University of Anbar

College of Engineering

Chemical and Petrochemical Engineering Department

Chemical Reacior Design

Third Year

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Lecture No. 15

1-

In an isothermal batch reactor 70% of a liquid reactant is converted in 13 min. What space-time and space-velocity are needed to effect this conversion in a plug flow reactor and in a mixed flow reactor?

2-

We plan to replace our present mixed flow reactor with one having double the volume. For the same aqueous feed (10 mol A/liter) and the same feed rate find the new conversion. The reaction kinetics are represented by

$$A \rightarrow R, \qquad -r_A = kC_A^{1.5}$$

and present conversion is 70%.

3-

An aqueous feed of A and B (400 liter/min, 100 mmol A/liter, 200 mmol B/liter) is to be converted to product in a plug flow reactor. The kinetics of the reaction is represented by

$$A + B \rightarrow R, \qquad -r_A = 200\, C_A C_B \frac{\text{mol}}{\text{liter} \cdot \text{min}}$$

Find the volume of reactor needed for 99.9% conversion of A to product.

4-

A plug flow reactor (2 m^3) processes an aqueous feed (100 liter/min) containing reactant A (C_{A0} = 100 mmol/liter). This reaction is reversible and represented by

$$A \rightleftharpoons R, \qquad -r_A = (0.04\ \text{min}^{-1})C_A - (0.01\ \text{min}^{-1})C_R$$

First find the equilibrium conversion and then find the actual conversion of A in the reactor.

5-

The off gas from a boiling water nuclear power reactor contains a whole variety of radioactive trash, one of the most troublesome being Xe-133 (half life = 5.2 days). This off gas flows continuously through a large holdup tank in which its mean residence time is 30 days, and where we can assume that the contents are well mixed. Find the fraction of activity removed in the tank.

6-

A specific enzyme acts as catalyst in the fermentation of reactant A. At a given enzyme concentration in the aqueous feed stream (25 liter/min) find the volume of plug flow reactor needed for 95% conversion of reactant A (C_{A0} = 2 mol/liter). The kinetics of the fermentation at this enzyme concentration is given by

$$A \xrightarrow{\text{enzyme}} R, \qquad -r_A = \frac{0.1\, C_A}{1 + 0.5\, C_A} \ \frac{\text{mol}}{\text{liter} \cdot \text{min}}$$

7-

A gaseous feed of pure A (2 mol/liter, 100 mol/min) decomposes to give a variety of products in a plug flow reactor. The kinetics of the conversion is represented by

$$A \rightarrow 2.5\,(\text{products}), \qquad -r_A = (10\ \text{min}^{-1})C_A$$

Find the expected conversion in a 22-liter reactor.

8-

A stream of pure gaseous reactant A (C_{A0} = 660 mmol/liter) enters a plug flow reactor at a flow rate of F_{A0} = 540 mmol/min and polymerizes there as follows

$$3A \rightarrow R, \qquad -r_A = 54\ \frac{\text{mmol}}{\text{liter} \cdot \text{min}}$$

How large a reactor is needed to lower the concentration of A in the exit stream to C_{Af} = 330 mmol/liter?

9-

A gaseous feed of pure A (1 mol/liter) enters a mixed flow reactor (2 liters) and reacts as follows:

$$2A \rightarrow R, \qquad -r_A = 0.05\, C_A^2 \; \frac{\text{mol}}{\text{liter} \cdot \text{sec}}$$

Find what feed rate (liter/min) will give an outlet concentration $C_A = 0.5$ mol/liter.

10-

Gaseous reactant A decomposes as follows:

$$A \rightarrow 3R, \qquad -r_A = (0.6\ \text{min}^{-1})C_A$$

Find the conversion of A in a 50% A–50% inert feed ($v_0 = 180$ liter/min, $C_{A0} = 300$ mmol/liter) to a 1 m^3 mixed flow reactor.

11-

An aqueous feed containing A (1 mol/liter) enters a 2-liter plug flow reactor and reacts away ($2A \rightarrow R$, $-r_A = 0.05\ C_A^2$ mol/liter · s). Find the outlet concentration of A for a feed rate of 0.5 liter/min.

12-

A mixed flow reactor is being used to determine the kinetics of a reaction whose stoichiometry is $A \rightarrow R$. For this purpose various flow rates of an aqueous solution of 100 mmol A/liter are fed to a 1-liter reactor, and for each run the outlet concentration of A is measured. Find a rate equation to represent the following data. Also assume that reactant alone affects the rate.

v, liter/min	1	6	24
C_A, mmol/liter	4	20	50

13-

We are planning to operate a batch reactor to convert A into R. This is a liquid reaction, the stoichiometry is $A \rightarrow R$, and the rate of reaction is given in Table . How long must we react each batch for the concentration to drop from $C_{A0} = 1.3$ mol/liter to $C_{Af} = 0.3$ mol/liter?

C_A, mol/liter	$-r_A$, mol/liter · min
0.1	0.1
0.2	0.3
0.3	0.5
0.4	0.6
0.5	0.5
0.6	0.25
0.7	0.10
0.8	0.06
1.0	0.05
1.3	0.045
2.0	0.042

14-

For the reaction of Problem 13, what size of plug flow reactor would be needed for 80% conversion of a feed stream of 1000 mol A/hr at C_{A0} = 1.5 mol/liter?

15-

(a) For the reaction of Problem 13, what size of mixed flow reactor is needed for 75% conversion of a feed stream of 1000 mol A/hr at C_{A0} = 1.2 mol/liter?

(b) Repeat part (a) with the modification that the feed rate is doubled, thus 2000 mol A/hr at C_{A0} = 1.2 mol/liter are to be treated.

(c) Repeat part (a) with the modification that C_{A0} = 2.4 mol/liter; however, 1000 mol A/hr are still to be treated down to C_{Af} = 0.3 mol/liter.

16-

A high molecular weight hydrocarbon gas A is fed continuously to a heated high temperature mixed flow reactor where it thermally cracks (homogeneous gas reaction) into lower molecular weight materials, collectively called R, by a stoichiometry approximated by $A \rightarrow 5R$. By changing the feed rate different extents of cracking are obtained as follows:

F_{A0}, millimol/hr	300	1000	3000	5000
$C_{A,out}$, millimol/liter	16	30	50	60

The internal void volume of the reactor is V = 0.1 liter, and at the temperature of the reactor the feed concentration is C_{A0} = 100 millimol/liter. Find a rate equation to represent the cracking reaction.

17-

The data in Table have been obtained on the decomposition of gaseous reactant A in a constant volume batch reactor at 100°C.

t, sec	p_A, atm	t, sec	p_A, atm
0	1.00	140	0.25
20	0.80	200	0.14
40	0.68	260	0.08
60	0.56	330	0.04
80	0.45	420	0.02
100	0.37		

stoichiometry of the reaction is $2A \rightarrow R + S$. What size plug flow reactor (in liters) operating at 100°C and 1 atm can treat 100 mol A/hr in a feed consisting of 20% inerts to obtain 95% converson of A?

18-

Repeat the previous problem for a mixed flow reactor.

19-

The aqueous decomposition of A produces R as follows:

$$A \rightleftharpoons R$$

The following results are obtained in a series of steady state runs, all having no R in the feed stream.

Space Time, τ, sec	C_{A0}, In Feed, mol/liter	C_{Af}, In Exit Stream, mol/liter
50	2.0	1.00
16	1.2	0.80
60	2.0	0.65
22	1.0	0.56
4.8	0.48	0.42
72	1.00	0.37
40	0.48	0.28
112	0.48	0.20

From this kinetic information, find the size of reactor needed to achieve 75% conversion of a feed stream of $v = 1$ liter/sec and $C_{A0} = 0.8$ mol/liter. In the reactor the fluid follows

(a) plug flow

(b) mixed flow