Department of Biosciences and Bioengineering
Indian Institute of Technology Guwahati
January – May, 2022

Mid Semester Examination

Course No.: **BT 209** Course Title: **Bioreaction Engineering**
Duration: **2 hours (9:00 AM-11:00AM)** Full marks = **30** Dated: **01.03.2022**

Note: There are 5 questions. Answer all questions. Clearly state the assumptions whenever required. Label what part of the problem you are working on, and define the symbols that you use. Good luck.

Q1. (1×5=5 marks)

(a) Under what condition space time and mean residence time of the flow reactor are same?

A) constant volume system B) varying volume system
C) homogeneous system D) it will never be same

(b) Batch reactor operation is a steady state process (True/False)

(c) If the time required to change the concentration of reactant to half of its original value is independent of the initial concentration, the order of reaction is

A. Zero B. one C. two D. three

(d) '*N* plug flow reactors in series with a total volume '*V* gives the same conversion as a single plug flow reactor of volume '*V* for _____ order reactions

(A) first (B) second (C) third (D) any

(e) For a given conversion and for reaction order 0 < n < 1, a mixed flow reactor is always smaller than that for a plug flow reactor. (True/False)

Q2. For the irreversible gas-phase reaction: A→2B the following correlation was determined from laboratory data (the initial concentration of A is 0.2 mol/liter):

$$\text{For } X_A \leq 0.5\,; \quad \frac{10^{-8}}{-r_A} = 3 \quad \frac{m^3.\text{sec}}{\text{mol}}$$

$$\text{For } X_A > 0.5\,; \quad \frac{10^{-8}}{-r_A} = 3 + 10(X_A - 0.5) \quad \frac{m^3.\text{sec}}{\text{mol}}$$

The volumetric flow rate is 5 m^3/sec.

a) Over what range of conversions are the plug-flow reactor and CSTR volumes identical?

b) What plug-flow reactor volume is necessary to achieve 70% conversion?

(1+4=5 marks)

Q3. Consider the set of elementary reactions, which occur simultaneously.

$$\boldsymbol{A \xrightarrow{k_1} B}$$

$$\boldsymbol{A + B \xrightarrow{k_2} C}$$

$$\boldsymbol{A + D \xrightarrow{k_3} 2E}$$

At time t=0, the batch reactor is filled with a mixture of A and D. What is the relation between concentration B and D at any time t ? Assume initial concentration of D is C_{D0}. **(5 Marks)**

Q4. We wish to treat 20 liters/min of liquid feed containing 2 mol A/liter to 97.5% conversion. The stoichiometry and kinetics of the reaction are given by

$$\text{A}\rightarrow\text{R}, \qquad -r_A = 0.01C_A^2 \ \frac{\text{mol}}{\text{liter. min}}$$

Suggest a good arrangement (minimum total reactor volume) for doing this using two mixed flow reactors, and find the size of the two units needed. **(10 marks)**

Q5. The elementary irreversible aqueous-phase reaction A → R is carried out isothermally as follows. The rate constant is 0.01 min^{-1}. The liquid feed stream (20 liter/min) is introduced into a 1000 liter CSTR. The feed stream contains 10 mol A/liter. The outlet stream from CSTR is then passed through a 1500 liter plug flow reactor. Find the concentration of R at the exit of the plug flow reactor. **(5 marks)**