- iii) Which of the following is the steady state reactor ?
 - a) Batch reactor b) CSTR
 - c) Plug flow reactor d) Both (b) & (c).

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- ix) Perfusion reactor is used for
- a) Vaccine formation
 - b) Animal cell culture
 - c) Alcohol production
 - d) Biomass production.
- x) Monod model for cell mass growth is a/an
- a) Mechanistic model
 - b) Deterministic model
 - c) Unstructured model
 - d) Structured model.
- xi) Microbial fermentation is best carried out for high yield of cell mass by
- a) Plug flow reactor
 - b) Fed batch reactor
 - c) Back-mixed reactor
 - d) Fluidized bed reactor.
- xii) Maximum growth of *E.coli* is obtained by which of the following combinations of reactors ?
- a) two plug flow reactors in series
 - b) two CSTRs in series
 - c) a CSTR followed by plug flow reactor
 - d) plug flow reactor followed by a CSTR.



GROUP – B

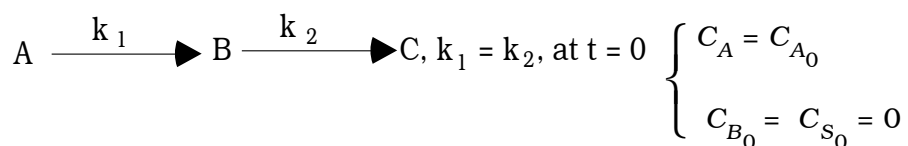
(Short Answer Type Questions)

Answer any *three* of the following.

$$3 \times 5 = 15$$

2. The pyrolysis of ethane proceeds with an activation energy of 300 kJ/mol. How much fast is the decomposition at 65°C than at 500°C ?

3. For the elementary reaction in series :



Find the maximum concentration of B. When is it reached ?

4. Write short notes on trickle bed reactor & d membrane reactor.
5. After 8 minutes in a batch reactor, reactant A ($C_{A_0} = 1$ mol./lt.) is 80% converted; after 18 minutes conversion is 90%. Find a rate equation to represent this reaction.
6. Consider the scale up of a fermenter from a 10 lt. to 10,000 lt. vessel. The small fermenter has a height to diameter ratio of 3. The impeller diameter is 30% of the tank diameter. Agitator speed is 500 rpm. Determine the dimension of large fermenter (D_t , D_i & H) by using geometric similarity.

**GROUP – C****(Long Answer Type Questions)**Answer any *three* of the following.

3 × 15 = 45

7. a) Find the overall order of the irreversible reaction

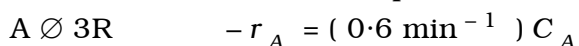


from the following constant volume data using equimolar amounts of hydrogen & nitric oxide :

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

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- b) Gaseous reactant A decomposes as follows :



Find the conversion of A in a 50% A – 50% inert feed
($v_0 = 180 \text{ lt/min}$, $C_{A0} = 300 \text{ mmol/lt}$ to a 1 m^3 mixed flow reactor.

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8. a) A value of $k_L a = 30 \text{ h}^{-1}$ has been determined for a fermenter at its maximum practical agitator rotational speed and with air being sparged at $0.5 \text{ lt gas/lt reactor volume-min}$. *E. coli* with a q_{O_2} of 10 mmol

$\text{O}_2 / \text{g-dry wt.-h}$ are to be cultured. The critical dissolved oxygen concentration is 0.2 mg/lt . The solubility of oxygen from air in the fermentation broth is 7.3 mg/lt at 30°C .

- What maximum concentration of *E. coli* can be sustained in this fermenter under aerobic conditions ?
- What concentration should be maintained if pure oxygen was used to sparge the reactor ?

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- b) Describe the operation of a CSTR with a perfusion system to obtain the high field of product in an animal cell culture.

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9. a) The specific growth rate for inhibited growth in a chemostat is given by the following equation :

$$\mu_g = \mu_m S / (K_s + S + IK_s / K_I)$$

where,

$S_0 = 10 \text{ g/l}$ $K_s = 1 \text{ g/l}$ $I = 0.05 \text{ g/l}$ $Y_{x/s}^M = 0.1 \text{ g cells/g subs}$

$X_0 = 0$ $K_I = 0.01 \text{ g/l}$ $\mu_m = 0.5 \text{ h}^{-1}$ $k_d = 0$

- i) Determine X and S as a function of D when $I = 0$
- ii) With inhibitor added to a chemostat, determine the effluent substrate concentration and X as a function of D .
- iii) Determine the cell productivity, DX , as a function of dilution rate. 10
- b) Describe the method of determining $k_L a$ by the steady state method where the oxygen uptake rate (OUR) is $q_{o_2} X$. 5
10. a) How does dispersion number correlate with the degree of mixing in a bioreactor ? 2
- b) A 1st order reaction is carried out in a reactor with specific reaction rate of 0.25 min^{-1} .

Following are the results of a tracer test carried out in this reactor :

Time (sec)	0	1	2	3	4	5	6	7	8	9	10	12	14
Concentration of Tracer (mg/l)	0	1	5	8	10	8	6	4	3	2.2	1.5	0.6	0

Calculate conversion using closed vessel dispersion model. 13



11. Attempt any three of the following :

- a) What are the advantages & disadvantages of a bubble column reactor for aerobic microbial fermentation ?
- b) What do you know about the perfusion reactor system for animal cell culture ?
- c) Describe an air-lift bioreactor with a neat diagram. What are its specific advantages over other conventional bioreactors ?
- d) Derive the design equation for CSTR & PFR.

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