INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Date 25.11.2010 Time : **3 Hrs** Full Marks : **50**
Autumn, 2010 III-yr.B.Tech.(Hons)
Subject No : CH31009 Subject Name : Reaction Engineering
No. of Students :**65** Department : **Chemical Engineering**
Instructions : Attempt all questions. Assume the missing parameters.

Part-A

1. (a) What do you mean by effective diffusivity ?

   (b) The dehydrogenation of propene is done at atmospheric pressure using a chromia-alumina catalyst at 530^0C. The catalyst is spherical in shape having diameter 0.45cm. The experimental data suggest a 1st order rate constant=0.94 $cm^3/s.gm$ of cat. The pore radius is given as 110 A^0. Assuming Knudsen diffusivity and estimating the pore volume as 0.35 cm^3/g, predict an effectiveness factor for the catalyst. Use parallel pore model with a tortuosity factor 3.0.

   [2+8=10]

2. What are the limitations of shrinking core model? Show with figure how the reaction is progressing for a non-catalytic solid-gas reaction with time for different controlling steps. [3+5]

3. Which methods are used to determine the pore volume of a solid catalyst? What do you mean by a 'Bidisperse pore system' for a solid catalyst? [2+2=4]

4. Show how the initial rate varies with the reactant concentration for a gas phase solid nonporous catalytic reaction, A → B, where the effect of adsorption and desorption steps are neglected and dual site mechanism is assumed. [4]

Part-B

5. (a) You want to produce R as desired product from the following liquid phase parallel reactions

$$A + B \rightarrow R, \quad \frac{dC_R}{dt} = 2C_A C_B^{0.2}$$

$$A + B \rightarrow S, \quad \frac{dC_S}{dt} = 2C_A^{0.2} C_B^{1.95}$$

Sketch the best contacting patters for both continuous and non continuous operations. [5]

(b) For the parallel decomposition of A , where R is desired,

$$A \begin{cases} \rightarrow R, & r_R = 1 \\ \rightarrow S, & r_S = 2C_A \\ \rightarrow T, & r_T = C_A^2 \end{cases}$$

with $C_{A0} = 1$

What is the maximum C_R we may expect in isothermal operations

(a) in a mixed reactor (b) in a plug flow reactor [3+3]

6. A first-order reaction is to be treated in a series of two mixed reactors. Show that the total volume of the two reactors is minimum when the reactors are equal in size. [6]

7. The RTD analysis for a reactor is performed using a pulse-input of a tracer. The following output signal is obtained.

time, sec	10	20	30	40	50	60	70	80
tracer concentration	0	3	5	5	4	2	1	0

(a) Show the E or J'(θ) -curve.

(b) What conversion can we expect in the reaction if conversion in a mixed flow reactor employing the same space time is 82.18%?

(c) If the vessel is well represented by a dispersion model, what is the conversion?

(d) Show that for mixed reactor, $J'(\theta) = \frac{1}{\theta} e^{-\theta/\theta}$ and compare the actual RTD plot with mixed reactor J'(θ) with the same θ using a graph sheet. [2+2+2+2]