Enrolment No./Seat No_______________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE- SEMESTER–VI (NEW) EXAMINATION – WINTER 2024

Subject Code:3160506 **Date:25-11-2024**

Subject Name:Chemical Reactions Engineering I

Time:02:30 PM TO 05:00 PM **Total Marks:70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

MARKS

Q.1 **(a)** Explain homogeneous and heterogeneous reactions with suitable example. **03**

(b) How can you identify dead zone and bypass non-idealities present in CSTR? Explain with suitable schematic diagrams. **04**

(c) Derive performance equation for PFR with recycle. **07**

Q.2 **(a)** Explain that non-elementary reactions are taking place in multiple steps. **03**

(b) Write short note on Activation Energy. **04**

(c) Pure gaseous A at about 5 atm and 50 °C (150 mmol/liter) is fed into a 2 liter mixed flow reactor at various flow rates. There it decomposes, and the exit concentration of A is measured for each flow rate. From the following data find a rate equation to represent the kinetics of the decomposition of A. Assume that reactant A alone affects the rate. **07**

Reaction is $A \rightarrow 3R$

v_0, lit/min	0.06	0.48	1.5	8.1
C_A, mmol/lit	30	60	80	105

OR

(c) An aqueous feed of A and B (500 liter/min, 200 mmol A/liter, 200 mmol B/liter) is to be converted to product in a mixed flow reactor. The kinetics of the reaction are represented by **07**

$A + B \longrightarrow R$, $-r_A = 120\, C_A C_B$ mol/(lit.min)

Find the volume of reactor needed for 99% conversion of A to product.

Q.3 **(a)** Derive rate of reaction for homogeneous catalytic reaction. **03**

(b) Derive rate expression for 2[nd] order reaction, $A + B \longrightarrow R + S$, where $C_{A0}=C_{B0}$ **04**

(c) Show that performance of multiple PFR in series is equal to performance of single PFR having total volume of single PFR and multiple PFR equal and volumetric flow rate remains same for both cases. **07**

OR

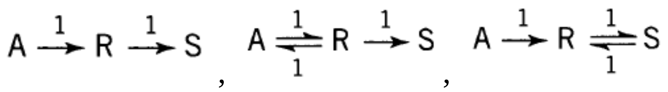
Q.3 **(a)** Given a gaseous feed, $C_{A0} = 100$, $C_{B0} = 200$, $A + B \longrightarrow R + S$, $X_A = 0.9$. Find X_B , C_A, C_B. **03**

(b) Write short note on Multiple CSTRs in series. **04**

	(c)	For multiple reactor, justify with suitable diagram that for all positive order reaction, PFR+small CSTR + large CSTR is best choice than any other combinations.	**07**
Q.4	**(a)**	Suggest selection of maximum operating temperature for, i) exothermic irreversible reaction, ii) exothermic reversible reaction iii) endothermic reversible reactions	**03**
	(b)	Draw schematic diagram for optimal temperature progression for adiabatic reactions in CSTR and explain its salient features.	**04**
	(c)	Derive a relation for overall fractional yield in PFR for following reaction in parallel $A \longrightarrow R$ and $A \longrightarrow S$.	**07**

OR

Q.4	**(a)**	Using separate feeds of A and B sketch the contacting pattern and reactor conditions which would best promote the formation of product R for the following systems of elementary reactions. $A + B \longrightarrow R$ and $A \longrightarrow S$ (Continuous flow reactor)	**03**
	(b)	Draw schematic diagram of concentration Vs time for following reactions,	**04**



	(c)	A liquid reactant stream (2 mol/liter) passes through two mixed flow reactors in a series. The concentration of A in the exit of the first reactor is 0.7 mol/liter. Find the concentration in the exit stream of the second reactor. The reaction is second-order with respect to A and $V_2/V_1 = 1.5$.	**07**
Q.5	**(a)**	Write short note on Uses of RTD studies.	**03**
	(b)	Draw an discuss C, E and F curve for ideal PFR for pulse input.	**04**
	(C)	A pipeline (10 cm I.D., 19.1 m long) simultaneously transports gas and liquid from here to there. The volumetric flow rate of gas and liquid are 60 000 cm^3/s and 300 cm^3/s, respectively. Pulse tracer tests on the fluids flowing through the pipe give results as shown in Fig A. below What fraction of the pipe is occupied by gas and what fraction by liquid?	**07**

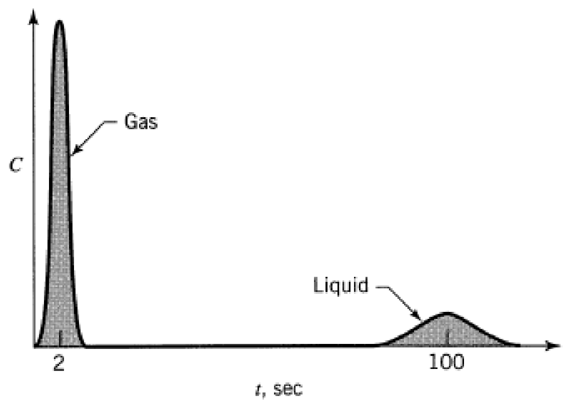


Figure P11.6

OR

Q.5	**(a)**	RTD of all the components for ideal PFR is same. Justify this statement.	**03**

(b) Draw C and E curve for ideal CSTR, PFR with bypass, PFR with dead zone reactions for pulse input. **04**

(c) **A** pulse input to a vessel gives the results shown in Fig. below **07**
(a) Check the material balance with the tracer curve to see whether the results are consistent.
(b) If the result is consistent, determine *t*, V and sketch the E curve.

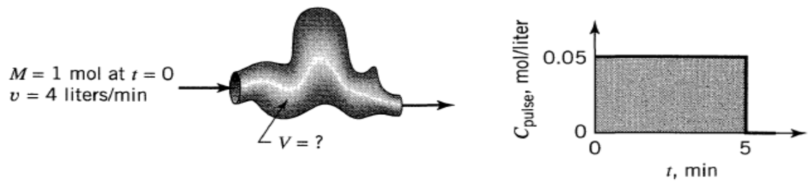


Table 5.1 Performance Equations for *n*th-order Kinetics and $\varepsilon_A = 0$

	Plug Flow or Batch	Mixed Flow
$n = 0$ $-r_A = k$	$\frac{k\tau}{C_{A0}} = \frac{C_{A0} - C_A}{C_{A0}} = X_A$ **(20)**	$\frac{k\tau}{C_{A0}} = \frac{C_{A0} - C_A}{C_{A0}} = X_A$
$n = 1$ $-r_A = kC_A$	$k\tau = \ln \frac{C_{A0}}{C_A} = \ln \frac{1}{1 - X_A}$ **(3.12)**	$k\tau = \frac{C_{A0} - C_A}{C_A} = \frac{X_A}{1 - X_A}$ **(14*a*)**
$n = 2$ $-r_A = kC_A^2$	$k\tau C_{A0} = \frac{C_{A0} - C_A}{C_A} = \frac{X_A}{1 - X_A}$ **(3.16)**	$k\tau = \frac{(C_{A0} - C_A)}{C_A^2} = \frac{X_A}{C_{A0}(1 - X_A)^2}$ **(15)**
any n $-r_A = kC_A^n$	$(n-1)C_{A0}^{n-1}k\tau = \left(\frac{C_A}{C_{A0}}\right)^{1-n} - 1 = (1 - X_A)^{1-n} - 1$ **(3.29)**	$k\tau = \frac{C_{A0} - C_A}{C_A^n} = \frac{X_A}{C_{A0}^{n-1}(1 - X_A)^n}$
$n = 1$ $A \underset{2}{\overset{1}{\rightleftharpoons}} R$ $C_{R0} = 0$	$k_1\tau = \left(1 - \frac{C_{Ae}}{C_{A0}}\right) \ln \left(\frac{C_{A0} - C_{Ae}}{C_A - C_{Ae}}\right) = X_{Ae} \ln \left(\frac{X_{Ae}}{X_{Ae} - X_A}\right)$	$k_1\tau = \frac{(C_{A0} - C_A)(C_{A0} - C_{Ae})}{C_{A0}(C_A - C_{Ae})} = \frac{X_A X_{Ae}}{X_{Ae} - X_A}$
General rate	$\tau = \int_{C_A}^{C_{A0}} \frac{dC_A}{-r_A} = C_{A0} \int_0^{X_{Ae}} \frac{dX_A}{-r_A}$ **(19)**	$\tau = \frac{C_{A0} - C_A}{-r_{Af}} = \frac{C_{A0} X_A}{-r_{Af}}$ **(13)**