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

Autonomous Institute Affiliated to VTU

June 2025 Semester End Main Examinations

Programme: B.E. **Semester: V**
Branch: Chemical Engineering **Duration: 3 hrs.**
Course Code: 23CH5PCCR1 / 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.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

		UNIT - I	***CO***	***PO***	**Marks**
1	a)	Given the reaction: $2NO_2 + \frac{1}{2} O_2 \rightarrow N_2O_5$, what is the relation between the rates of formation and disappearance of the three reaction components?	*CO1*	*PO2*	**02**
	b)	Differentiate between the order and molecularity of reactions.	*CO1*	*PO2*	**04**
	c)	From basics, prove the following relation. $Vr_A = Wr'_A = Sr''_A = V_s r'''_A = V_r r''''_A$.	*CO1*	*PO2*	**06**
	d)	For the hydrolysis of a reactant '*A*' as per Arrhenius theory, the rate constant at 60°C is 6.698×10^{-3} L/min and the activation energy is 16,200 Cal/mol. Calculate the rate constant at 80°C by collision and transition state theories. Determine the percentage difference in rate constants predicted by these two methods.	*CO2*	*PO2*	**08**
		OR			
2	a)	A reaction: $2A \rightarrow B$ is carried out in a reactor. Write the rate expression with respect to components A and B, assuming it is a second-order elementary reaction. Give the unit of rate constant.	*CO1*	*PO2*	**04**
	b)	Explain the factors affecting the rate of a chemical reaction for both homogenous and heterogenous phases.	*CO2*	*PO2*	**06**
	c)	A rocket engine burns a stoichiometric mixture of fuel (liquid hydrogen) in oxidant (liquid oxygen). The combustion chamber is cylindrical, 75 cm long and 60 cm in diameter and the combustion process produces 108 kg/s of exhaust gases. If combustion is complete, find the rate of reaction of hydrogen and oxygen.	*CO2*	*PO2*	**10**
		UNIT - II			
3	a)	For an irreversible, bimolecular type II order reaction, $A + B \rightarrow$ products. Derive an expression in terms of conversion for the rate equation. Assume that M=2.	*CO2*	*PO2*	**10**
	b)	What are the differences between the elementary and non-elementary reactions? Mention suitable examples	*CO2*	*PO2*	**10**

			OR			
	4	a)	The thermal decomposition of C_2H_6 to ethane, methane, butane, and hydrogen is believed to follow the sequence as follows. $C_2H_6 \xrightarrow{k_1} 2CH_3^*$ $CH_3^* + C_2H_6 \xrightarrow{k_2} CH_4 + C_2H_5^*$ $C_2H_5^* \xrightarrow{k_3} C_2H_4 + H^*$ $H^* + C_2H_6 \xrightarrow{k_4} H_2 + C_2H_5^*$ $2C_2H_5^* \xrightarrow{k_5} C_4H_{10}$ Derive the rate equation for the formation of C_2H_4.	*CO1*	*PO2*	**12**
		b)	Mention the different methods used to analyze the kinetic data. Explain any one method with help of graphical interpretation.	*CO2*	*PO2*	**08**
			UNIT - III			
	5	a)	An aqueous reactant stream (4 mol of A/liter) passes through a mixed flow reactor followed by a plug flow reactor. Find the concentration at the exit of the plug flow reactor if in the mixed flow reactor, C_A = 1 mol/liter. The reaction is second order with respect to 'A', and the volume of the plug flow unit is three times of the mixed flow reactor.	*CO3*	*PO3*	**10**
		b)	The liquid phase isomerization of butane was carried out in three reactors connected in series. Conversion achieved in the first reactor MFR is 20%, conversion achieved in the second reactor PFR is 40% and final conversion achieved in the third MFR reactor is 65%. The experimental data is given for your reference. $-r_A$ $\frac{kmol}{m^3.h}$: 30, 53, 59, 38, 25 X_A: 0, 0.2, 0.4, 0.6, 0.65 Estimate the volume of each reactor connected in series for the entry flow rate of 50 kmol/h.	*CO3*	*PO3*	**10**
			OR			
	6	a)	Elucidate the graphical procedure for finding the outlet composition from a series of mixed-flow reactors of various sizes.	*CO3*	*PO3*	**10**
		b)	Derive the design equation for the plug flow reactor.	*CO3*	*PO3*	**10**
			UNIT - IV			
	7	a)	A series reaction is assumed to be taking place as: $A \xrightarrow{k_1} R \xrightarrow{k_2} S$. The desired product is R. Obtain an expression for $C_{R\,max}/C_A$ when $k_1 = k_2$.	*CO4*	*PO3*	**12**
		b)	What are the instantaneous fractional yield, overall fractional yield, and selectivity in the case of parallel reaction schemes? Explain with equations.	*CO4*	*PO3*	**08**

			OR			
	8	a)	Consider the irreversible unimolecular type first-order reaction in series $A \xrightarrow{k_1} R \xrightarrow{k_2} S$ occurring in an MFR. For this reaction, develop the concentration-time relationship. Assume that the feed contains no R and S, and show that $\tau_{m,\,\mathrm{opt}} = \sqrt{\dfrac{1}{k_1 k_2}}$.	*CO4*	*PO3*	**12**
		b)	A series-parallel reaction $$A + B \xrightarrow{k_1} R$$ $$R + B \xrightarrow{k_2} S$$ occurs in a tubular reactor with the rate constants $k_1 = 3k_2$. Find the concentration of R and S leaving the reactor for 50% conversion of A, when A is introduced at 100 mol/L and no R and S are present in the feed.	*CO4*	*PO3*	**08**
			UNIT - V			
	9	a)	A reversible elementary reaction of type A⇌R has the following relations for k_1 and k_2. $k_1 = \exp(20 - 1200/T)$, and $k_2 = \exp(60 - 2400/T)$. Find the reaction temperature to achieve 77% conversion of A at equilibrium.	*CO5*	*PO2*	**10**
		b)	What is optimum temperature progression? Discuss the optimum temperature progression for an exothermic reversible reaction.	*CO5*	*PO2*	**10**
			OR			
	10	a)	Explain with a neat graph the step-by-step design procedure for an adiabatic operation of a batch reactor.	*CO5*	*PO2*	**10**
		b)	Between 0 and 100°C, determine the equilibrium conversion for the elementary aqueous reaction. $A \underset{k_2}{\overset{k_1}{\rightleftarrows}} R$. Data: $\Delta G^0_{298} = -14{,}130\ \frac{J}{\mathrm{mol}}$, $\Delta H^0_{298} = -75{,}300\ \frac{J}{\mathrm{mol}}$ and $C_{PA} = C_{PB}$ = constant. Present the results of the analysis in a temperature–conversion chart.	*CO5*	*PO2*	**10**

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