M.TECH/BT/2ND SEM/BIOT 5202/2022

ADVANCES IN BIOREACTOR DESIGN, DEVELOPMENT AND 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.
Symbols are of usual significance

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Amount of CO_2 produced per amount of O_2 consumed is known as
(a) yield coefficient (b) respiratory quotient
(c) degree of reduction (d) maintenance coefficient.

(ii) Balanced growth occurs in
(a) lag phase (b) log phase
(c) stationary phase (d) death phase.

(iii) The approximate doubling time of a microbial culture where specific growth rate is 0.35/hr. is
(a) one hour (b) two hour
(c) three hour (d) six hour.

(iv) Monod model is an equation of the following types
(a) linear (b) nonlinear
(c) hyperbolic (d) parabolic.

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

(vi) The criteria for the selection of animal cell culture reactor is
(a) low share rate (b) removal of toxic metabolites
(c) combination of (a) & (b) (d) high cell concentration.

(vii) The design parameter of a chemostat is
(a) residence time (b) dilution factor
(c) specific growth rate (d) space time.

(viii) The slowest specific growth rate has been observed for
(a) bacterial cells (b) fungi
(c) animal cells (d) plant cells.

(ix) Low flow rate of gas is measured by
(a) rotameter (b) orificemeter
(c) wet gas meter (d) thermo-anemometer.

(x) Dispersion number is given by
(a) D/UL (b) DU/L (c) DL/U (d) L/DU.

Group- B

2. Calculate the productivity (DP) of a chemostat under the following conditions:
(i) Assume Monod kinetics apply.
(ii) Assume Luedeking-Piret equation for product formation.
(iii) Assume steady state.
Given $D = 0.8\ \mu_m$, $Y^m_{x/s} = 0.5$ gX/gS, $\mu_m = 1h^{-1}$, $S_0 = 1000$ mg/L, $\alpha = 0.4$ mgP/gX, $\beta = 0.5h^{-1}$ mgP/gX, $K_s = 10$ mg/L. [(CO1)(Analyze/HOCQ)]
12

3. A simple, batch fermentation of an aerobic bacterium growing on methanol gave the results shown in the table. Calculate:
(i) Maximum growth rate (μ_{max})
(ii) Yield on substrate ($Y_{x/s}$)
(iii) Mass doubling time
(iv) Specific growth rate at t = 10h.

Time, h	0	2	4	8	10	12	14	16	18
X, g/L	0.2	0.211	0.305	0.98	1.77	3.2	5.6	6.15	6.2
S, g/L	9.23	9.21	9.07	8.03	6.8	4.6	0.92	0.077	0

[(CO1)(Analyze/IOCQ)]
12

Group - C

4. (a) Enzyme E catalyzes the transformation of reactant A to product R in batch reactor as follows.

$$A \rightarrow R,\ -r_A = (200\ C_A\ C_{E0}) / (2 + C_A)\ \text{mol / L min.}$$

[(CO4)(Analyse/HOCQ)]
If we introduce enzyme ($C_{E0} = 0.001$ mol/L) and reactant ($C_{A0} = 10$ mol/L). Into a batch reactor and let the reaction proceed, find the time needed for the concentration of reactant to drop to 0.025 mol/L. Conc. of enzyme remain unchanged.

(b) Find the first order rate constant for the disappearance of A in the gas phase reaction $A \rightarrow 1.5\ R$ if the volume of the reaction mixture, starting with pure A increases by 51 % in four minutes. The total pressure within the system stays constant at 1.2 atm, and the temp. is 25 ^{0}C. [(CO4)(Calculate/HOCQ)]

6 + 6 = 12

5. (a) Derive n th. Order rate equation. Does it valid for any value of 'n'? [(CO1)(Understand/LOCQ)]
   (b) Derive rate equation for autocatalytic reaction. [(CO1)(Understand/IOCQ)]

4 + 8 = 12

Group - D

6. (a) Define membrane Bioreactor. [(CO5)(Remember/LOCQ)]
   (b) Explain the operating principles of different types of membrane bioreactors with the help of clean diagram. [(CO5)(Remember/LOCQ)]

3 + 9 = 12

7. (a) With the help of a schematic diagram explain the operating principles of Ait-lift bioreactors. [(CO3)(Remember/LOCQ)]
   (b) What do you understand by perfusion system? [(CO5)(Understand/LOCQ)]
   (c) Why perfusion system is suitable for animal cell culture? [(CO5)(Understand/IOCQ)]

7 + 3 + 2 = 12

Group - E

8. (a) Describe and compare the functioning of galvanic and polarographic oxygen electrode with the help of a clean diagram. [(CO6)(Remember/IOCQ)]
   (b) Explain the operating principle of a pH meter. [(CO6)(Understand/LOCQ)]

(4 + 4) + 4 = 12

9. (a) What do you understand by the term bioprocess ? Why oxygen mass transfer is so important in aerobic fermenter? [(CO2)(Remember/LOCQ)]
   (b) Explain in detail the process instrumentation of a modern bioreactor. [(CO6)(Understand/IOCQ)]

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	37.5	37.5	25

Course Outcomes (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