BT209

Bioreaction Engineering

16/02/2023

Problem 1

A specific enzyme acts as catalyst in the fermentation of reactant A. At a given enzyme concentration in the aqueous feed stream (25 litre/min) find the volume of plug flow reactor needed for 95% conversion of reactant A (CA0 = 2 mol / liter). The kinetics of the fermentation at this enzyme concentration is given by

$A \rightarrow R$

$$-r_A = \frac{0.1C_A}{1+0.5C_A}\frac{mol}{liter.min}$$

Solution:

$$\frac{V}{F_{A0}} = \frac{\tau}{C_{A0}} = \int_0^{X_{Af}} \frac{dX_A}{-r_A} = -\frac{1}{C_{A0}}\int_{C_{A0}}^{C_{Af}} \frac{dC_A}{-r_A}$$

$$k_1\frac{V}{v} = ln\frac{C_{A0}}{C_A} + k_2(C_{A0} - C_A)$$

$k_1 = 0.1$, $k_2 = 0.5$, $C_{A0} = 2$ mol/lt, $v = 25$ lt/min, $C_A = 0.1$ mol/lt

$V = 986$ lt ~ 1 m^3

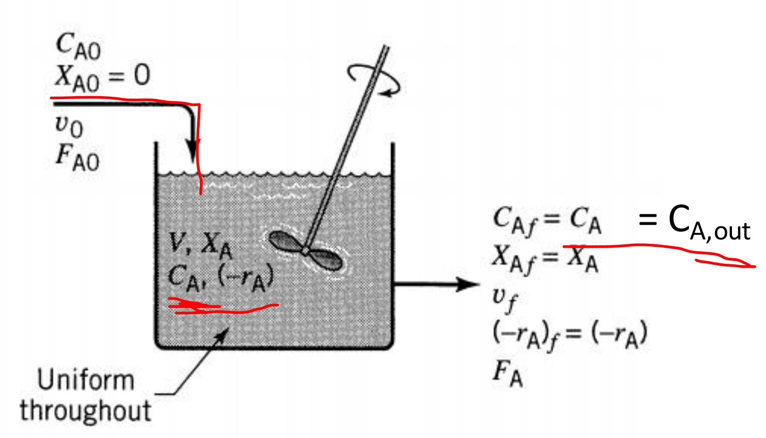
Problem 2

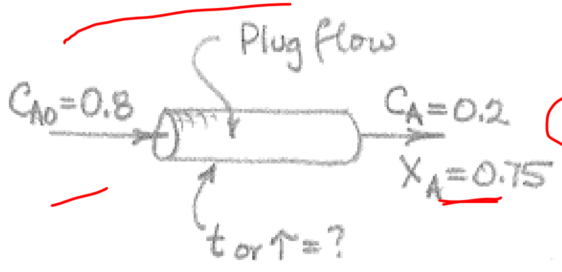
The aqueous decomposition of A is studied in an experimental mixed flow reactor. The results in Table are obtained in steady-state runs. To obtain 75% conversion of reactant in a feed, C_{A0} = 0.8 mol/liter, what holding time is needed in a plug flow reactor?

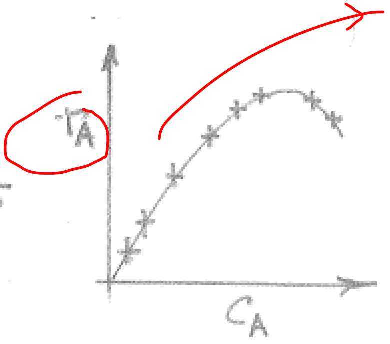
Concentration of A, mol/liter		Holding Time,
In Feed	In Exit Stream	sec
2.00	0.65	300
2.00	0.92	240
2.00	1.00	250
1.00	0.56	110
1.00	0.37	360
0.48	0.42	24
0.48	0.28	200
0.48	0.20	560

Solution: Problem 2

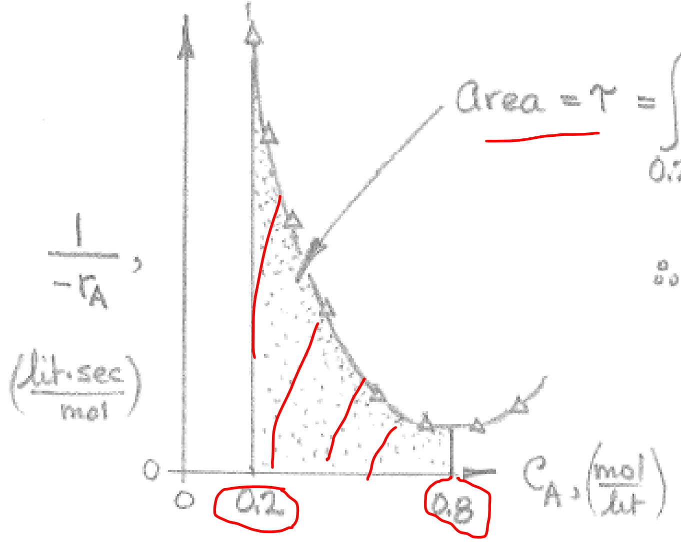
τ, sec	C_{A0}	$C_{A,out}$	$-\frac{1}{r_A} = \frac{\tau}{C_{A0} - C_{A,out}}$ … at $C_{A,out}$
300	2	0.65	300/(2-0.65) = 222
240	2	0.92	222
250	2	1.00	250
110	1	0.56	250
360	1	0.37	572
24	0.48	0.42	400
200	0.48	0.28	1000
560	0.48	0.20	2000







No simple rate expression will fit the data, so graphical method



Area $= \tau = \int_{0.2}^{0.8} \frac{dC_A}{-r_A} = 300$ sec

∴ for a plug flow reactor

$\tau = t = 300$ sec

$$\frac{V}{F_{A0}} = \frac{\tau}{C_{A0}} = \int_0^{X_{Af}} \frac{dX_A}{-r_A} = -\frac{1}{C_{A0}} \int_{C_{A0}}^{C_{Af}} \frac{dC_A}{-r_A}$$

$$\varepsilon_A = 0$$