



Name :
Roll No. :
Invigilator's Signature :

CS/B.TECH(BT)/SEM-5/BT-502/2011-12

2011

BIOREACTOR DESIGN AND 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) Sherwood Number is given by the expression

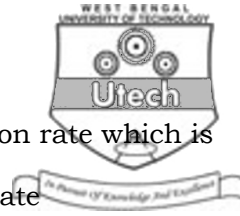
a) $K_L d_f / D_{AB}$ b) $K_L d_b / D_{AB}$

c) $K_L L_C / D$ d) $K_L \rho / D_{AB}$.

ii) If the rate is given as $-r_A = k C_A^{0.6} C_B^{0.4}$ then the
molecularity and order of the reaction is

a) 1 and 1 b) 1 and 2

c) 2 and 1 d) 2 and 2.



- iii) 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.
- iv) A non-ideal reactor is characterized by
- a) residence time distribution
 - b) Peclet number
 - c) combination of reactor
 - d) segregated model.
- v) For enzymatic reactions, at low substrate concentration, rate is
- a) 1st order with respect to substrate concentration
 - b) zero order with respect to substrate concentration
 - c) fractional order with respect to substrate concentration
 - d) none of these.
- vi) If effectiveness factor is less than 1, the conversion in immobilized enzymatic reaction is
- a) reaction rate limiting
 - b) oxygen concentration limiting
 - c) diffusion limiting
 - d) shear rate limiting.



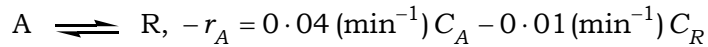
- vii) Animal cell culture is best carried out in
- batch culture
 - stirred tank reactor
 - bubble column reactor
 - air-lift fermentor.
- viii) Monod model is an equation of which of the following types ?
- Linear
 - Nonlinear
 - Hyperbolic
 - Parabolic.
- ix) A bubble column used for aerobic fermentation is best modelled by
- plug flow
 - stirred tank
 - dispersion model
 - plug flow with axial dispersion.
- x) Trickle bed reactor is characterized by
- high L/D ratio
 - high flow rate of the liquid
 - counter current flow of gas and liquid stream
 - mass transfer.
- xi) Change in impeller tip speed depends on
- shear rate
 - viscosity
 - density
 - surface tension.
- xii) In inhibitory enzyme kinetics, the inhibitor is substrate analogue in
- allosteric enzymatic reaction
 - competitive inhibition
 - uncompetitive inhibition
 - non-competitive inhibition.



GROUP – B
(Short Answer Type Questions)

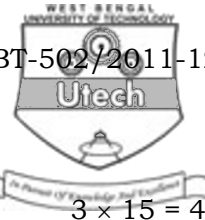
Answer any *three* of the following. $3 \times 5 = 15$

2. Liquid A decomposes by second order kinetics and in a batch reactor 50% of A is converted in a 5 minute run. How much longer would it take to reach 75% conversion ?
3. A plug flow reactor (2 m^3) processes an aqueous feed (100 litre/min) containing reactant A ($C_{A0} = 100 \text{ mmol/litre}$). This reaction is reversible and represented by



What is the equilibrium conversion and the actual conversion in the reactor ?

4. Write short notes on trickle bed reactor & membrane reactor.
5. Describe the method of determining $K_L a$ by the steady state method where the oxygen uptake rate is $q_{O_2} x$.
6. The optimum agitation speed for the cultivation at plant cells in a 3L fermenter equipped with four leafless was found to be 150 rpm. The length and diameter ratio at the fermenter is 3. What should be the (a) dimensions of a geometrically similar 1 m^3 fermenter and (b) the impeller speed based on the same power consumption per unit volume ? Given, impeller diameter $D_I = 0.3D$, where D is the diameter (internal) of the reactor.



GROUP - C
(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

7. a) Write short note on Hollow fiber reactor for the production of monoclonal antibodies.
- b) How does dispersion no. link with the degree of mixing in a bioreactor ?
- c) What is the significance of tanks-in-series model to explain the behaviour of non-ideal reactors ? How does the parameter N affect the E -curve generated by pulse input to the flowing stream in a vessel ? $5 + 3 + 7$
8. a) What are the characteristic features of a bubble column bioreactor used for aerobic fermentation ? How does the liquid phase mass transfer coefficient affect the performance of a reactor ?
- b) A high molecular weight hydrocarbon gas is fed continuously to a heated mixed flow reactor where it cracks as follows : $A \rightarrow 5R$.

By changing the feed rate, different extent of cracking are obtained as follows :

F_{A_0} , mol/hr	0.3	1.0	3.0	5.0
$C_{A_{out}}$, mol/m ³	0.016	0.030	0.050	0.06

7 + 8



9. a) A specific microorganism is used for a chemostat culture of 60 m³ fermenter to produce alcohol from glucose. The feed contains 12 kg/m³ glucose. The kinetic parameters of the system are : $K_s = 0.2 \text{ kg/m}^3$, $\mu_{\max} = 0.3 \text{ hr}^{-1}$, $Y_{X/S} = 0.06$, $Y_{P/X} = 7.7$ and q_p (specific product formation rate) = 3.4 hr^{-1} .

Calculate the flow rate which is required for an outlet substrate concentration $s = 1.5 \text{ kg/m}^3$.

- b) In a number of separate runs different concentrations of substrate and enzyme are introduced into a batch reactor and allowed to react. After a certain time the reaction is quenched and the vessel contents analyzed. From the results found below find a rate equation to represent the action of enzyme on substrate.

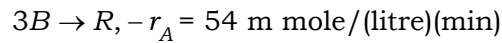
Run	C_{E0} (mol/m ³)	C_{A0} (mol/m ³)	C_A (mol/m ³)	t (hr)
1	3	400	10	1
2	2	200	5	1
3	1	20	1	1

7 + 8

10. a) What are the differences between plant cells & microbes & implication for bioreactor design ?
- b) The rule of thumb that the rate of reaction doubles for a 10°C increase in temperature occurs only at specific temperature for a given activation energy (*i.e.* for specific combination of temperature and activation energy). Show that the relationship between activation energy and temperature for which the rule holds is $T = [10(K) \cdot E / R \cdot \ln^2]^{1/2}$.
- c) Write short note on Fluidized Bed Reactor. 5 + 5 + 5

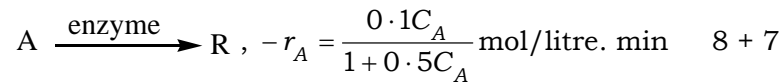


11. a) A stream of pure gaseous reactant A (C_{AO} m mol/L) enters a plug flow reactor at a flow rate of $F_{AO} = 540$ m mol/min and polymerizes there as follows :



How large a reactor is needed to lower the concentration of A in the exit stream to $C_{Af} = 330$ m mol/L ?

- b) Enzyme E catalyses the fermentation of substrate A (the reactant) to product R . Find the size of mixed flow reactor needed for 95% conversion of reactant in a feed stream (25 litre/min) of reactant (2 mol/litre) and enzyme. The kinetics of the fermentation at this enzyme concentration are given by



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