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 <u>any 5 (five)</u> from Group B to E, taking <u>at least one</u> 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) For a high degree of agitation, which reactor is used?
(a) Stirred tank (b) Tubular reactor
(c) Longitudinal reactor (d) All of the mentioned

(ii) In an ideal plug flow reactor at steady state
(a) there may be diffusion along the flow path.
(b) there must be lateral mixing of fluid.
(c) the composition of the reactant remains constant along a flow path.
(d) the fractional conversion of the reactant varies from point to point along a flow path.

(iii) In an ideal mixed reactor at steady-state
(a) the composition throughout the reactor remains same
(b) the exit stream has the same composition as the fluid within the reactor
(c) the space-time is equivalent to holding time for constant density system
(d) all of the above.

(iv) 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 energies of a reaction.

(v) For perfect mixed flow the dispersion number must be
(a) zero (b) less than 2100
(c) less than 2 (d) infinity

(vi) Which of the following types of tracer input signal can be used to study the extent of non-ideal flow?
(a) Periodical signal (b) Step signal
(c) Pulse signal (d) All of the above

(vii) Rate of a chemical reaction is not influenced by the
(a) catalyst (b) temperature
(c) reactants concentration (d) number of molecules of reactants

(viii) A catalyst
(a) decreases the activation energy
(b) alters the reaction mechanism
(c) increases the frequency of collisions of reacting species
(d) all of the above

(ix) The rate constant of a reaction increases by
(a) increasing the concentration of reactants
(b) increasing the pressure
(c) increasing the temperature
(d) carrying out the reaction for a longer time.

(x) Which of the following does not influence the rate of a reaction?
(a) Temperature
(b) Concentration of reactants
(c) Catalyst
(d) Number of molecules of reactants taking part in a reaction.

Group – B

2. (a) Pseudomonas Sp. has a mss doubling time of 2.4 hr when grown on acetate as the sole carbon source. This is the minimum doubling time corresponding to cells growing at $\mu_{\max}$. The saturation constant for acetate is 1.3 g/L and the yield coefficient is $Y_{X/acetate} = 0.46$ g cells/g acetate. For a chemostat operated on a feed stream containing 38 g/L acetate caiculate the following:
(i) Critical dilution rate.
(ii) Substrate concentration when the dilution rate one half of the maximum.
(iii) Cell concentration at that condition.

(b) A strain of mold was grown in a batch culture on glucose and the following data were obtained.

Time, hr	0	9	16	23	30	34	36	40
Cell concentration, g/L	1.25	2.45	5.1	10.5	22	33	37.5	41
Glucose concentration, g/L	100	97	90.4	76.9	48.1	20.6	9.38	0.63

(i) Calculate the maximum net specific growth rate.
(ii) Calculate the apparent growth yield.
(iii) What maximum cell concentration could one expect if 150 g of glucose were used with the same size inoculums?

(2 + 2 + 2) + (2 + 2 + 2) = 12

3. (a) A value of k_{La}= 30 hr^{-1} has been determined for a fermentor at its maximum practical agitator rotational speed and with air being sparged at 0.5 L gas/L reactor volume- min. *E. coli* with a q_{O2} of 10 mmol/g dry weight-hr are to be cultured. The C_{CRIT} is 0.2 mg/L. The solubility of O_2 from air in the fermentor broth is 7.3 mg/L at 30°C.
(i) What maximum concentration of *E. coli* can be sustained in this bioreactor under aerobic condition?
(ii) What concentration could be maintained if pure O_2 was used in the bioreactor?

(b) What are the significances of Prandtl number and Dispersion number in bioreactor design?

(3 + 3) + (3 + 3) = 12

Group – C

4. (a) A liquid phase reaction A+B$\rightarrow$Product is conducted in an isothermal batch reactor. The reaction is first order with respect to each reactant, with k_A= 0.025 $Lmol^{-1}s^{-1}$, C_{A0}= 0.50 mol/L and C_{B0}= 1.0 mol/L. Determine the time required for 75% conversion of A.

(b) For the second order reaction A$\rightarrow$R, starting with initial concentration of A, C_{A0}= 1mol/L, we get 50% conversion after 1 hr in a batch reactor. What will be the conversion and concentration of A after 1 hr if C_{A0}= 10 mol/L.

6 + 6 = 12

5. (a) 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?

(b) What will be the required volume of a CSTR to achieve 90% conversion of a gas phase irreversible reaction A + B$\rightarrow$C, when the entering flow rate of a is 10 mol/min and entering concentration is equal for A and B. The entering concentration of A is 0.4 mol/dm^3. k = 2 dm^3/mol.min and T_0 = 500K.

(2 + 2 + 2) + 6 = 12

Group – D

6. (a) The following RTD data were obtained for a reactor vessel by using a pulse tracer introduced at the inlet flow. Plot E curve.

t, min	0	5	10	15	20	25	30	35
C, tracer concentration, g/cm^3	0	3.0	5.0	5.0	4.0	2.0	1.0	0

(b) Assume a first order reaction is taking place in a reactor vessel, $A \rightarrow R$, k = 0.05min^{-1}. Using the RTD data from the previous problem, calculate X_A from the segregated model.

t, min	0	5	10	15	20	25	30	35
C, tracer concentration, g/cm^3	0	3.0	5.0	5.0	4.0	2.0	1.0	0

6 + 6 = 12

7. (a) A tubular reactor of L= 3m and cross section of 25cm^2 is used to process a first order irreversible reaction $A \rightarrow R$ with 98% conversion with a flow rate of 0.03 m^3/s. Now a pulse tracer test is made and the following data were obtained: Mean residence time, $\bar{t}$ = 10sec, Variance, σ^2 = 65 sec^2. What conversion can be expected from the reactor using

(b) What is Residence Time Distribution (RTD)? How RTD can be expressed? Explain with a proper graphical representation.

6 + (2 + 4) = 12

Group – E

8. (a) *Lactobaccilus casei* is propagated under essentially anaerobic conditions to provide a starter culture for manufacture of Swiss cheese. The culture produces lactic acid as by-product of energy metabolism. The system has following characteristics:

$Y_{X/S}$ = 0.23 kg/kg, K_s = 0.15 kg/m^3, μ_{max} = 0.35 h^{-1} and m_S = 0.135 kg/kg.h

A stirred fermentor is operated in fed batch mode at quasi steady state with a feed flow rate of 4 m^3/h and feed substrate concentration of 80 kg/m^3. After 6 h the liquid volume is 40 m^3.

(i) What was the initial culture volume?
(ii) What is the concentration of substrate at quasi-steady state?
(iii) What is the cell mass concentration at quasi-steady state?

(b) Write short notes on Any two from the following topics:
(i) Membrane bioreactor
(ii) Photobioreactor
(iii) Surface and submerged fermentation

6 + (3 + 3) = 12

9. (a) What are the merits and demerits of immobilized cell system?

(b) Discuss the significance of diffusional limitations in immobilized cell sytem

6 + 6 = 12

Department & Section	Submission Link
BT	https://classroom.google.com/c/MzE1ODkxODA0OTA5/a/MzQzMjM3NzIwNzkw/details