Reg. No. :

J 3094

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2009.

Sixth Semester

Biotechnology

BT 1352 — CHEMICAL REACTION ENGINEERING

(Regulation 2004)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. An enzyme catalyses the reaction $4A \rightleftharpoons B + 6C$. A decomposes at rate of $10*10^{-5}$ gm mol/sec lit.

   (a) Find the rate of appearance of B and C

   (b) Find the rate of appearance of A.

2. At 500° K the rate of bimolecular reaction is 10 times the rate at 400° K. Find the activation energy.

3. What assumptions were made in the derivation of the design equation for the (a) CSTR (b) Batch ?

4. Find the first order rate constant for the disappearance of A in the gas reaction $A \longrightarrow 1.6R$ if the volume of the reaction mixture, starting with pure A increases by 50% in 4 min. The total pressure within the system stays constant at 1.2 atm and the temperature is 25°C.

5. What are the methods of injection to study the RTD characteristics?

6. Define Damkohler Number and depict its significance.

7. Show the Concentration–time curves for the following reaction:

(a) Unimolecular–type series reaction $(A \longrightarrow R \longrightarrow S)$

(b) Autocatalytic reaction $A + R \longrightarrow R + R$

8. What is Langmuir–Hinshelwood kinetics of surface reaction?

9. Explain: Unreacted Core model.

10. List the advantages and disadvantages of Trickle bed reactor.

PART B — (5 × 16 = 80 marks)

11. (a) *Aspergillus niger* is used to produce gluconic acid. Product synthesis is monitored in a fermenter; gluconic acid concentration is measured as a function of time for the first 39 h of culture.

Time (h):	0	16	24	28	32	39
Acid concentration (g/l):	3.6	22	51	66	97	167

Determine the rate constant.

Estimate the product concentration after 20 h.

Or

(b) The decomposition of a substance A, has been studied in a batch reactor. The substance A decomposes to form a product B which itself decomposes to form a product C. Both the decomposition reactions are of first order and irreversible. Determine the maximum concentration of B and the time at which it occurs.

12. (a) (i) The first order reversible liquid reaction $A \longrightarrow P$, $C_{AO} = 0.5$ mol/lit, $C_{PO} = 0$, takes place in a batch reactor. After 8 minutes, conversion of A is 35% while equilibrium conversion is 75%. Find the rate equation for this reaction.

(ii) 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 $A \longrightarrow R$, $-r_A = kc^{1.5}$ and the present conversion is 70%. (8 + 8)

Or

(b) Calculate the individual reactor volume as well as the total reactor volume for each scheme for the reaction data given in Table (1) when the intermediate conversion is 60% and $F_{A0} = 0.8$ mol/sec. Give your comments also.

Scheme A: PFR is followed by CSTR.

Scheme B: CSTR is followed by PFR.

Table 1:

X	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.85
1/-r	189	192	200	222	250	303	400	556	800	1000

13. (a) The first order reaction $A \longrightarrow B$ is carried out in a 12 cm dia tubular reactor 6.56 m in length. The specific reaction rate is 0.5 min^{-1}. Following are the results of a tracer test carried out on this reactor :

Time sec	0	1	2	3	4	5	6	7	8	9	10	12	14
Conc. mg/l	0	1	5	8	10	8	6	4	3	2.2	1.5	0.6	0

Calculate conversion using

(i) Closed vessel dispersion model

(ii) Tank in series model. (8 + 8)

Or

(b) (i) A small diameter pipe 32 m long runs from the fermentation room of a winery to the bottle filling cellar. Sometimes red wine is pumped through the pipe, sometimes white and whenever the switch is made from one to the other a small amount of house blend is produced (8 bottles). Because of some construction in the winery the pipeline length will have to be increased to 50 m. For the same flow rate of wine, how many bottles of rose may we now expect to get each time we switch the flow?

(ii) Explain the models for non-ideal reactors. (10 + 6)

14. (a) When the chemical reaction is rate-controlling step for particles of unchanging size, find the conversion of the solids by the untreated core model. The stoichiometric of the reaction is $A(g) + b\,B(s) \longrightarrow c\,C(g) + d\,D(g)$.

Or

(b) The following kinetic data on the reaction $A \longrightarrow R$ are obtained in an experimental packed bed reactor using various amounts of catalyst and a fixed feed rate $F_{AO} = 10$ kmol/hr.

W, kg cat	1	2	3	4	5	6	7
X_A	0.12	0.2	0.27	0.33	0.37	0.41	0.44

(i) Find the reaction rate at 40% conversion.

(ii) In a designing a large packed bed reactor with feed rate $F_{AO} = 400$ kmol/hr, how much catalyst would be needed for 40% conversion?

(8 + 8)

15. (a) The first order reaction $A \longrightarrow R$ was carried over two different size pellets. The results of two experimental runs made under identical conditions are as given below. Estimate the Thiele modulus and effectiveness factor for each pellet.

	Measure rate (mol/g cat sec)* 10^5	Pellet Radius (m)
Run 1	4	0.08
Run 2	17	0.007

Or

(b) (i) Explain the operation of a slurry reactor. Predict the rate equation for a first order reaction in a slurry reactor.

(ii) Explain the different models to predict the design equation of a fluidized bed reactor.

(8 + 8)