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MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

V SEMESTER B.TECH (BIOTECHNOLOGY)

END SEMESTER EXAMINATIONS, DEC/JAN 2020/21 (REGULAR)

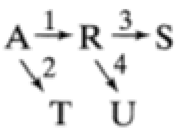
SUBJECT: BIOREACTION ENGINEERING (BIO 3153)

REVISED CREDIT SYSTEM

Time: 3 Hours (06/01/2021) MAX. MARKS: 50

Instructions to Candidates:

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

1A.	With the suitable examples explain the parameters affecting the rate of reaction in homogeneous and heterogeneous reaction system.	**3**
1B.	Biochemicals A, B and D combine to give the bioproducts R and S in submerged fermentation with stoichiometry A+B+D → R+S. After the reaction has proceeded to a significant extent the observed rate (experimental rate) is $r_R = k\, C_A.C_B.C_D/C_R.$ The following two mechanisms involving formation of active intermediate have been proposed to explain the observed kinetics. Kinetic Mechanism 1: $A+B \Leftrightarrow X^* + R$ $D+X^* \rightarrow S$ Kinetic Mechanism 2: $A + D \Leftrightarrow Y^* + R$ $B + Y^* \rightarrow S$ Are these mechanisms consistent with the kinetic data?	**3**
1C.	A biochemical desired product (R) is produced using *Bacillus species* in a batch fermenter. It was found that reaction obeys the following elementary reaction scheme:  $k_{12} = k_1 + k_2$ $k_{34} = k_3 + k_4$ C_{A0}=10 M, C_{R0}=0, C_{S0}=0,C_{T0}=0,C_{U0}=0,k1=1.5 d^{-1}, k2=0.2 d^{-1}, k3=1.9d^{-1}, k4=0.1 d^{-1} Find i. Maximum concentration of desired product ($C_{R\,max}$) ii. Time when it occurs (t_{max})	**4**

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

3

2B. The following biochemical reaction is carried out in a batch fermenter with Bacillus species to produce certain product P with stoichiometry 3A + 4B →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.

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

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2C Find the DRRG for 2nd order gaseous reaction that is taking place in PFR

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3A. Pure gaseous A at about 3 atm and 30ºC (120 mmol/liter) is fed into a 1-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. A → 3 R

υ_0, liter/min	0.06	0.48	1.5	8.1
C_A, mmol/liter	30	60	80	105

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3B. We wish to treat 10liters/min of liquid feed containing 1 mol A/liter to 99% conversion. The stoichiometry and kinetics of the reaction are given by

$$A \rightarrow R, \qquad -r_A = \frac{1C_A}{0.2 + C_A} \; \frac{mol}{liter.\min}$$

Suggest a good arrangement for doing this using two mixed flow reactors, and find the size of the two units needed. Sketch the final design chosen.

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4A. What do you mean by optimum recycle ratio? Derive the condition for optimum recycle ratio and represent it graphically.

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4B. 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

5

5A. A macro fluid reacts according to A → R as it flows through a non-ideal Bioreactor . Find the conversion of macro fluid A for the following flow pattern and kinetics.
Kinetics: C_{A0}=2 mol/liter, $-r_A=KC_A^2$, K=2 liter.mol^{-1} min^{-1}

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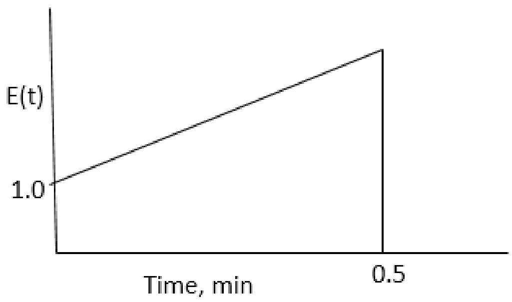
<tr><td></td><td>
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<tr><td>5B.</td><td>Find the RTD for the following cascade reactor system
i. PFR followed by MFR
ii. MFR followed by PFR</td><td>3</td></tr>
<tr><td>5C</td><td>RTD results for the non-ideal bioreactor are shown in the following table for pulse input. Find the conversion for macro fluid with kinetics (-rA)=k, k=0.5, CA0=10 M
<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>E (t)</td><td>0</td><td>0.03</td><td>0.05</td><td>0.05</td><td>0.04</td><td>0.02</td><td>0.01</td><td>0</td></tr>
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