National Exams May 2018

16-Chem-B4, Biochemical Engineering

3 hours duration

NOTES:

1. **If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.**

2. **This is a CLOSED BOOK EXAM. One of two calculators is permitted - any Casio or Sharp approved model.**

3. **FIVE (5) questions constitute a complete exam paper. ANSWER ALL FIVE QUESTIONS.**

4. **Each question is of equal value.**

5. **Most questions require an answer in short essay format. Clarity and organization of the answer are important.**

Question 1 (20 marks)

A substrate (S) is converted to a product (P) by an enzyme. The reaction kinetics followed is Michaelis-Menten given by:

$$v = \frac{v_{max} S}{K_m + S}$$

where v = rate of enzyme reaction $mol.m^{-3}.s^{-1}$

V_{max} = maximum rate of enzyme reaction $mol.m^{-3}.s^{-1} = 7.45 \times 10^{-2}$

K_m = Michaelis-Menten constant = 8 $mol.\ m^{-3}$

k_s = External mass transfer coefficient for substrate = $9.3125 \times 10^{-5}\ s^{-1}$

A packed bed enzyme column of diameter 30 cm is to be used to carry out the reaction using immobilized enzyme with a feed substrate concentration of 100 $mol.m^{-3}$. The feed flow rate can be assumed to be 0.03 m^3/min. Assuming plug-flow in the column, calculate the length of the column for 80% conversion for the following cases:

(i) zero order with no mass transfer limitations; **(5 marks)**

(ii) first order with external mass transfer limitations only. **(5 marks)**

(iii) first order with internal mass transfer limitations only. Assume the Thiele modulus for internal mass transfer limitations is 80. **(10 marks)**

Make appropriate assumptions as needed.

Question 2 (20 marks)

Explain briefly (i) the principles of the Air On-Air Off method for experimental determination of mass transfer coefficient in bioreactors; (ii) Principles of batch sterilization of liquid media

Question 3 (20 marks)

Discuss with a flowsheet the high temperature, short time (HTST) process for the continuous sterilization of nutrient media. What are the specific advantages of this approach compared to the batch process?

Question 4 (20 marks)

Discuss different approaches for cell disruption used in biochemical engineering processes. Compare and contrast the advantages and disadvantages for each approach.

Question 5 (20 marks)

What is enzyme and cell immobilization? What are common approaches applied to immobilize cells and enzymes? What are the specific advantages and limitations of enzyme and cell immobilization? Provide one example of industrial applications for immobilized enzymes.