BITS PILANI HYDERABAD CAMPUS

FIRST SEMESTER 2022-23

CHE F311 KINETICS AND REACTOR DESIGN

Mid-semester Examination

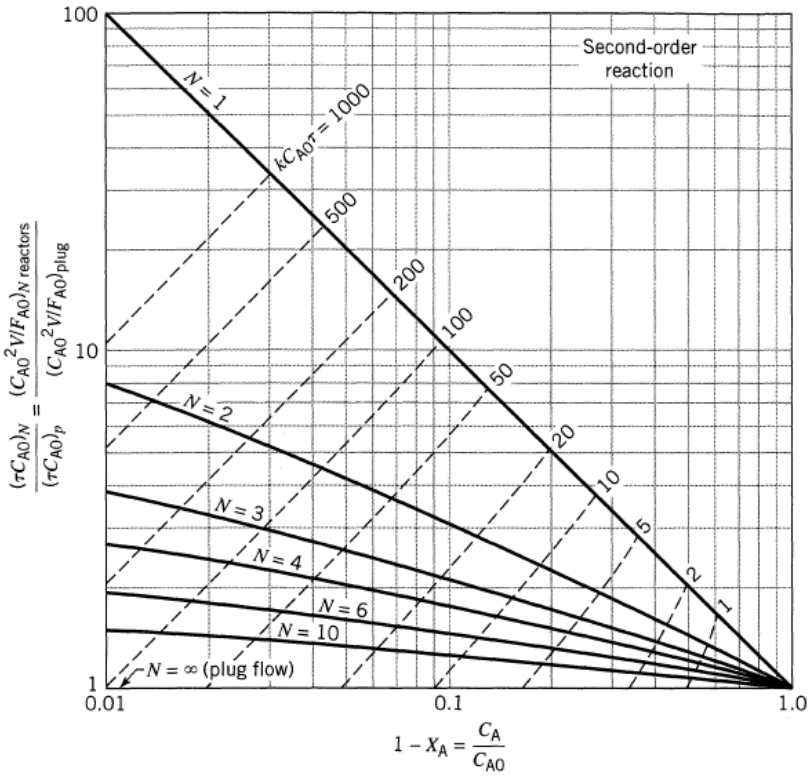
Total Marks: 60 (30% weightage) **Total Time: 90 minutes**

General Instructions

(1) ALL questions are compulsory (No optional questions).
(2) ONLY hand-held scientific calculators are to be used for calculations.
(3) Calculations have to be clearly shown in the answer script.
(4) Graphs, if used, must be properly labelled and numerical answers must have units.
(5) The answer to a particular question should start on a fresh page.
(6) Parts A and B must be written in separate answer booklets.

PART A (Closed Book, 38 Marks)

1. 93% of A (liquid) is converted into product by a 2nd order isothermal reaction in a series of 2 equal volume CSTRs (each having volume V). If a third reactor, also of volume V, is added to the existing arrangement, what will be the new conversion? Note that the treatment rate is not altered. Use the graph below to obtain your answer. [**4 marks**]



2. Gas-phase isothermal reaction $\boldsymbol{A + B \rightarrow R}$ is carried out in a flow reactor with no pressure drop. The feed stream, consisting of 50% A and 40% B, enters the reactor at 400 K and 10 atm. Set up a stoichiometric table and calculate the concentration of the product at the exit of the reactor if 50% conversion (with respect to the limiting reactant) is achieved. [**8 marks**]

3. For the liquid-phase isothermal reaction $\boldsymbol{A \rightarrow R}$, C_{A0} = 1 mol/L, in a batch reactor, the conversion is 75% after 1 hour. The reaction is just complete after 2 hours. Find a rate equation to represent this kinetics. [**8 marks**]

4. 100 L/h of radioactive fluid having half-life of 20 hours passes through two ideal CSTRs in series with volume of each CSTR being 40,000 L. After passing through this arrangement, how much does the activity decay? If the same 2 CSTRs were arranged in parallel instead of series, would that be better than the current arrangement and why? [**10 marks**]

5. Suppose you want to carry out a liquid-phase irreversible isothermal reaction (A→D) to obtain the desired product (D) using a flow reactor. It is unavoidable to eliminate an unwanted side reaction (A→ U) at the experimental condition. The rate expressions of the two reactions are as follows:

$$A \rightarrow D, \quad r_D = k_1 C_A^{1.5} \qquad \text{and} \quad A \rightarrow \text{U}, \quad r_U = k_2 C_A^{0.5}$$

   i) What type of flow reactor (CSTR or PFR) do you suggest to maximize the selectivity of 'D' if $k_1 = k_2 = 1$. Give justification for your answer.
   ii) Suppose the activation energy of the desired reaction and undesired reaction is 160 kJ/mol and 240 kJ/mol, respectively. If you increase the reactor temperature by 20 units, will the selectivity of 'D' be increased/ decreased/ unchanged? Give justification for your answer. **[4+4 = 8 marks]**

PART B (Open Book & Notes, 22 Marks)

1. The following data is obtained for a liquid phase reaction $\boldsymbol{A \rightarrow R}$. It is desired to reduce the concentration of A from 1 mol/L to 0.1 mol/L.

C_A, mol/L	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0
$-r_A$, mol/L.min	0.1	0.3	0.5	0.6	0.5	0.25	0.1	0.06	0.05

   If one CSTR and one PFR are available for use, suggest the best arrangement (along with justification) to achieve the desired concentration, and determine the space time for each of the reactor for the chosen arrangement. [**12 marks**]

2. For an irreversible first-order isothermal liquid phase reaction with C_{A0} = 10 mol/L, the conversion achieved is 90% in a PFR. If a portion of the reactor exit stream is recycled to the reactor entrance with R=2, and if the throughput to the whole reactor-recycle system is kept unchanged, what is the new conversion? [**10 marks**]
