ADVANCES IN BIOREACTOR DESIGN, DEVELOPMENT AND SCALE UP (BIOT 5202)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any4 (four) from Group B to E, taking one from each group.

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

SYMBOLS ARE OF USUAL SIGNIFICANCE

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) Which of the following equation must be perfunctorily satisfied while dealing with fluid flow problems?
(a) Newton's third law (b) Law of conservation of momentum
(c) Continuity equation (d) Newton's second law.

(ii) Balanced growth occurs in
(a) Lag phase (b) Log phase
(c) Stationary phase (d) Death phase.

(iii) If the reaction rate doubles as the concentration of the reactant A increases by a factor of two, what is the order of the reaction with respect to A?
(a) First order (b) Zero order
(c) Pseudo first order (d) None of these.

(iv) Immobilized cell reactors for wastewater treatment have the advantage of having / being
(a) higher cell concentration
(b) more stable prevents washout
(c) higher dilution rate before the cell washout
(d) all of the above.

(v) The kinetics of monoclonal antibodies are described by the kinetics of the type
(a) growth associated (b) non-growth associated
(c) Monod model (d) combination of (a) and (b).

(vi) Airlift fermenter is used for the production of
(a) Alcohol (b) Penicillin G
(c) Enzyme (d) Antibody.

(vii) Cell suspension is a non-Newtonian fluid of the type
(a) Bingham plastic (b) Pseudo plastic
(c) Dialant (d) None of the above.

(viii) The criterion for the selection of animal cell culture reactor is
(a) low share rate (b) removal of toxic metabolites
(c) combination of (a) and (b) (d) high cell mass concentration.

(ix) The best method to control bioreactor system is
(a) PI control system (b) PD control system
(c) PID control system (d) Proportional control system.

(x) The concentration of A in a first order reaction, A → R, decreases
(a) linearly with time (b) exponentially with time
(c) logarithmically with time (d) very abruptly with time.

Fill in the blanks with the correct word

(xi) At steady state in a continuous reactor dilution rate is _____.

(xii) For nth. order reaction if n < 1
The reaction will complete in _____ time.

(xiii) For nth. order reaction if n > 1
The reaction will complete in _____ time.

(xiv) Monod model behaves as a reaction of _____ order for small substrate concentration.

(xv) nth order rate equation is not valid for n= _____.

Group – B

2. Calculate the productivity (i.e. DP) of a chemostat under the following conditions:
I. Assume Monod kinetics apply
II. Assume LuedekingPiret equation for product formation applies
III. Assume steady state
$D=0.8\mu_{max}$, $\mu_{max}=1.0h^{-1}$, $K_s=10mg/L$, $\alpha= 0.4mg\ P/gX$, $Y^M_{x/S}= 0.5gX/gS$, $S_0=1000mg/L$, $\beta= 0.5h^{-1}mg\ P/gX$. *[(CO2)(Calculate/IOCQ)]*
12

3. The following date were obtained in a chemostat for the growth of *E. aerogenes* on a glycerol limited growth medium.

D, h^{-1}, Dilution rate	0.05	0.1	0.2	0.4	0.6	0.7	0.8	0.84
S, mg/ml, glycerol concentration	0.012	0.028	0.05	0.1	0.15	0.176	0.8	9.00
X, mg/ml, cell concentration	3.2	3.7	4	4.4	4.75	4.9	4.5	0.5

$S_0= 10mg/ml$
For this system estimate the values of K_s, μ_m, $Y^M_{x/s}$, maintenance coefficient (m_s). *[(CO1)(Calculate/HOCQ)]*
12

Group - C

4. (a) Find the conversion after 70 minutes in a batch reactor for $A \rightarrow R$, $-r_A = 3\ C_A^{0.5}$ (mol) / (liter. hr.), $C_{A0} = 1$ mol/lit. *[(CO4)(Apply/IOCQ)]*

   (b) Derive 2^{nd} order rate equation and show the result graphically in terms of C_A and X_A. *[(CO4)(Apply/IOCQ)]*

6 + (3 + 3) =12

5. (a) Liquid A decomposes by second-order kinetics, and in a batch reactor 50% of A is converted in a 5-minutes run. How much longer would it take to reach 75 % Conversion? *[(CO3)(Analyse/IOCQ)]*

   (b) After 8 minutes in a batch reactor, reactant ($C_{A0} = 1$ mol/lit.) is 80 % converted, after 18 minutes, conversion is 90 %. Find a rate equation to represent this reaction. *[(CO4)(Remember/IOCQ)]*

6 + 6 = 12

Group - D

6. (a) Explain different techniques for immobilization. *[(CO4)(Apply/LOCQ)]*

   (b) Discuss the merits and demerits of immobilization both for cells and enzyme. *[(CO4)(Calculate/LOCQ)]*

4 + (4 + 4) = 12

7. (a) Discuss the application and advantages of hollow fibre reactor. *[(CO5)(Remember/LOCQ)]*

   (b) Explain the special considerations for animal cell culture bioreactors. *[(CO5)(Remember/LOCQ)]*

6 + 6 = 12

Group - E

8. (a) What do you understand by the term bioprocess? Why oxygen transfer is so important in aerobic fermentation? *[(CO5)(Evaluate/LOCQ)]*

   (b) How do you control dissolved oxygen (DO) and pH in a CSTR? *[(CO6)(Evaluate/LOCQ)]*

(2 + 4) + 6 = 12

9. (a) Explain the basic operating principles of pH meter. *[(CO6)(Understand/LOCQ)]*

   (b) How do you control the temperature and R P M in a bioreactor? *[(CO6)(Understand/LOCQ)]*

6 + (3 + 3) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	50	37.5	12.5

Course Outcome (CO):

After completing this course, students should be able to:

1. Develop basic concept of reaction engineering including microbial growth kinetics.
2. Determine mass transfer coefficient.
3. Cultivate knowledge about different reactor operations and scale up and scale down.
4. Interpret batch reactor data with reference to basic reactor design for a single reaction in an ideal reactor.
5. Develop understanding about different advanced bioreactors.
6. Be familiar with the bioreactor instrumentation for monitoring and control of bioprocesses.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*