BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: B. Tech **SEMESTER : IV**
BRANCH: CHEMICAL ENGINEERING **SESSION : SP/2023**

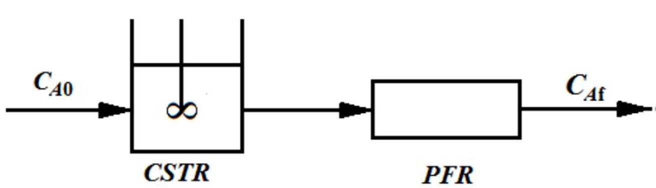
SUBJECT: CL223 CHEMICAL REACTION ENGINEERING I

TIME: 3 Hours **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
4. Before attempting the question paper, be sure that you have got the correct question paper.
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

		Marks	CO	BL
Q.1(a)	A high temperature, nitrogen pentoxide decomposes to oxygen and nitrogen dioxide: $2N_2O_5 \rightarrow O_2 + 4NO_2$ Experimental observations are found to be good agreement with the following mechanism. $N_2O_5 \underset{k_2}{\overset{k_1}{\rightleftharpoons}} NO_2 + NO_3$; $NO_3 + NO_2 \xrightarrow{k_3} NO + NO_2 + O_2$; $NO + NO_3 \xrightarrow{k_4} 2NO_2$ The reaction with rate constant k3 was found to be slowest step and hence, effectively determine the overall rate of the reaction. Derive a rate expression from the given mechanism.	[5]	CO1	L3
Q.1(b)	A second-order reaction was observed. The reaction rate constant at three degrees Celsius was found to be 8.9 x 10^(-3)L/mol and 7.1 x 10^(-2)L/mol at 35 degrees Celsius. What is the activation energy of this reaction?	[5]	CO1	L3
Q.2(a)	Draw and proper label all the points on X_A versus t; and $-r_A$ versus C_A plots for an autocatalytic reaction.	[2]	CO1	L1
Q.2(b)	Show the following relationship for an irreversible bimolecular type second-order reaction: A + B → products. $ln\left(\frac{C_B C_{Ao}}{C_{Bo} C_A}\right) = (C_{Bo} - C_{Ao})kt, \quad C_{BO} \neq C_{AO}$	[3]	CO3	L3
Q.2(c)	For the elementary reaction in series where the reaction is zero order followed by first order reaction $A \xrightarrow{k_1} R \xrightarrow{k_2} S$ and at $t = 0, C_A = C_{A0}, C_{R0} = C_{S0} = 0$ Find the maximum concentration of R and when it is reached.	[5]	CO2	L3
Q.3(a)	A high reactant concentration favors the reaction of higher order, and a lower reactant concentration favors the reaction of lower order- Explain.	[2]	CO1	L2
Q.3(b)	A *CSTR* and a *PFR* of equal volume are connected in series as shown below to carry out a first-order, isothermal, liquid phase reaction.	[3]	CO5	L3

$$A \rightarrow P$$



The rate constant is 0.2 s^-1. The space-time is 5 s for both the reactors. Find the overall fractional conversion of *A*.

		Marks	CO	BL
Q.3(c)	A first order gas phase reaction A → B + C takes place in a PFR. Pure A enters the reactor at 750°C and at 2 atm pressure with flow rate of 0.1 kg/s. If the molecular weight of A is 60 and the reaction constant is expressed as 109 exp(-20000/T) s-1, then calculate the reactor volume needed for 95% conversion of A. The operation is carried out isothermally.	[5]	CO5	L2

Q.4(a)	Draw the optimum temperature progression lines for minimum reactor size for irreversible, reversible endothermic, and reversible exothermic reactions. Write the factors which are considered while setting the maximum allowable temperature.	[2]	CO5	L1
Q.4(b)	Between 0˚C and 100˚C, determine the equilibrium conversion at 75˚C for the following elementary aqueous reaction:	[3]	CO5	L3

$$A \rightleftarrows R \begin{cases} \Delta G^{\circ}_{298} = -14\,130 \text{ J/mol} \\ \Delta H^{\circ}_{298} = -75\,300 \text{ J/mol} \end{cases} \qquad C_{pA} = C_{pR} = \text{constant}$$

Q.4(c)	Show the following relationship for an adiabatically operated MFR.	[5]	CO5	L3

$$(T - T_o) = \beta X_A, \quad where \quad \beta = \frac{C_{Ao}(-\Delta H_r)}{\rho c_p}$$

T_o and T are the inlet and outlet temperature of the streams, respectively. Other notations have their usual meaning.

Q.5(a)	Write down the limitations of Dispersion model.	[2]	CO4	L1
Q.5(b)	Discuss macro and microfluid behavior with example.	[3]	CO4	L1
Q.5(c)	Derive the Dispersion model with chemical reaction.	[5]	CO4	L4

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