मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
प्रयागराज-211004 (भारत)
Motilal Nehru National Institute of Technology Allahabad
Prayagraj - 211 004 (India)

Chemical Engineering Department
Mid Semester Examination 2023-24 (Even)

Programme Name : B. Tech.
Course Code : CHN14108
Branch : Chemical Engineering
Duration : 1.5 Hours

Semester : IV
Course Name : Chemical reaction Engineering-I
Student Reg. No. : 20222068
Max. Marks : 25

Instructions: (Related to Questions)
1. *Attempt all the questions.*

Marks Co outc

Q1 For an elementary reaction, $A + B \rightarrow R + S$, what are the order and the molecularity of the reaction? 2 C

Q2 What are chain reactions? Describe different steps involved in a chain reaction. 4 C

Q3 One liter per minute of liquid containing A and B (C_{A0} = 0.10 mol/liter, C_{B0} = 0.01 mol/liter) flow into a mixed flow reactor of volume 1 liter. The materials react in a complex manner for which the stoichiometry is unknown. The outlet stream from the reactor contains A, B, and C (C_{Af} = 0.02 mol/liter, C_{Bf}= 0.03 mol/liter, C_{Cf} = 0.04 mol/liter). Find the rate of reaction of A, B, and C for the conditions within the reactor. 3 C

Q4 The thermal decomposition of hydrogen iodide $2HI \rightarrow H_2 + I_2$ is reported as follows: 6

T, °C	508	427	393	356	283
k, $cm^3/mol. s$	0.1059	0.00310	0.000588	80.9×10^{-6}	0.942×10^{-6}

Find the complete rate equation for this reaction. Use units of joules, moles, cm^3 and seconds.

Q5 A gaseous feed of pure A (1mol/liter) enters a mixed flow reactor (2 liters) and reacts as follows: $2A \rightarrow R$, $-r_A = 0.05\ C_A^2\ \frac{mol}{liter.sec}$. Find what feed rate (liter/min) will give an outlet concentration, C_A = 0.5 mol/liter. 4

Q6 At present the elementary liquid-phase reaction $A + B \rightarrow R + S$, takes place in a plug flow reactor using equimolar quantities of A and B. Conversion is 96%, $C_{A0} = C_{B0}$ = 1 mol/liter. If a mixed flow reactor ten times as large as the plug flow reactor were hooked up in series with the existing unit, which unit should come first and by what fraction could production be increased for that setup? 6

******************All the Best***********************

Course Outcomes:

CO1: To provide general overview of homogeneous system and the capability to determine reactio mechanism and rate expression for a reacting system

CO2: To develop understanding and the capability to design the frequently used isothermal ideal reacto along with their various possible variants and combinations for single and multiple types of reaction

CO3: To develop understanding and the capability to design non-isothermal ideal reactors, and adiabati reactors for single and multiple types of reactions.

CO4: To develop understanding about the identification/quantification of non-ideal flow in real reactors the capability to design reactors with non-ideal flow.

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Chemical Engineering Department
End Semester Examination 2023-24 (Even)

Programme Name : B. Tech.
Course Code : CHN14108
Branch : Chemical Engineering
Duration : 2.5 Hours

Semester : IV
Course Name : Chemical reaction Engineering-I
Student Reg. No. : 20222068
Max. Marks : 40

Instructions: (Related to Questions)

1. *Attempt all the questions.*

<table>
<tr><th></th><th></th><th></th><th>Marks</th><th>Course outcome</th></tr>
<tr><td>Q1</td><td>a</td><td>Define the following terms: homogeneous reactions, elementary reactions, space time and space velocity.</td><td>4</td><td>CO1</td></tr>
<tr><td></td><td>b</td><td>Aqueous A reacts to form R ($A \rightarrow R$) and in a first minute in a batch reactor its concentration drops from $C_{AO} = 2.03$ mol/liter to $C_{AF} = 1.97$ mol/liter. Find the rate equation for the reaction if the kinetics are second order with respect to A.</td><td>3</td><td>CO2</td></tr>
<tr><td>Q2</td><td>a</td><td>For the stoichiometry $A + B \rightarrow P$, find the reaction orders with respect to A and B, and the reaction rate constant. The three data sets are as follows:
<table>
<tr><th>Data set</th><th>1</th><th>2</th><th>3</th></tr>
<tr><td>C_A</td><td>4</td><td>1</td><td>1</td></tr>
<tr><td>C_B</td><td>1</td><td>1</td><td>8</td></tr>
<tr><td>$-r_A$</td><td>2</td><td>1</td><td>4</td></tr>
</table>
</td><td>3</td><td>CO1</td></tr>
<tr><td></td><td>b</td><td>The pyrolysis of ethane proceeds with an activation energy of about 300 kJ/mol. How much faster is the decomposition at 650 °C than at 500 °C.</td><td>3</td><td>CO3</td></tr>
<tr><td>Q3</td><td></td><td>A liquid reactant stream (1mol/liter) passes through two mixed flow reactors in a series. The concentration of A in the exit of the first reactor is 0.5 mol/liter. Find the concentration in the exit stream of the second reactor. The reaction is second-order with respect to A and $V_2/V_1 = 2$.</td><td>3</td><td>CO2</td></tr>
<tr><td>Q4</td><td>a</td><td>Consider unimolecular type reactions, $A \xrightarrow{n1=1} R \xrightarrow{n2=1} S$, taking place in a mixed flow reactor. Develop an equation for the concentration-time curves of A and R.</td><td>5</td><td>CO2</td></tr>
<tr><td></td><td>b</td><td>Under appropriate conditions A decomposes as follows:
$$A \xrightarrow{k1=0.1/min} R \xrightarrow{k2=0.1/min} S,$$
R is to be produced from 1000 liter/hr of feed in which $C_{A0} = 1\frac{mol}{liter}, C_{R0} = C_{S0} = 0$. Find the size of mixed flow reactor that will maximize the concentration of R, and what is $C_{R,max}$ in the effluent stream from this reactor?</td><td>5</td><td>CO2</td></tr>
<tr><td>Q5</td><td></td><td>Define optimum temperature progression, and show it qualitatively for irreversible, reversible endothermic and reversible exothermic reactions.</td><td>4</td><td>CO</td></tr>
</table>

Q6 A sample of the tracer is injected as a pulse to a reactor and the effluent concentrations measured are as follows: CO4

t (min)	0	4	8	12	16	20	24	28
C (g/liter fluid)	0	2	3	3	2.5	1.5	0.5	0

The reactor is to be used to run the following reaction:

$$-r_A = kC_A, \qquad k = 0.383\ min^{-1}$$

Calculate the following:

a	Exit age distribution values with time.	2
b	Mean and variance of the E curve.	4
c	Mean conversion of A in a batch reactor assuming the Segregation Model.	4

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