

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

Mid Semester Examination

Course No.: **BT 209**

Duration: **2 hours (9:00 AM-11:00AM)**

Full marks = **30**

Course Title: **Bioreaction Engineering**

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: $A \rightarrow 2B$ the following correlation was determined from laboratory data (the initial concentration of A is 0.2 mol/liter):

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

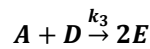
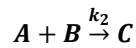
$$\text{For } X_A > 0.5; \quad \frac{10^{-8}}{-r_A} = 3 + 10(X_A - 0.5) \frac{\text{m}^3 \cdot \text{sec}}{\text{mol}}$$

The volumetric flow rate is 5 m³/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?

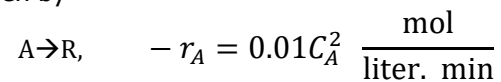
(1+4=5 marks)

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



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



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 $A \rightarrow R$ 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)**