BIOPROCESS TECHNOLOGY
(BIOT 5241)

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) The process of Lactic acid fermentation occurs without _____
(a) free oxygen (b) free carbon-di-oxide
(c) free hydrogen (d) free nitrogen.

(ii) Which of the following methods is used for killing microorganisms of only certain types and not all microorganisms?
(a) Pasteurization (b) Incineration
(c) Boiling water (d) Fractional Sterilization.

(iii) Molasses and corn steep liquor are usually used as
(a) Carbon source for large scale industrial fermentation process
(b) Carbon source for small scale industrial fermentation process
(c) Mineral source for large scale industrial fermentation process
(d) Mineral source for small scale industrial fermentation process.

(iv) Continuous sterilization is better over Batch sterilization due to
(a) Protection of nutrient value (b) Easier automatic control
(c) Decrease in sterilization time (d) All of the above.

(v) Number of generation that take place in an bioreactor with $\mu = 0.693$ for 25 hrs operation is
(a) 2 (b) 20 (c) 10 (d) 25.

(vi) V_{max} remains unchanged in value in presence of inhibitor for
(a) Competitive inhibition (b) Uncompetitive inhibition
(c) Non-competitive inhibition (d) All the above.

(vii) The dissolved oxygen concentration in the mediu below which the microbial system becomes oxygen limited is called
(a) Saturation level (b) Critical level
(c) Optimum level (d) None of (a), (b) & (c).

(viii) When the cells grow on lysis products of the lysed cell, it is known as
(a) trans-substrate genesis (b) dialism
(c) diauxic (d) cryptic growth.

(ix) Wash out in steady state fermentation occurs when
(a) dilution rate is less than maximum specific growth rate
(b) dilution rate is higher than the maximum specific growth rate
(c) cell concentration reaches the maximum
(d) specific growth rate is maximum.

(x) Which of the following is not correct for the Monod model and the Michaelis Menten Model?
(a) The Michaelis Menten Model was derived from a curve fitting exercise
(b) The Michaelis Menten model was derived from an analysis of the mechanism of microbial growth
(c) The Monod model was derived from an analysis of the mechanism of microbial growth
(d) All of the above.

Group- B

2. The enzyme fumarase has the following kinetic constants:

$$E + S \underset{k_{-1}}{\overset{k_1}{\rightleftarrows}} ES \xrightarrow{k_2} E + P$$

where $k_1 = 10^9 M^{-1}s^{-1}$
$k_{-1} = 4.4 \times 10^4\ s^{-1}$
$k_2 = 10^3\ s^{-1}$

(i) What is the value of Michaelis constant for this enzyme?
(ii) At an enzyme concentration of 10^{-6} M, what will be the initial rate of product formation at a substrate concentration of 10^{-3} M? *[(CO1)(Remember/LOCQ)]*

(6 + 6) = 12

3. An inhibitor I is added to the enzymaztic reaction at a level of 1.0g/l. The following data were obtained for K_m= 9.2g/l. Find K_I for competitive inhibition.

v, g/(L.min)	0.909	0.658	0.493	0.4	0.333	0.289	0.227
S, g/L	20	10	6.67	5	4	3.33	2.5

[(CO1, CO2)(Calculate, Analyze/IOCQ)]

12

Group – C

4. Aerobic degradation of benzoic acid by a mixed culture of organisms in waste water can be represented by the following reaction.

$$C_6H_5COOH + aO_2 + bNH_3 \rightarrow cC_5H_7NO_2 + dH_2O + e\,CO_2$$

(i) Determine a,b,c,d, and e if RQ= 0.9.
(ii) Determine the yield coefficients $Y_{x/O2}$ and $Y_{x/s}$.

(iii) Determine the degree of reduction for the substrate and bacteria.

[(CO2)(Calculate/HOCQ)]

(8 + 2 + 2) = 12

5. 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= 10 mg/ml.

For this system estimate the values of K_s, μ_m, $Y^M_{x/s}$, maintenance coefficient (m_s).

[(CO4)(Compute/IOCQ)]

(3 + 3 + 3 + 3) = 12

Group - D

6. (a) Derive the rate equation for cell death kinetics during heat sterilization of media. *[(CO4)(Derive/LOCQ)]*

(b) What is Del Factor? *[(CO3)(Remember/LOCQ)]*

(c) Show the plot between $\ln(N_t/N_o)$ vs time for sterilization of media containing a mixed culture with high concentration of heat resistant organism and low concentration of heat sensitive organism. *[(CO4)(Analysis/IOCQ)]*

6 + 2 + 4 = 12

7. It is desired to pasteurise 200 litre/min milk in a continuous pasteuriser by heating to 71°C for a sufficient time to achieve a 15 power reduction in the number of organism. An existing pasteuriser comprising of well insulated pipe 55 mm ID and 30 m long fed from a plate heat exchanger is available for the duty. Will it provide sufficient holding time? K_d for the organism is 1.84 sec^{-1}. *[(CO5)(Compute/HOCQ)]*

12

Group – E

8. (a) List the steps involved in the downstream process of citric acid.

[(CO6)(Explain/LOCQ)]

(b) Draw the flowchart of Baker's yeast production. *[(CO5)(Understand/LOCQ)]*

6 + 6 = 12

9. (a) Derive the following equation in relation with growth of plasmid containing and plasmid free cell in a chemostat:

$D = \mu_+ f_+ + \mu_+ f_+$

(D= Dilution rate of chemostat, μ_+ and μ_- are specific growth rate of plasmid containing and plasmid free cell , $f_+$and f_- are fraction of plasmid containing and plasmid free cell respectively in the reactor). *[(CO6)(Derive/IOCQ)]*

(b) State the operating conditions of Ethanol fermentation. *[(CO6)(Remember/LOCQ)]*

8 + 4 = 12

Cognition Level	*LOCQ*	*IOCQ*	*HOCQ*
Percentage distribution	*37.5*	*37.5*	*25*

Course Outcome (CO):

After completion of the course the students will be able to

1. Describe the mechanism of all types of enzyme substrate reactions,
2. Calculate various kinetic parameters associated therewith,
3. Comprehend various factors affecting the growth of cells and formation of products,
4. Solve mathematical problems related to various bioprocesses
5. Design mathematically model upstream and fermentation processes, and
6. Apply the concepts in real time industrial scenarios in biotechnology.

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