Thapar Institute of Engineering and Technology, Patiala

Department of Biotechnology and Environmental Sciences

End Semester Examination, BT-007, Bioprocess Engineering

Time 3 Hrs **M.M 72**

Answers must be brief and to the point.
Assume any missing data by stating the suitable reason.
Same parts of a question should be attempted at the one place.

Section – A

Note: Attempt any **two** questions.

I. (a) Describe the process of oxygen transfer methodology from the air bubble to the cell or cluster of cells in fermentation broths? Also describe the effect of gas velocity on the mass transfer rate in broths? **(4)**

(b) Explain why studies involving the immobilized enzymes are so complex? Explain distributed model for calculating various parameters in internal mass transfer problems? **(4)**

(c) Differentiate between:

(i) Active immobilization and Passive immobilization
(ii) PFR and CSTR **(3)**

(d) Define apparent error and steady state error in controller theory? Also define non-regulating systems in controller theory? **(3)**

II. (a) The specific death constants of heating and cooling during sterilization of a medium at 121°C are 0.1 min^{-1} and 0.2 min^{-1}, respectively.
$t_{heating}$ = 20 min, $t_{holding}$ = 30 min, $t_{cooling}$ = 30 min

The decimal reduction time during holding is 2 min. The initial batch contains 6 x 10^{15} organisms at 30°C. Find the sterilization effect i.e. N_t? **(4)**

(b) "Fermentation Biotechnology is truly an interdisciplinary subject." Justify the statement? What are the traditional and modern applications of fermentation biotechnology? **(2.5)**

(c) How OTR (oxygen transfer rate) is related to mass transfer coefficient? Explain? **(3)**

(d) Write short notes on:

(i) Specific cake resistance
(ii) Filter aid
(iii) Factors that affect the filtration rate **(4.5)**

III. (a) Show Graphically in Batch, Fed batch and continious systems, how:

(i) Volume varies time
(ii) Cell conc. with time
(iii) Substrate conc. with time **(4.5)**

(b) A substrate is converted to a product by the catalytic action of an enzyme. Assume that the Michaelis- Menton parameters for this enzyme reaction are:

K_M = 0.03mol/L
r_{max} = 13 mol/L. min

(i) What should be the size of a steady state CSTR to convert 95% of the incoming substrate (C_{S0} = 10 mol/L) with a flow rate of 10 l/hr?

(ii) What should be the size of the reactor if you employ a plug flow reactor instead of the CSTR in part (i)? **(5)**

(c) Show with an example to control the valve sequences during:

(i) sterilization of filter and fermenter

(ii) sampling **(4.5)**

Section – B

Note: Attempt any **two** questions.

IV. (a) A 50 L stirred fermenter is used to culture *Torula utilis* at 28°C. The dissolved oxygen concentration was measured (given in Table) after initially shutting off the oxygen supply and then restarting, for calculating k_La using dynamic gassing out method . The steady state oxygen concentration is 7.05 ppm.

Time(s)	0	5	10	15	20	25	30	37
DO concentration(ppm)	0.5	2.5	3.7	4.4	5.1	5.5	6.0	6.3

Calculate $\mathbf{k_La}$ by using dynamic method? **(5)**

(b) Explain the following:

(i) Mass transfer with chemical reaction

(ii) Effectiveness factor for enzyme kinetics **(4)**

(c) Explain various methods for calculating cell no. density and cell mass density? And also give their applications? **(3)**

(d) Give the physical significance of Monod equation? **(2)**

V. (a) Why effective diffusivity term is used instead of simple diffusivity in immobilized enzyme kinetics? Also discuss various factors involved in that? **(4)**

(b) In a Fermenter of 20 m^3, air is provided at a rate of 10 m^3/min. for a fermentation lasting for 100 hrs. Optimum linear air velocity was 0.15m/sec, at which value of K was 1.535 cm^{-1}. The air contained 200 microorganisms/m^3. Calculate the dimensions of the filter? **(4)**

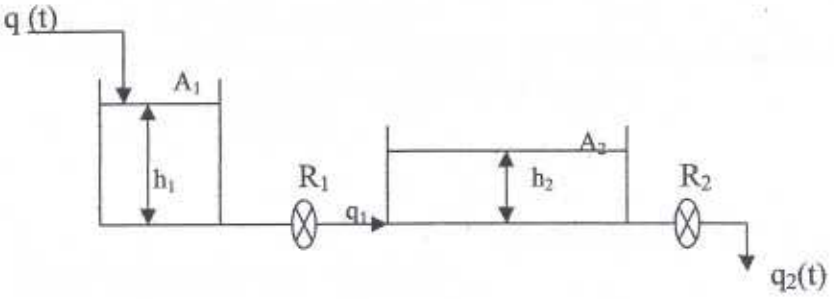
(c) Explain about additive and interactive expressions for specific growth rate in the case of multiple substrates? **(3)**

(d) Discuss about various types of support material used for immobilization? Describe an immobilized cell bioreactor? **(3)**

VI. (a) Describe the various methods for measuring k_La? Describe the various factors affecting oxygen mass transfer in the fermentation process? How do you access the effect of bubble size on the mass transfer rate in fermentation broth? **(4)**

(b) Describe what is meant by "critical oxygen concentration" in fermentation broth? Also derive an expression for the maximum cell concentration? **(4)**

(c) Find the transfer function that relates q (t) to q_2 (t) for the following interacting system? Also calculate the unit step response of the system if two tanks are non-interacting assuming that $\tau_1 = \tau_2 = \tau$. **(6)**



Section – C

Note: Attempt any **Eight** parts. **(2 x 8 = 16)**

(a) In an aerobic fermentation process, the typical average bubble diameter is 3 mm, with an average raise velocity of 18 cm/s. If the diffusivity coefficient is 8×10^{-10} m^2/s, find the mass transfer coefficient on the basis of the penetration theory.

(b) What are the criteria for choosing a particular product recovery step? Describe foam separation process as a tool for downstream processing?

(c) Define and explain the term "dilution rate". Also show how recycling improves the production rate in chemostat?

(d) Results of the Chemostat experiment may differ from those predicted by theory. Comment?

(e) Define distribution coefficient? What is its effect on mass transfer?

(f) Define the efficiency of filter and give steps to design a depth filter?

(g) What are the various unit operations for the separation of suspended solids in downstream processing steps? Thus compare sedimentation and centrifugation?

(h) Explain filter sterilization? Why we need filter sterilization and how they can be classified?

(i) Explain necessary and sufficient condition for operating Plug flow Reactor? Give its advantages and drawbacks?

(j) Why foaming should be controlled in fermentation broths? What are the various methods available for controlling foam?

(k) Explain total collection efficiency of a fibrous filter?