U.S.N.										

B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

September / October 2024 Supplementary Examinations

Programme: B.E. **Semester: V**
Branch: Chemical Engineering **Duration: 3 hrs.**
Course Code: 22CH5PCCR1 **Max Marks: 100**
Course: Chemical Reaction Engineering -I

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

		UNIT - I	***CO***	***PO***	**Marks**
1	a)	How do you define the order of reaction for the elementary reactions? Give two examples.	***CO1***	***PO2***	**5**
	b)	What is rate equation? Write the rate equations in terms of rate of disappearance of reactants and rate of formation of products for the following reactions. Reaction 1: $B + 2D \xrightarrow{k_1} 3T$ Reaction 2: $A + E \rightleftharpoons X$	***CO1***	***PO2***	**5**
	c)	The gas phase reaction was carried at 450 K and the rate equation was expressed in terms of pressure as follows $-\frac{dp}{dt} = 3.66 p_A^2 \quad \left(\frac{atm}{hr}\right)$ (i) Identify the unit of rate constant from the above expression. (ii) Determine the value of rate constant if the above equation is expressed as $-r_A = \frac{1}{V}\frac{dN_A}{dt} = kC_A^2 \ \left(\frac{mol}{m^3.sec}\right)$	***CO1***	***PO2***	**10**
		UNIT - II			
2	a)	Consider the following reaction and derive the rate expression. Plot the rate-concentration curve for the reaction. $A + R \rightarrow R + R$	***CO2***	***PO2***	**10**
	b)	Explain different kinetic models for non-elementary reactions.	***CO2***	***PO2***	**10**
		OR			
3	a)	Derive the rate expression for the second order reaction, $2A \xrightarrow{k_1} B$. Draw the general trend of the graph if the experimental data is plotted between t v/s $1/C_A$.	***CO2***	***PO2***	**10**

<table>
<tr><td></td><td></td><td>b)</td><td>The aqueous reactant A reacts to form R in a batch reactor. In a first minute, the concentration of A drops from 2.03 mol/L to 1.97 mol/L.
(i) Find the rate constant and write the rate equation if the kinetics are second order with respect to A.
(ii) After one minute, the concentration of reactant drops as tabulated below. Determine the rate constant graphically.
<table><tr><td>t, min</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr><tr><td>C_A (mol/L)</td><td>2.03</td><td>1.97</td><td>1.84</td><td>1.77</td><td>1.62</td><td>1.55</td></tr></table></td><td>CO2</td><td>PO2</td><td>10</td></tr>
<tr><td></td><td></td><td></td><td>UNIT - III</td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>a)</td><td>Develop the performance equation by applying the material balance around the plug flow reactor. Show the relevant plots which represent the significance of design equation.</td><td>CO3</td><td>PO3</td><td>10</td></tr>
<tr><td></td><td>b)</td><td>An industry is planning to replace the existing Mixed Flow Reactor (MFR) with one having the double the reactor volume. The conversion of reactants in existing reactor is 70%. The initial concentration for aqueous feed is 10 mol/L for both the cases. Estimate the conversion in new reactor. The reaction kinetics are represented by $-r_A = kC_A^{1.5}$.</td><td>CO3</td><td>PO3</td><td>10</td></tr>
<tr><td></td><td></td><td>OR</td><td></td><td></td><td></td></tr>
<tr><td>5</td><td>a)</td><td>The two MFR's of different reactor volumes were connected in series. Interpret the arrangement of two reactors with the assistance of maximization of rectangles concept to determine the best combination.</td><td>CO3</td><td>PO3</td><td>10</td></tr>
<tr><td></td><td>b)</td><td>A MFR followed by PFR of equal volume are connected in series to carry out a first order liquid phase reaction under isothermal condition. The rate constant and space time are given as 0.2 s^{-1} and 5 sec respectively for both the reactors. Estimate the conversion of reactant A at the exit of PFR reactor.</td><td>CO3</td><td>PO3</td><td>10</td></tr>
<tr><td></td><td></td><td>UNIT - IV</td><td></td><td></td><td></td></tr>
<tr><td>6</td><td>a)</td><td>Consider the following irreversible first order series reactions carried out in PFR as shown below.
$$A \xrightarrow{k_1} B \xrightarrow{k_2} C$$</td><td>CO4</td><td>PO2</td><td>8</td></tr>
</table>

			Derive the expressions for C_A and C_B and draw concentration v/s time plots.			
		b)	Explain the contacting patterns for various combinations of high and low concentration of reactants in continuous flow operations with the help of neat sketches.	***CO4***	***PO2***	**4**
		c)	Liquid reactant A decomposes as follows $A \xrightarrow{k_1} R \text{ and } A \xrightarrow{k_2} S$ $$r_R = k_1 C_A^2;\ k_1 = 0.5\ \frac{mol}{m^3.s}$$ $$r_S = k_2 C_A;\ k_2 = 1\ s^{-1}$$ An aqueous feed of composition C_{A0} = 30 mol/m^3, C_{R0} = 2 mol/m^3 and C_{S0} = 1 mol/m^3 enters a CSTR in which the above parallel reaction occurs. Assume the reaction carried under isothermal and steady state conditions. If the conversion of reactant A is 80%, what is the concentration of R (mol/m^3) at the exit stream of CSTR reactor?	***CO4***	***PO2***	**8**
			UNIT - V			
	7	a)	How do you estimate the size of plug flow and mixed flow reactor for a given duty and for a given temperature progression? Explain the general graphical design procedure with the help of neat sketches?	***CO3***	***PO3***	**10**
		b)	A batch adiabatic reactor at an initial temperature of 373 K is being used for the following reaction. Assume the heat of reaction is -1 kJ/mol at 373 K and the heat capacity of both A and B to be constant and equal to 50 J/mol.K. Estimate the temperature rise after 50% conversion of the reactants. $$A \xrightarrow{k_1} R$$	***CO4***	***PO2***	**10**

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