ADVANCES IN BIOREACTOR DESIGN, DEVLOPMENT & SCALE UP (BIOT 5202)

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

(ii) In a CSTR, the composition of the exit stream
(a) is same as that in the reactor
(b) is different than that in the reactor
(c) depends upon the flow rate of inlet stream
(d) none of the above

(iii) Rate of a chemical reaction is not influenced by the
(a) catalyst
(b) temperature
(c) reactant concentration
(d) number of molecules of reactants taking part in a reaction

(iv) The concentration of A in a first order reaction, $A \rightarrow B$, decreases
(a) linearly with time
(b) exponentially with time
(c) very abruptly towards the end of the reaction
(d) logarithmically with time

(v) 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.

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

(vii) 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) Pluse signal (d) All of the above

(viii) 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.

(ix) 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

(x) Antibiotics are best produced in the reactor type
(a) Packed bed (b) Bubble column
(c) CSTR (d) Air-lift fermenter

Group – B

2. (a) Find the first-order rate constant for the disappearance of A in the gas reaction $2A \rightarrow R$ if, on holding the pressure constant, the volume of the reaction mixture, starting with 81 % A, decreases by 20% in three minutes.
E. coli is to be cultivated in a steady state CSTR of volume, V_R= 0.8 m^3 with a flow rate of 0.3 m^3/hr. The limiting substrate used is glucose, fed with initial concentration, S_0= 10 kg/m^3. Other data are given below.
μ_{max} = 0.8 hr^{-1}, K_S= 0.7 kg/m^3, $Y_{X/S}$ = 0.6

(b) (i) What will be the doubling time?
(ii) What will be the cell and substrate concentration?

6 + (3 + 3) = 12

3. (a) A chemostat of volume 1 m^3 was used to study the kinetics of cell growth of a microorganism. The inlet stream is sterile (S_0= 30 kg/m^3). The flow rate was varied and the steady-state outlet substrate concentration was measured. The following data were obtained:

Flow rate, m^3/hr	0.2	0.35	0.50	0.70	0.80
Outlet substrate concentration, kg/m^3	0.5	1.1	1.6	3.3	10

Use Monod Model and find out the parameters.

(b) Write down the significance of Schmidt number and Nusselt number in bioreactor design.

6 + (3 + 3) = 12

Group – C

4. (a) Derive rate equation for autocatalytic reaction.

(b) Find out the conversion of a nth order reaction after 1 hr in a batch reactor for $A \rightarrow R$, $-r_A = 3C_A^{0.5}\ \frac{mol}{L.hr}$, C_{A0}= 1 mol/L.

6 + 6 = 12

5. (a) What will be the required volume of a PFR to achieve 90% conversion of a gas phase irreversible reaction A + B → 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.

(b) In a fed batch culture operating with intermittent addition of glucose solution, values of the following parameters are given at time t= 2 hr, when the system is at quasi-steady state.

V= 1000 ml, F= $\frac{dV}{dt}$ = 200 ml/hr, S_0= 100 g/L, μ_{max} = 0.3 hr^{-1}, K_S= 0.1 g/L, X_0^t = 30 g, $Y_{X/S}^M$ = 0.5 gdw cell/ g glucose

(i) Find initial volume of the culture (V_0)?

(ii) Determine the concentration of growth limiting substrate in the vessel at quasi-steady state.

(iii) Determine the concentration and total amount of biomass in the vessel at t= 2 hr (at quasi-steady state).

6 + (2 + 2 + 2) = 12

Group – D

6. (a) Write a short note on Perfusion system.

(b) What is solid state fermentation (SSF)? What are the advantages of SSF over submerged fermentation?

6 + (2 + 4) = 12

7. (a) What is a perfusion system? Explain with schematic diagram.

(b) What is solid state fermentation (SSF)? What are the advantages of SSF over submerged fermentation?

(3 + 3) + (2 + 4) = 12

Group – E

8. (a) Why digital controller is essential for computer controlled fermenter?

(b) How temperature and Dissolved Oxygen can be controlled in a bioreactor.

6 + (3 + 3) = 12

9. (a) How mass flow rate and volumetric flow rate can be controlled in a bioreactor?

(b) What is the principle behind pressure and broth level control in a bioreactor?

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

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