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]**

Ref. No. : Ex/Che/PC/B/T/312/2023(S)

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/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 $\tau_{Optimum,plug} = \dfrac{\ln(\frac{k_2}{k_1})}{(k_2 - k_1)}$ 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:

$$A \longrightarrow \text{products}$$

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

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

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

20 [CO5]