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

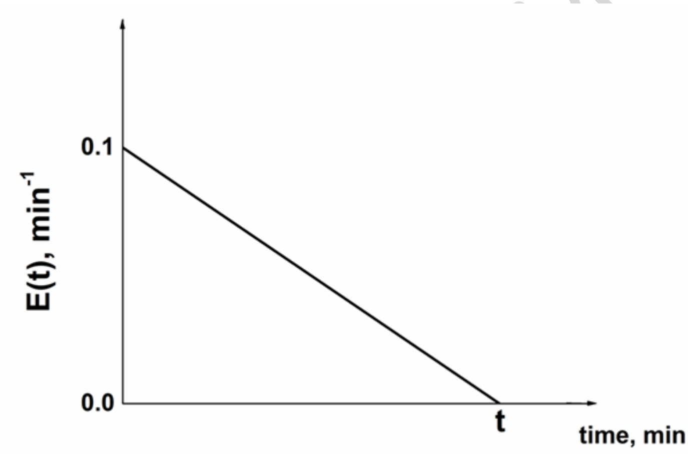
Autonomous Institute Affiliated to VTU

June 2025 Semester End Main Examinations

Programme: B.E. **Semester: VI**
Branch: Chemical Engineering **Duration: 3 hrs.**
Course Code: 23CH6PCCR2 / 22CH6PCCR2 **Max Marks: 100**
Course: Chemical Reaction Engineering - II

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)	The following E-curve was obtained from a tracer test:  i. Calculate the mean residence time spent by the molecules. ii. Calculate the vessel dispersion number.	*CO2*	*PO 3*	**12**
	b)	Apply tracer balance around the ideal CSTR and PFR and develop the correlations for E(t). Depict the E(t) curves for the ideal CSTR and PFR.	*CO1*	*PO3*	**08**
		OR			
2	a)	A pulse trace experiment was conducted and the following tracer concentration was recorded with respect to time, and also estimated the area under the C- curve as 80 mol.min/L.	*CO2*	*PO3*	**12**

Time, min	1	3	5	7	9	11	13	15
Concentration (mol/lit)	0	0	10	10	10	10	0	0

i) Plot time v/s E(t) curve.

			ii) Suggest the number of tanks (use Tanks-in-series) required to obtain the above E-curve distribution. iii) Apply the dispersion single parameter model for the closed vessel, and calculate the vessel dispersion number and reactor Peclet number.			
		b)	Explain the non-ideal flow patterns that may arise in the process equipment's with the help of neat sketches.	*CO1*	*PO3*	**08**
			UNIT - II			
	3	a)	Derive the equation for the time required for complete conversion, assuming the shrinking core model when the gas film is controlling the spherical solid particles of unchanging size. State all the assumptions.	*CO3*	*PO3*	**10**
		b)	Spherical particles of zinc blende of size R = 1 mm are roasted in an 8% oxygen stream at 900°C and 1 atm. The stoichiometry of the reaction is $$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$$ Assuming that reaction proceeds by the shrinking-core model calculate the time needed for complete conversion of a particle and the relative resistance of ash layer diffusion during this operation. Data: Density of solid, ρ_B = 4.13 gm/cm^3 = 0.0425 mol/cm^3 Reaction rate constant, k" = 2 cm/sec For gases in the ZnO layer, D_e = 0.08 cm^2/sec Note that film resistance can safely be neglected as long as a growing ash layer is present.	*CO3*	*PO3*	**10**
			OR			
	4	a)	Hydrogen sulfide (H_2S) is absorbed by a solution of Methanol Amine (MA) in a packed column. At the top of the column, gas is at 20 atm, and it contains 0.1% of H_2S, while the absorbent contains 250 mol/m^3 of free MA. The diffusivity of MA in solution is 0.64 times that of H_2S. The reaction is normally regarded as irreversible and instantaneous. $$H_2S + RNH_2 \rightarrow HS^- + RNH_3^+$$ For the flow rates and packing used $k_{Al}.a = 0.03\ \frac{1}{s}$; $k_{Ag}.a = 60\ \frac{mol}{m^3.\ s.\ atm}$ $H_A = 1 * 10^{-4}\ \frac{m^3 \times atm}{mol}$ Estimate the rate of absorption of H_2S in MA solution.	*CO3*	*PO3*	**10**

		b)	Derive the general rate expression for a fluid-fluid reaction system for an instantaneous reaction with a low C_B value.	*CO3*	*PO3*	**10**
			UNIT - III			
	5	a)	The decomposition of cumene (C) on the surface of catalyst undergoes the reactions and forms benzene (B) and propylene (P). The reaction mechanism is given below. $C + S \leftrightarrow C.S$ (Adsorption) $C.S \leftrightarrow B.S + P$ (Surface reaction) $B.S \leftrightarrow B + S$ (Desorption) Develop the rate equation if the surface reaction is the rate-controlling step.	*CO3*	*PO3*	**12**
		b)	Write a short note on the following. i. Promoters and inhibitors ii. Properties of the catalysts.	*CO3*	*PO3*	**08**
			OR			
	6	a)	Consider any reaction occurring on the surface of a catalyst, and develop the rate expressions for the following. i) Molecular adsorption ii) Single-site reaction mechanism iii) Eley-Rideal mechanism	*CO3*	*PO3*	**10**
		b)	Explain the different steps involved in solid-catalyzed reactions with the help of a neat diagram.	*CO3*	*PO3*	**10**
			UNIT - IV			
	7	a)	Explain the various mechanisms for catalyst deactivation.	*CO3*	*PO3*	**08**
		b)	Apply material balance on a single cylindrical pore of solid catalyst particle and develop the following expression considering pore diffusion resistance combined with surface kinetics for a first-order reaction. $\frac{C_A}{C_{As}} = \frac{coshm(L-x)}{coshmL}$	*CO3*	*PO3*	**12**
			OR			
	8	a)	A first-order reaction occurs in a spherical catalyst pellet. The following solid-catalyzed reaction kinetics is given. Diameter of pellets = 6 mm Rate constant, $k''' = 0.02\ s^{-1}$ Effective diffusivity, $D_e = 8 \times 10^{-9}\ m^2/s$ i) Calculate the Thiele modulus and interpret its value. ii) Calculate the effectiveness factor and interpret its value.	*CO3*	*PO3*	**10**

		b)	Develop the performance equation for plug constant flow of fluid which represent the catalyst deactivation.	*CO3*	*PO3*	**10**
			UNIT - V			
	9	a)	Determine the amount of catalyst needed in a packed bed reactor with a very large recycle rate (assume MFR). The 35% conversion of A to R was observed for a feed rate of 2000 mol/hr of pure A at 3.2 atm and 117º C for the reaction. $$A \rightarrow 4R, -r'_A = 96C_A \frac{mol}{kg.cat.hr}$$	*CO4*	*PO3*	**10**
		b)	How do you determine the rates in the following reactors? i. Differential catalytic reactor ii. Integral reactor	*CO4*	*PO3*	**10**
			OR			
	10	a)	Discuss in detail the construction and working of slurry reactor with a neat sketch.	*CO4*	*PO3*	**10**
		b)	Develop the performance equations for plug flow and mixed flow reactors containing porous catalyst particles.	*CO4*	*PO3*	**10**

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