U.S.N.

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

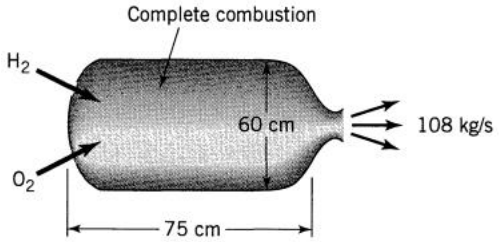
Autonomous Institute Affiliated to VTU

January / February 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)	Define reaction rate based on various units and list the factors affecting the rate of reaction.	*CO1*	*PO2*	**07**
	b)	Discuss the salient features of collision and transition state theories.	*CO1*	*PO2*	**06**
	c)	Milk is pasteurized if heated to 63 °C for 30 min, but it only needs 15 s to achieve the same result if heated to 74°C. Find the activation energy of this sterilization process.	*CO1*	*PO2*	**07**
		OR			
2	a)	Discuss molecularity and order of reaction with suitable examples.	*CO1*	*PO2*	**04**
	b)	Discuss how different variables affect the rate of reaction with suitable examples.	*CO1*	*PO2*	**06**
	c)	A rocket engine burns a stoichiometric fuel mixture (liquid hydrogen) and an 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 hydrogen and oxygen reaction rate.  	*CO1*	*PO2*	**10**
		UNIT - II			
3	a)	Define an elementary and non-elementary reaction and explain the kinetic models for non-elementary reactions.	*CO2*	*PO2*	**10**
	b)	Experiments show that the reaction between $H_2\ (g) and\ I_2(g)$ to produce $HI\ (g)$ proceeds with a rate	*CO2*	*PO2*	**10**

$$\frac{1}{2}\frac{d[HI]}{dt} = k\,[H_2][I_2]$$

Suggest a two-step mechanism that is consistent with this rate.

OR

4 a) The reaction between CO and NO_2 at low temperatures proceeds with the rate:

$$-r_{NO_2} = k[NO_2]^2$$

Suggest a mechanism to explain this rate. — *CO2* *PO2* **10**

b) Mention the different methods used to analyze the kinetic data. Explain any one method with help of graphical interpretation. — *CO2* *PO2* **10**

UNIT - III

5 a) Develop a design equation of a stirred tank reactor for a constant density system. — *CO3* *PO3* **10**

b) The following kinetic data are obtained in a constant volume batch reactor at 273 K using pure gaseous A, and the partial pressure of A is given in mm Hg. — *CO3* *PO3* **10**

Time, min	0	2	4	6	8	10	12	14	∞
Partial pressure	760	600	475	390	320	275	240	215	150

OR

6 a) From the following data, find a satisfactory rate equation for the gas phase decomposition A → R + S occurring isothermally in a mixed-flow reactor. — *CO3* *PO3* **14**

Run Number	1	2	3	4	5
τ, s	0.423	5.10	13.5	44	192
X_A	0.22	0.63	0.75	0.88	0.96

All the runs are conducted with $C_{Ao} = \frac{0.002mol}{l}$, i.e., with the same initial concentration.

b) The half-life for converting ammonium cyanate into urea at 303 K at initial concentrations of ammonium cyanate of 0.1 mol/l and 0.2 mol/l is 1152 min and 568 min, respectively. Determine the order of the reaction. — *CO3* *PO3* **06**

UNIT - IV

7 a) What are the guidelines for the best arrangement of a combination of reactors? — *CO4* *PO3* **08**

b) A gas mixture containing 50 mole % A and 50 mole % inerts at 10 atm enters a reactor system with a flow rate of 6 L/s at 144 ^oC. The laboratory measurements of the rate as a function of conversion at 144^{o}C and 10 atm are: — *CO4* *PO3* **12**

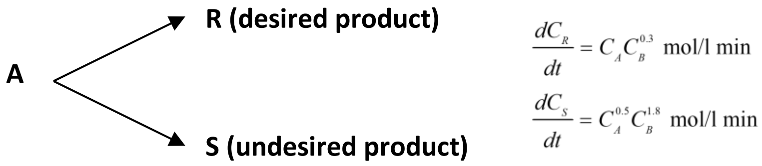
X_A	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.85
$-r_A$ $\times 10^{-2}$	0.53	0.52	0.5	0.45	0.4	0.33	0.25	0.18	0.125	0.1

If the reaction is carried out in two reactors in series, with 40% conversion in the first reactor and 85 % overall conversion.

Estimate the total volume of the two reactors when

i. Mixed flow reactor is used.

ii. Plug flows reactor is used.

			OR			
	8	a)	Explain the graphical method to find the conversion in a series of mixed-flow reactors of different sizes.	*CO4*	*PO3*	**8**
		b)	Liquid reactant A produces R and S by the following reactions in parallel. A→ R $r_R = 0.40\ C_A^2$ $k_1 = 0.4 m^3/(mol.min)$ A→ S $r_s = 0.40\ C_A$ $k_2 = 0.2\ (min)^{-1}$ A feed of aqueous A with $C_{Ao} = 40\ mol/m^3$ enters a reactor, reacts to produce R and S, and a mixture of A, R and S leaves the reactor. Find $C_S, C_R\ and\ \tau$ for 90 % conversion of A in a mixed flow reactor.	*CO4*	*PO3*	**12**
			UNIT - V			
	9	a)	What is optimum temperature progression? Discuss the optimum temperature progression for irreversible, reversible endothermic, reversible exothermic reactions.	*CO5*	*PO2*	**12**
		b)	For the competitive liquid-phase reaction: $\frac{dC_R}{dt} = C_A C_B^{0.3}$ mol/l min  Find the fraction of impurities in the product stream for 90% conversion of pure A and pure B, each having a concentration of 20 mol/L for (a) PFR and (b) MFR	*CO5*	*PO2*	**08**
			OR			
	10	a)	What are the instantaneous fractional yield, overall fractional yield, and selectivity in the case of parallel reaction schemes? Explain with equations.	*CO5*	*PO2*	**08**
		b)	Explicate the general graphical design procedure for a single homogeneous non-isothermal reaction.	*CO5*	*PO2*	**12**

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