INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Date ....FN/AN, **Time :** 3 Hrs **Full Marks :** 50, **Deptt.** Chemical Engineering

No. of Students : 89 , Mid Autumn Semester Examination

Subject No : CH31009 **Subject Name :** Reaction Engineering

3rdYr. B. Tech.(Hons)

Instructions : Attempt all questions. Assume the missing parameters.

PART-A

1. At present the elementary liquid-phase reaction A + B → R + S takes place in a plug-flow reactor feeding A and B in equimolar quantities with $C_{Ao} = C_{Bo} = 1$ mol/liter. The conversion is 96%

If a mixed-rector ten times as large as the plug-flow reactor were hooked up in series with the existing unit, which unit should come first and by what fraction could production be increased for that setup?

[8]

2. (a) The homogeneous gas reaction A→ 2B is run at 100°C at a constant pressure of 1 atm in an experimental batch reactor. The following data were obtained starting with pure A.

Time,min	0	1	3	5	7	9	11	13	14
V/V_0	1	1.2	1.48	1.66	1.78	1.86	1.91	1.94	1.95

What size plug flow reactor operated at 100°C and 10 atm would yield 90% conversion of A for a total feed rate of 10 mol/sec, the feed containing 40% inerts ? [7]

(b) For the parallel reactions

$$A \xrightarrow{k_1=0.1/min} R \text{ (desired product)}, \quad r_R = C_A^{1.2}$$
$$A \xrightarrow{k_2=0.2/min} S \text{ (unwanted)}, \quad r_S = C_A^{0.5}$$

Select a suitable type of reactor and operating conditions for the better conversion of desired product. [2]

3. 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 $J'(\theta)$ -curve.

(b) Determine the conversion for a first order reaction with k_1=0.114 sec^{-1} employing $J'(\theta)$ –curve.

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

(d) Show that for mixed reactor, $J'(\theta) = \frac{1}{\bar{\theta}} e^{-\theta/\bar{\theta}}$ [8]

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PART-B

4. (a) At steady sate, where the rates of adsorption, reaction and desorption are all equal for a solid catalytic reaction, define the concept of "Rate-limiting Step".

(b) For a reaction, what do you mean by pure feed data and product inhibited data?

(c) The dehydrogenartion of n-butyl alcohol over an alumina catalyst was investigated and the data obtained are as follows:

Initial rate (lbmol/h. lb of cat)	0.26	0.51	0.78	0.776	0.55
P_{A0} (atm)	10	30	55	115	220

The feed is pure Butyl alcohol.
Suggest a mechanism and rate-controlling step that is consistent with the experimental data.

[2+2+5=9]

5. (a) Write the physical significance of Thiele Modulus.

(b) A solid porous catalyst is employed for the dehydrogenation of n-butyl alcohol reaction at a temperature 300C. Porosity and tortuosity of the catalyst pellet are 0.5 and 2.5 and the average pore radius calculated as 50 Å. The bulk diffusivity is found to be 0.75×10^{-4} m^2/sec. Find out the effective diffusivity for the system.

[2+6=8]

6. (a) How pelleting pressure affects the pore volume and pore radius of a solid catalyst?

b) How do you get average pore radius of a solid catalyst using parallel pore model.

(c) A batch of solids of uniform size is treated by gas in a uniform environment. Solid is converted to give a non flaking product according to the shrinking core model. Conversion is about 7/8 for a reaction time of 1 hr; conversion is complete in two hours. What mechanism is rate controlling?

(d) Distinguish between Shrinking core model and unreacted core model.

[2+2+3+1=8]