Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

V SEMESTER B.TECH (BIOTECHNOLOGY)

END SEMESTER EXAMINATIONS, NOVEMBER 2019 (REGULAR)

SUBJECT: BIOREACTION ENGINEERING (BIO 3104)

REVISED CREDIT SYSTEM

Time: 3 Hours (25/11/2019) MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.

1A.	Write the various forms of rate expressions used in heterogeneous reaction system.	**2**
1B.	During a biochemical path way A_2B decomposes with stoichiometry $A_2B = AB + ½A_2$. Much effort has been expended to discover the kinetics of this reaction, but the results are discouraging, and no concise rate equation can be made to fit the data. The following observations can be made from the data, however. At the start of any experimental run the reaction seems to be of first order with respect to reactant. When the reactant is just about gone, the data are well correlated by an equation which is second order with respect to reactant. Introducing product A_2 into the feed slows down the rate of reaction; however, no proportionality can be found between the amount of A_2 added and the slowing effect. With the hope that a theoretical treatment may suggest a satisfactory form of rate expression, the following mechanisms are being considered. Mechanism I : $2A_2B \Leftrightarrow (A_4B_2)^*$ $(A_4B_2)^* \Leftrightarrow A_2 + 2AB$ Mechanism II : $A_2B \Leftrightarrow A^* + AB$ $A_2B + A^* \Leftrightarrow A_2 + AB$ Are either of these mechanisms consistent with the experimental findings? If a mechanism is rejected, state on what basis you reject it.	**4**
1C.	A biochemical product is produced using *Bacillus species* in a batch fermenter. It was found that reaction follows the first order elementary series reaction type: $A \rightarrow R \rightarrow S$, $k_1=k_2=2\ d^{-1}$ at t=0, $C_{A0}=10$ M and $C_{R0}=C_{S0}=0$. In the above series reaction it was found that R is the desired product and S is the undesired product. Two researchers, John & Reed have conducted the fermentation reaction for 1.5 d and 0.9 d respectively.	**4**

	a. Find the amount of desired product formed in both the cases. Comment on the downstream processing cost. b. If they want to minimize the undesired product (S) and maximize the desired product (R), suggest how they need to carry out the above series reaction	
2A.	What do you mean by shifting order reactions? How do find the kinetics in the following shifting order reactions i. Shift from low to high order as the concentration drops ii. Shift from high to low order as the concentration drops	**4**
2B.	The following biochemical reaction is carried out in a batch fermenter with Bacillus species to produce certain product P with stoichiometry $3A + 4B \rightarrow 2P$. Researcher has taken 6 M of A and 8 M of B at the start to carry out the above fermentation reaction. Researcher has suspected that above reaction obeys 2nd order reaction kinetics. Substantiate the following batch reactor data to 2nd order kinetics and find the rate equation.	**4**

Time, h	0	4	8	12	16	20	24
C_P, M	0	0.83	1.31	1.78	1.98	2.20	2.39

C_P= concentration product

2C	When do you prefer the Fed-batch reactor in bioprocess industry-explain?	**2**
3A.	Aqueous biochemical reaction is carried out in a plug flow reactor with v_0=2 liter/min, C_{A0}=100 mmol/liter, C_{R0}=10 mmol/liter. This reaction is reversible and represented by $A \Leftrightarrow R$,$-r_A$= (0.04 min^{-1}) C_A - (0.01 min^{-1}) C_R. Find the volume of PFR required to achieve 85 % of maximum possible conversion.	**4**
3B.	In the presence of a specific enzyme E, which acts as a homogeneous catalyst, a harmful organic substance A present in industrial wastewater degrades into harmless chemicals. At a given enzyme concentration C_E tests in a laboratory mixed flow reactor give the following results	**6**

C_{A0}, mmol/m^3	2	5	6	6	11	14	16	24
C_{Af}, mmol/m^3	0.5	3	1	2	6	10	8	4
τ, min	30	1	50	8	4	20	20	4

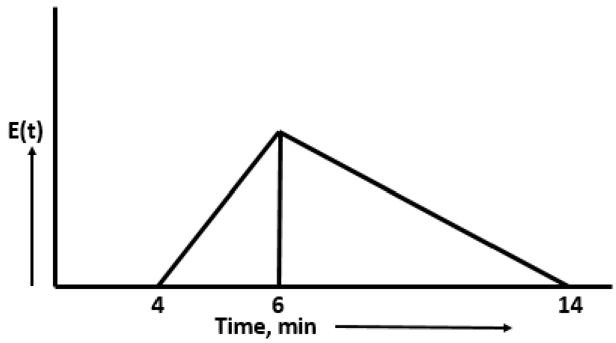
We wish to treat 0.1 m^3/min of this wastewater having C_{A0}=10 mmol/m^3 to 90 % conversion with this enzyme at concentration C_E.

(i) One possibility is to use a long tubular reactor (assume Plug flow) with possible recycle of exit fluid. What design do you recommend? Give the size of the reactor, tell if it should be used with recycle and if so determine the recycle flow rate in m^3/min. Sketch your recommended design.

(ii) Another possibility is to use two stirred tank reactors. What two tank design do you recommend?

(iii) Also do the cost estimation assuming 1m^3=12.5 lakhs including material cost, consultancy and installation charges in all the above cases

4A.	An Enzymatic reaction is taking place in a recycle reactor with Michealis-Menten kinetics: $-rs = \frac{Vmax.S}{(KM+S)}$, $S=S_0(1-X_{Af})$. Prove the condition for optimum recycle ratio as $ln\frac{[Ro(1-XAf)+1]}{[(Ro+1)(1-XAf)]} = \frac{XAf}{Ro(1-XAf)+1}$	**5**

<table>
<tr><td></td><td>Where Ro=optimum recycle ratio, X_{Af}=Final desired conversion from recycle reactor</td><td></td></tr>
<tr><td>4B.</td><td>Chemostat of 1500 liters capacity is used for the production of biomass using glucose as the substrate. The microbial system follows a Monod's growth kinetics with μ_m = 0.5 h^{-1}, K_S = 1.5 g/l and the yield factor $Y_{X/S}$ = 0.6 g biomass/g substrate consumed. The sterile feed containing 10 g/l substrate is pumped at flow rate corresponding to optimum dilution rate in to the chemostat. Determine
i. Optimum dilution rate
ii. Biomass and substrate concentration at optimum dilution rate
iii. Productivity of biomass
iv. Washout dilution rate</td><td>5</td></tr>
<tr><td>5A.</td><td>A liquid macrofluid reacts according to A → R with zero order kinetics $-r_A$ = k ; k =0.03 mol/liter.min, C_{A0} = 1 mol/liter; as it flows through a bioreactor. Find the conversion of A for flow patterns shown in the following figure

</td><td>4</td></tr>
<tr><td>5B.</td><td>The concentration readings in the following table represent a continuous response to a pulse input tracer signal into a non-ideal bioreactor. The liquid decomposing with rate $-r_A=kC_A$, k=0.307 min^{-1}. Find the fraction of reactant unconverted in the non-ideal reactor with macrofluid and compare this with the fraction unconverted in an ideal plug flow reactor with same mean residence time.
<table>
<tr><td>Time, min</td><td>0</td><td>5</td><td>10</td><td>15</td><td>20</td><td>25</td><td>30</td><td>35</td></tr>
<tr><td>C(t), g/L</td><td>0</td><td>3</td><td>5</td><td>5</td><td>4</td><td>2</td><td>1</td><td>0</td></tr>
</table></td><td>4</td></tr>
<tr><td>5C</td><td>Write any two differences between step and pulse input tracer signals that used in RTD experiment.</td><td>2</td></tr>
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