

B. Chemical Engineering 3rd Year 1st Semester Supplementary Examination 2023**Chemical Reaction Engineering – I****Time: Three hours****Full Marks: 100****PART – I (Marks: 50)****Use separate answer script for each part**

Assume any missing data

All the symbols have their usual meaning

Answer ALL the questions

1. The saponification reaction between NaOH and ethyl acetate is an irreversible second order reaction. A conversion of 15% is achieved in a well stirred reactor with equal 0.1 molar initial concentrations of NaOH and ethyl acetate in 25 minutes. What time is required to achieve 30% conversion in the same reactor if the initial charge contains equal 0.2 molar initial concentrations of NaOH and ethyl acetate? [10]

2. At certain temperature, the half-life periods and initial concentrations for a reaction are:

$$t_{1/2} = 420 \text{ s}, C_{A0} = 0.405 \text{ mol/l}$$

$$t_{1/2} = 275 \text{ s}, C_{A0} = 0.64 \text{ mol/l}$$

Find the order and rate constant of the reaction.

[10]

3. In an isothermal batch reactor, 70% of a liquid reactant A is converted in 13 minutes. Find the space time and space velocity needed to carry out the same conversion in a plug flow reactor and in a mixed flow reactor. Consider the reaction follows first order kinetics. [10]

4. An elementary liquid phase second order reaction ($2A \rightarrow R$) carried out in a single CSTR results in 60% of the reactant. It is proposed to put another similar CSTR in series with the existing one. For all other parameters remain unchanged, how much improvements in conversion will occur? [10]

5. The desired liquid phase reaction $A + B \rightarrow R$, $r_R = k_1 C_A C_B^{1.7}$ is accompanied by the undesired side reaction $A + B \rightarrow S$, $r_S = k_2 C_A^{1.4} C_B^{0.5}$. Discuss about what contacting schemes (reactor types) would you use to carry above reactions to minimize the production of S? [10]

[Turn over

**B.E. CHEMICAL ENGINEERING THIRD YEAR FIRST SEMESTER
SUPPLEMENTARY EXAM – 2023
3rd Year, 1st Semester
Chemical Reaction Engineering –I**

Part – II

Full Marks: 50

Assume any missing data

1.
 - a. Briefly describe Tanks-in-Series Model and its significance 5 [CO 5]
 - b. Briefly describe dispersed Plug flow model and write down the correlations for axial dispersion 5 [CO 5]
 - c. Derive the expression of general mass and energy balance equation of fractional conversion for CSTR adiabatic reactor (1st order reaction). 5 [CO 4]

2.

i.

Acetic anhydride is hydrolysed in 4 stirred tank reactor operated in series. The feed flows to the 1st reactor (Volume – 1 lt) at a rate of 500 cc/min. The 2nd, 3rd and 4th reactor has volume of 2, 1.5 and 1.5 lt respectively. The temperature is 25C and 1st order rate constant is 0.16 min⁻¹. Calculate the fraction hydrolysed in the effluent from the 4th reactor. rate equation is $r=0.16C_i$.

15 [CO1 & CO2]

Or

ii.

Under appropriate condition, A decomposes as follows:

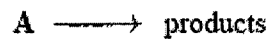
$A \xrightarrow{k_1} R \xrightarrow{k_2} S$ R is to be produced from 150 lt/hr of feed in which $C_{A0} = 1$ mol/lt, $C_{R0} = C_{S0} = 0$, $K_1=K_2 = 0.2/\text{min}$.

- a) What size of plug flow reactor will maximize the yield of R and what is the concentration of R in effluent stream from this reactor?
- b) What size mixed reactor will maximize the yield of R & what is the $C_{R \max}$ in the effluent stream from this reactor.

Use the following expression $\tau_{Optimum,plug} = \frac{\ln(\frac{k_2}{k_1})}{(k_2 - k_1)}$ for $k_2 \neq k_1$

15 [CO1 & CO3]

3. Calculate the mean conversion in the reactor characterized by RTD measurements for a first-order, liquid-phase, irreversible reaction in a completely segregated fluid:



The specific reaction rate is 0.1 min^{-1} at 320 K.

$t \text{ (min)}$	0	1	2	3	4	5	6	7	8	9	10	12	14
$C \text{ (g/m}^3\text{)}$	0	1	5	8	10	8	6	4	3.0	2.2	1.5	0.6	0

$$\int_0^{\infty} C(t) dt = 50.0 \text{ g} \cdot \text{min/m}^3$$

20 [CO5]