INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

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

No. of Students :82 End Autumn Semester Examination

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

3rd Yr. B. Tech.(H)/M.Tech.Dual

Instructions : Attempt all questions. Assume the missing parameters.

PART-A

Q1. Answer the following questions.

(a) Describe the use of different feeding arrangements for the following multiple reactions and their respective product distributions.

$A + B \rightarrow R$ (desired product), $r_R = k_1 C_A C_B$

$R + B \rightarrow S$ (unwanted product), $r_S = k_1 C_R C_B$

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

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

with $C_{A0} = 1$

What is the maximum C_R we may expect in isothermal operations

(i) in a mixed reactor (ii) in a plug flow reactor [3+5]

Q2. (a) Using a color indicator which shows when the concentration of A falls below 0.1 mol/liter, the following scheme is devised to explore the kinetics of the decomposition of A. A feed of 0.6 mol A/liter is introduced into the first reactor of the two mixed reactors in series, each having a volume of 400 cm^3. The color change occurs in the first reactor for a steady sate feed rate of 10 cm^3/min and in the second reactor for a steady-state feed rate of 50 cm^3/min. Find the rate equation for the decomposition of A from this information. [4]

(b) Define $J(\theta)$ and $J'(\theta)$ plots. Describe the method for finding average residence time using both the $J(\theta)$ and $J'(\theta)$ plots.

[3]

Q3. (a) Write the mole balance equation for recycle reactor. How do you find the optimum recycle ratio?

(b)For an elementary second-order reaction $A \rightarrow R$, $-r_A = k_A C_A^2$, 66.7 % conversion is achieved in an isothermal plug flow reactor operating with a recycle ratio of unity. What will be the conversion if the recycle stream is shut off? [2+3+5]

PART-B

Q4. (a) What do you mean by effectiveness factor for a solid catalytic reaction?

(b)How do you compare this factor for the different shape of the catalyst pellet for an isothermal first order reaction?

(c) If the reaction is not isothermal, how does the value of the factor change for exothermic and endothermic reactions and why?

(d)Write the physical significance of Thiele modulus.

[1+2+(1+3)+2=9]

Q5. (a) What do you mean by bidispersed catalyst? How the pelleting pressure determines the pore volume distribution of this type of catalyst?
(b)Low temperature (−195.8^{0}C) nitrogen-adsorption data were obtained for a solid catalyst of 50.4g as,

Pressure, mm Hg	8	30	50	102	130	148	233	258	330	442	480
Volume adsorbed, cm^3(at 0^{0}C and 1atm)	103	116	130	148	159	163	188	198	221	270	294

Determine the surface area/gm.

(c) Alumina particles prepared in laboratory are made into pellet which is having the following properties, mass= 3.15 g, diameter =1.00 in., volume= 3.22 cm^3. The pellet is bidispersed. The macropore volume of the pellet is 0.645 cm^3 and micropore volume is 0.40 cm^3/g. Calculate the micropore and macropore void fractions of the catalyst.

[2+2+3+3=10]

Q6. (a)Write how is a solid-fluid noncatalytic reaction assumed to happen according to progressive conversion model and unreacted core model?

(b)Calculate the time needed to burn to completion of the particles (R_0=5 mm, ρ_B = 2.2 gm/cm^3, k_s= 20 cm/sec) of graphite in an 8% oxygen stream. For the high gas velocity used assume that film diffusion does not offer any resistance to transfer and reaction. Reaction temperature is 900^{0}C. [3+3=6]

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