Code No: RR312303 **Set No.1**

III B.Tech. I Semester Regular Examinations, November -2005
BIO-CHEMICAL ENGINEERING
(Bio-Technology)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. The following data is reported for the decomposition of N_2O_5 in the gas phase at 45^0C. The reaction takes place in a constant volume batch reaction.

Time (Min)	10	20	30	40	50	60	70	80	90	100
$P_{N_2o_5}$ (mm Hg)	247	185	140	105	78	58	44	33	24	18

Determine the order of the reaction and the reaction rate constant? [16]

2. Enumerate in detail various environmental conditions that effect the Growth kinetics? [16]

3. One liter/sec of a 20% ozone-80% air mixture at 1.5 atm and 93^0C passes through a plugflow reactor. Under these conditions ozone decomposes by homogenous reaction.
$2O_3 \rightarrow 3O_2$, $-r_{ozone} = KC^2_{ozone}$ $K = 0.05\frac{Liter}{Mol/s}$
What size reactor is needed for 50% decomposition of Ozone? [16]

4. For the reaction $A \xrightarrow{K_1=1,n_1=1} R \xrightarrow{K_2=1,n_2=1} S$ $find\, \frac{C_{R,\max}}{C_{AO}}$ and τ_{opt} at the outlet of the two equal sized mixed reactors in series. [16]

5. Explain Rate, Temperature and conversion profiles for exothermic and endothermic Reactions in Adiabatic flow Reactors? [16]

6. A closed vessel has flow for which $\frac{D}{UL}$=0.2 to represent the vessel by the tanks in series model. What value of 'N' should be selected ? [16]

7. Discuss the Techniques employed in Diagnosing the ills of operating equipment with regard to Non ideal flow ? [16]

8. The Reactor with a rate expression $\mu = \frac{\mu max S}{Ks+S}$ is carried out in a series of two stirred tanks of equal size. Calculate the dilution rate required to reduced the substrate concentration to 50 gm/lit with sterile feed given μ.max = $1hr^{-1}$ S_0=20 gm/lit K_s=2 gm/lit $Y_{x/s}$=0.6? [16]

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1. (a) For a first order reaction A→R, the rate constant is equal to 30 min^{-1}. Find the time needed for 95% conversion in a batch reactor if C_{AO} = 1 mol/lit ?
   (b) At 500^0K the rate of bimolecular reaction is 10 times the rate at 400^0K. Find the activation energy of this reaction from Arrhenius law ? [8+8]

2. Enumerate in detail various environmental conditions that effect the Growth kinetics? [16]

3. In an Isothermal Batch Reactor 70% of 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 mixed flow reactor. [16]

4. A reaction with following kinetics
   $r_A = KC_A$ where K = 0.0387 min^{-1} is to be carried out in each case of the following systems at an initial concentration of A as C_{AO} = 1.3 g mol/litre and it is desired to obtain a conversion of 95%. Find residence times required.
   (a) For equal Distribution of feed stream into two perfectly mixed flow reactors in parallel.
   (b) For the perfectly mixed equal sized reactors in series. [8+8]

5. The vapour phase decomposition of phosphine, which is irreversible and first order, follows the reaction
   $4P_{H_3(g)} \rightarrow P_4(g) + 6H_{2(g)}$
   Pure phosphine is fed to a tubular flow reactor, operating at 1 atm and adiabatically with a feed temperature of 953 K. The reaction is endothermic, Δ_{HR} = 23900 J/mol of phosphine at 25^0C. The molal heat capacities (J/mol K) are
   P_4(g) C_P = 25.1 + 0.0040 T
   $P_{H_3(g)}$ C_P = 28.0 + 0.027 T
   H_2(g) C_P = 30.1
   The Rate constant K, S^{-1} is the following function of temperature ln K = -27.94 + 2 ln T 43,672 What volume to molal feed ratio (V/F) would be required to obtain a conversion of 10% in one pass through the reactor ? What would be the conversion for the same V/F if the reactor operated isothermally at 953 K ? [16]

6. The first order reaction A → B is carried out in a 10 mm diameter tubular reactor 6.36 m in length. The specific reaction rate is 0.25 min^{-1}. Following are the results of a tracer test carried out in this reactor. Calculate the conversion using tanks-in-series model. [16]

t(sec)	0	1	2	3	4	5	6
c(mg/lit)	0	1	5	8	10	8	6
t(sec)	7	8	9	10	12	14	
c(mg/lit)	4	3	2.2	1.5	0.6	0	

7. Determine the residence time distribution for an isothermal tubular-flow reactor in which the liquid is in laminar flow in an annulus of inner radius r_1 and outer radius r_2. Take α=r_1/r_2. the velocity in the Axial direction at any radius r is given by $u(r) = A\left[1 - \left(\frac{r}{r_2}\right)^2 + \frac{1-\alpha^2}{1n\left(\frac{1}{\alpha}\right)} 1n\frac{r}{r_2}\right]$
   Express residence time distribution in terms of mean residence time θ . [16]

8. Explain in detail the stiochiometry involved in the cell growth? [16]

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Code No: RR312303 **Set No.3**

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Time: 3 hours **Max Marks: 80**

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1. (a) Define the following terms: order of a reaction, molecularity, elementary and non-elementary reactions.
   (b) Explain the term steady-state approximation ? [8+8]

2. (a) What are the advantages of continuous Bioreactors over Batch Bioreactors?
   (b) If continuous Bioreactors have so many advantages over batch bioreactors, why they are not widely used in industry? [8+8]

3. The flow through a plug flow reactor affecting a first order irreversible reaction is increased by 20% and in order to maintain the same fractional conversion it is decided to increase the reactor operating temperature. If the reaction has an activation energy of 4000 Cal/mole and the initial temperature is 150^0C. Find the New operating temperature of the reactor? [16]

4. A first order liquid phase reaction takes place in a mixed reactor with 92% conversion. The suggestion is to recycle a fraction of the product stream with no additional treatment. In what way it effects the conversion as long as the feed rate is not altered? [16]

5. The exhaust from an internal combustion engine contains some unburned fuel and carbon monoxide, combustion can be continued if an after burner is placed in the exhaust line. Suppose such an after burner operates as an adiabatic, stirred tank reactor with an average residence time of 9 seconds. Consider only the further oxidation of CO and Assume that in excess air, the oxidation is first order and irreversible with the following rate constant

   $K(^{s-1}) = 1.5\times10^{10}$ e $\frac{-272}{RT}$
   E = 272 KJ / mol.
   If the combustion gases enter at 1073 K. What are the steady state values of the temperature and CO conversion in the effluent. [16]

6. Water is drawn from a lake flows through a pump and passes down a long pipe in turbulent flow. A slug of tracer enters the intake line at the lake and is recorded at two locations in the pipe L meters apart. The mean residence time of fluid between recording points is 100 sec and the spread in the two recorded signals is
   $\sigma_1^2 = 800\ sec^2$; σ_2^2 900 sec^2
   What would be the spread of C curve for a section of this pipe, free from end effects and of length L/5 ? [16]

7. Explain the role of RTD, State of Aggresation, earliness of mixing in determining reactor behaviour? [16]

8. A strain of mold was grown in Batch culture on Glucose and the following data were obtained.

Time(h)	0	9	16	23	30	34	35	40
Cell concentration (g/1)	1.25	2.45	5.1	10.5	22	33	37.5	41
Glucose Concentration (g/1)	100	97	90.4	76.9	48.1	20.5	9.38	0.63

   (a) Calculate the Maximum Specific Growth Rate.

   (b) Calculate the Apparent Growth Yield

   (c) What maximum cell cencentration could one expect of 150g of Glucose were used with the same size inoculam? [4+6+6]

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Code No: RR312303 **Set No.4**

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Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
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1. A Bimolecular Reaction A+B → R+S, with the rate equation $r_A = KC_AC_B$ is carried out isothermally in a batch reactor.

   (a) Derive the following reaction

   $l_n \frac{M-X_A}{M\,(1-X_A)} = C_{AO}\,(M-1)\;Kt$

   Where $M = \frac{C_{AO}}{C_{BO}}$

   (b) Using the following data, find the time needed for 50% conversion of A. No R and S are present initially.
   K = 0.003 lig/gm mol-hr
   C_{AO} = 4 gm mol/lit; C_{BO} = 10 gm mol/lit.

   (c) Also determine the volume of Batch reactor required for producing 1000 Kg of R per day if half an hour time is needed for charging, discharging and cleaning each batch. Molecular weight of R is 88. [8+4+4]

2. The specific growth Rate for inhibited growth in a chemostat is given by the following equation
   $\mu_g = \frac{\mu MaxS}{Ks+S+IKs/KI}$
   Where S_0= 10 g/lit K_s= 1 g/lit I=0.05 g/lit
   $Y^M_{x/s} = 0.1\,\frac{gCells}{g\ subs}$ $X_0 = 0$ $K_1 = 0.01/lit$
   μ_{Max}=0.5 hr^{-1} K_d=0

   (a) Determine X and s as a function of 'D' when I=0

   (b) With inhibitor added to a chemostat, Determine the effluent substrate concentration and X as a function of D.

   (c) Determine Cell productivity DX, as a function of Dilution rate. [4+6+6]

3. Write short notes on:

   (a) Fed-batch reactors

   (b) Enzyme catalyzed reactions in CSTR [8+8]

4. Equimolar quantities of A, B and D are continuously fed to a mixed flow reactor. The elementary reactions that proceed in the reactor are as follows:
   $A + D \xrightarrow{K_1} P$; $B + D \xrightarrow{K_2} Q$

   Given $K_1/K_2 = 0.2$, calculate the fraction of 'P' forced when

(a) 50% of A is consumed and

(b) 50% of D is consumed [8+8]

5. Explain Rate, Temperature and conversion profiles for exothermic and endothermic Reactions in Adiabatic flow Reactors? [16]

6. Develop an expression for external age distribution of N number of equal sized back mixed reactor in series assuming tank in series model holds good. [16]

7. Explain about Tracer pulse experiment to calculate conversion with respect to tanks-in-series model? [16]

8. Derive the Equation $\frac{dci}{dt}$ =rfi + $\frac{f(t)}{V_R}$ (c if -c_i) representing the kinetics of a fed batch reactor system by applying mass Balance? [16]

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