Register Number……

B.TECH. DEGREE EXAMINATIONS: APRIL / MAY 2010

Sixth Semester

BIOTECHNOLOGY

U07BT601: Chemical Reaction Engineering

Time: Three Hours **Maximum Marks: 100**

Answer ALL the Questions:-

PART A (10 x 1 = 10 Marks)

1. If 'n' is the order of the reaction, then unit of rate constant is

   (a) 1/ (time) (concentration) $^{n-1}$ (b) (time)$^{-1}$ (concentration) $^{n-1}$

   (c) (time) $^{n-1}$ (concentration) (d) (time) $^{n-1}$ (concentration) $^{n-1}$

2. Variables affecting the rate of homogeneous reactions are

   (a) pressure and temperature only (b) temperature and composition only

   (c) pressure and composition only (d) pressure temperature and composition

3. A batch reactor is characterized by

   (a) constant residence time

   (b) the variation in extent of reaction and properties of the reaction mixture with time

   (c) variation in reactor volume

   (d) very low conversion

4. A space time of 3 hours for a flow reactor means that

   (a) the time required to process one reactor volume of feed (measured at specified conditions) is 3 hours

   (b) three reactor volumes of feed can be processed every hour

   (c) it takes three hours to dump the entire volume of the reactor with feed

   (d) conversion is cent percent after three hours

5. For large value of Thiele modulus (L√ (K/D)) of solid catalyzed first-order reaction, the effectiveness factor (ε) is equal to

   (a) 1 (b) L√(K/D) (c) 1 + L√(K/D) (d) 1 / (L√K/D)

6. If a solid-gas non-catalytic reaction occurs at very high temperature, then rate controlling step is

   (a) film diffusion (b) chemical reaction

   (c) ash layer diffusion (d) pore diffusion

7. For high conversion in a highly exothermic solid catalysed reaction, use a

   (a) fixed bed reactor

   (b) fluidised bed reactor followed by a fixed bed reactor

   (c) fixed bed reactor followed by a fluidised bed reactor

   (d) fluidised bed reactor

8. The vessel dispersion number (D/μL) for plug flow is

(a) 0 (b) 500 (c) 750 (d) ∞

9. A photochemical reaction is ----------light.

(a) initiated by (b) accompanied with emission of

(c) catalysed by (d) used to convert heat energy into

10. Higher free energy of activation of a chemical reaction (at a given temperature) implies

(a) slower rate of reaction (b) higher rate of reaction

(c) higher equilibrium conversion (d) both (b) and (c)

PART B (10 x 2 = 20 Marks)

11. Differentiate between an elementary and a non-elementary reaction with suitable examples
12. Given the reaction $2NO_2 + ½ O_2 \longrightarrow N_2 O_5$. What is the relation between the rate of formation and disappearance of these three components?
13. What are the types of ideal reactors?
14. Distinguish between 'Holding Time' and 'Space Time' for flow reactors
15. What are the characteristics of tracer material?
16. What are the three rate controlling steps assumed in the shrinking core model for gas-solid reactions?
17. Define Dispersion number. State its limitation.
18. What are the methods of injection to study the RTD characteristics?
19. What are the advantages of slurry reactors over fixed beds?
20. What is a semi batch reactor? What are the advantages of this reactor?

PART C (5 x 14 = 70 Marks)

21. (a) Experimental analysis shows that the homogeneous decomposition of ozone proceeds with a rate

$$-r_{O3} = k [O_3]^2 [O_2]^{-1}$$

i.e. $$-r_{O3} = k C^2O_3 / C_{O2}$$

(i) Suggest a two step mechanism to explain this rate and what is the overall order of reaction? (7)

(ii) In case of first order reaction, show that time required for 75% conversion is double the time required for 50% conversion? (7)

(OR)

(b) Explain the Integral and differential method of analysis for finding the rate of reaction.

22. (a) To operate a mixed reactor to convert A into R. This is a liquid reaction, with the stoichiometry A $\longrightarrow$ R. The rate of reaction is given in table below. What size of mixed flow reactor is needed for 75% conversion of a feed stream of 1000 mol A/h at C_{A0} = 1.2 mol/l? (b) Repeat part (a) with the modification that the feed rate is doubled, hence 2000 mol A/h at C_{A0} = 1.2 mol/l are treated.

C_A, mol/l	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.3	2.0
$-r_A$, mol/(l.min)	0.1	0.3	0.5	0.6	0.5	0.25	0.1	0.06	0.05	0.045	0.042

(c) Repeat part (a) with the modification that C_{A0} = 2.4 mol/l; however, 1000 mol A/h are still to be treated down to C_{Af} = 0.30 mol/l.

(OR)

(b) A gas mixture consisting of 50 mol % A and 50 mole % inerts enters the reactor with the flow rate of 6 *l/s* at 144ºC.

The rate data is as follows:

X_A	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.85
$-r_A$	0.0053	0.0052	0.005	0.0045	0.004	0.0033	0.0025	0.0018	0.00125	0.001

If the reaction is carried out in two reactors in series with 40% conversion in the first reactor and 85% overall conversion, estimate the total volume of reactors when
(i) reactors are both mixed flow and (ii) reactors are both plug flow.

23. (a) (i) Explain Tank in series model for non-ideal reactors (7)

(ii) Explain C curve, E curve and F curve. Derive the relation between them. (7)

(OR)

(b) A sample of tracer hytane was injected as pulse into a vessel to be used as reactor and the effluent concentration is measured as a function of time. The data collected is given below:

t, min	0	1	2	3	4	5	6	7	8	9	10	12	14
C (g/m^3)	0	1	5	8	10	8	6	4	3	2.2	1.5	0.6	0

Construct C and E curves and determine the fraction of material leaving the reactor that has spent between 3 and 6 min in the vessel and the fraction of material leaving that has spent between 7.75 and 8.25 min in the vessel.

24. (a) Two small samples of solids are kept in a constant environment oven for period of 1h. Under the conditions prevailing in a oven the 4 mm particles are 57.8 % converted, the 2 mm particles are 87.5 % converted:

(i) Find the rate controlling mechanism for the conversion of solids.

(ii) Find the time required for complete conversion of 1 mm particle in this oven.

(OR)

(b) For a particle which reacts under 'ash diffusion' control, what is the ratio of time required for the radius of unreacted solid to be reduced to R/2 to that required for complete reaction? 'R' is the radius of the solid particle. Assume shrinking core model. Derive the equation used.

25. (a) The first-order reaction

$$A \longrightarrow B$$

was carried out over two different-sized pellets. The pellets were contained in a spinning basket reactor that was operated at sufficiently high rotation speeds that external mass transfer resistance was negligible. The results of two experimental runs made under identical conditions are as given in table. Estimate the Thiele modulus and effectiveness factor for each pellet. How small should the pellets be made to virtually eliminate all internal diffusion resistance?

	Measured Rate (mol/g cat.$\cdot$ s) X 10^5	Pellet Radius (m)
Run 1	3.0	0.01
Run 2	15.0	0.001

(OR)

(b) (i) Explain the operation of a slurry reactor. Predict the rate equation for a first order reaction in a slurry reactor. (7)

(ii) Explain the different models to predict the design equation of fluidized bed reactor. (7)

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