Code No: 07A60803 **R07** **Set No. 2**

III B.Tech II Semester Examinations,December 2010
CHEMICAL REACTION ENGINEERING - II
Chemical Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. What are the general complications encountered in a heterogeneous reaction rate equation compared to that of a homogeneous one. Distinguish with an appropriate example. [16]

2. (a) Write about dispersion model and mention its applications and limitations
   (b) Water is drawn from a lake, flows through a pump and passes down a long pipe in turbulent flow. A slug of tracer (not an ideal pulse input) enters the intake line at the lake and is recorded downstream at two locations in the pipe L meters apart. The mean residence time of fluid between recording points is 100sec and variance of the two recorded signals is
   $\sigma_1^2 = 800\ \text{sec}^2 \qquad \sigma_2^2 = 900\ \text{sec}^2$

   What would be the spread of an ideal pulse response for a section of this pipe, free from end effects and of length L/5? [8+8]

3. (a) From a pulse input into a vessel we obtain the following output signal

Time, min	1	3	5	7	9	11	13	15
Concentration (arbitrary)	0	0	10	10	10	10	0	0

   We want to represent the flow through the vessel with the tanks-in-series model. Determine the number of tanks to use.
   (b) Explain briefly the tanks-in-series model. [8+8]

4. What are the models postulated for the adsorption of carbon monoxide on metal. Develop an equation for the rate of adsorption of CO and explain about the parameters that influence the adsorption phenomenon. [16]

5. Explain how would you design an isothermal packed bed reactor using integral kinetic data. Write the performance equation and briefly describe the various terms in it. [16]

6. (a) Explain RTD and give an account of the experimental methods of determining RTD.
   (b) Dispersed noncoalescing droplets (C_{A0} = 2 mol/liter) react ($A \rightarrow R$, $-r_A = kC_A^2$, k = 0.5 liter/mol.min) as they pass through a contactor. Find the average concentration of A remaining in the droplets leaving the contactor if their RTD is given by the curve in the figure 6. (E = 0.5) [8+8]

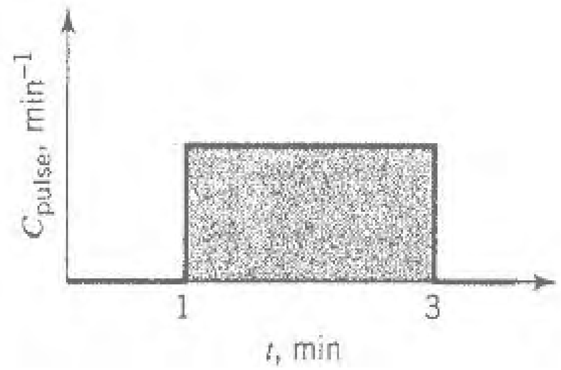

Figure 6

7. In measurement for a reaction of A (g) + bB(s) → E(g) + F(s) which obeys the shrinking core model, the time required for equal conversion is found to be directly proportional to particle diameter at low conversion but becomes proportional to the square of the particle size as the conversion becomes larger. what can be said about the mechanism that controls the rate. Neglect the diffusion resistance in the gas film. [16]

8. (a) Find the expression for conversion of a macrofluid in two equal-size mixed reactors for a zero-order reaction. If conversion is 99% for the microfluid, what is it for a macrofluid having the same reaction rate?

   (b) Discuss about mixing of two miscible fluids. [10+6]

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Code No: 07A60803 **R07** **Set No. 4**

III B.Tech II Semester Examinations,December 2010
CHEMICAL REACTION ENGINEERING - II
Chemical Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. A reactor with a number of dividing baffles is to be used to run the reaction $A \rightarrow R$ with $-r_A = 0.05C_A$ mol/liter.min . A pulse tracer test gives the following curve.

Time, min	0	10	20	30	40	50	60	70
Concentration Reading	35	38	40	40	39	37	36	35

   (a) Calculate the variance of the curve
   (b) How many tanks in series is this vessel equivalent to?
   (c) Calculate X_A assuming the tanks-in-series model. [8+2+6]

2. Write short notes on:
   (a) Catalyst preparation
   (b) Catalyst supports, promoters and inhibitors. [8+8]

3. Calculate the effectiveness factor of a single catalyst pore and of a catalyst slab for Zeroth - order kinetics. [16]

4. Derive the equation for the conversion of a first-order reaction using a macrofluid when the RTD is equivalent to
   (a) an ideal PFR
   (b) an ideal CSTR
   (c) Compare these conversions with those obtained from ideal reactors using micro fluid. [6+6+4]

5. (a) Give a brief account of diagnosing reactor ills in a reactor expected to be a mixed flow reactor.
   (b) A specially designed vessel is to be used as a reactor for a first-order liquid reaction. Since flow in this vessel is suspected to be nonideal, tracer tests are conducted and the following concentration readings represent the response at the vessel outlet to a delta-function tracer input to the vessel input. What conversion can we expect in this reactor if conversion in a mixed flow reactor employing same space time is 82.18%. [6+10]

Time t, sec	10	20	30	40	50	60	70	80
Tracer concentration (arbitrary reading)	0	3	5	5	4	2	1	0

6. The catalytic reaction A→4R is run at 3.2 atm and 117 ^{0}C in a plug flow reactor which contains 0.01 of catalyst and uses a feed consisting of the partially converted product of 20 lit/ hr of pure unreacted A. The results are as follows:

Run	1	2	3	4
C_A in ,mol/lit	0.1	0.08	0.06	0.04
C_A out mol/lit	0.084	0.07	0.055	0.038

Find a rate equation to represent this reaction. [16]

7. ZnS spherical particles of 1.5 mm in size are roasted in an air containing 21% O_2 at 900^{0}C and 1 atm. The reaction is
$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$
Density of particle = 415 kg/m^3 = 43 kmol/ m^3
Reaction rate constant , K = 2.4 cm/s
Effective diffusion coefficient for gas in Zinc Oxide layer ,D_e = 1.1×10^{-6}m^2/s.
Film resistance can be neglected as long as growing ash layer is present. Calculate the time needed for complete reaction of ZnS particle. [16]

8. A reactor has flow characteristics given by the non-normalised C curve in the given table and by the shape of this curve we feel that the dispersion or tanks-in-series models should satisfactorily represent flow in the reactor.

Time	Tracer concentration	Time	Tracer concentration
0	0	10	67
1	9	15	47
2	57	20	32
3	81	30	15
4	90	41	7
5	90	52	3
6	86	67	1
8	77	70	0

Find the conversion expected in this reactor assuming that the dispersion model holds.

Data: The elementary liquid-phase reaction taking place is A + B→ products, with a large enough excess of B so that the reaction is essentially first order. In addition, if plug flow existed, conversion would be 99% in the reactor. [16]

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Code No: 07A60803 **R07** **Set No. 1**

III B.Tech II Semester Examinations,December 2010
CHEMICAL REACTION ENGINEERING - II
Chemical Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks
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1. (a) Explain the difference in behavior of microfluids and macrofluids in a mixed flow reactor.
   (b) For a single fluid, discuss the role of segregation and earliness of mixing with respect to
      i. effect of kinetics, or reaction order
      ii. effect of mixing factors for non-first order reactions,
      iii. effect of conversion level and
      iv. effect on product distribution. [8+8]

2. A reactor with a number of dividing baffles is to be used to run the reaction $A \rightarrow R$ with $-r_A = 0.05\ C_A$ mol/liter. min.

Time, min	0	10	20	30	40	50	60	70
Concentration reading	35	38	40	40	39	37	36	35

   (a) Calculate X_A assuming plug flow.
   (b) Calculate X_A assuming mixed flow.
   (c) Calculate X_A assuming the tanks-in-series model. [5+5+6]

3. What is the basis for classification of catalyst? Explain about the type of catalysts used in hydrogenation and dehydrogenation reactions of commercial importance. [16]

4. Show that $t/\tau = X_B$, when major resistance to reaction is in gas film for a non catalystic Fluid-particle reaction. [16]

5. Hydrogen sulfide is removed from coal gas by contact with a moving bed of iron oxide particles which convert to the sulfide as follows:
   $Fe_2O_3 \rightarrow FeS$
   In our reactor the fraction of oxide converted in any particle is determined by its residence time t and the time needed for complete conversion of the particle τ and this is given by
   $1 - X = \left(1 - \frac{t}{\tau}\right)^3$ when $t < 1$ hr and with $\tau = 1$ hr and $X = 1$ when $t \geq 1$ hr.
   Find the conversion of iron oxide to sulfide if the RTD of solids in the contactor is approximated by the curve shown in the figure 5. [16]

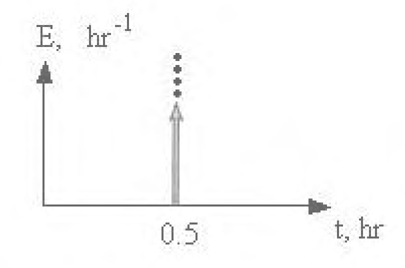

Figure 5

6. (a) Discuss about fitting the dispersion model for large deviation from plug flow.

   (b) A packed bed reactor is injected with a tracer. The pulse is injected into the bed about 4 particle diameters from the entrance, which is not perfect. The variance in the injection is $\sigma^2 = 15$ sec^2. The variance at the measuring point 3 meters downstream is $\sigma^2 = 50$ sec^2. The superficial velocity is 0.01 m/s.

      i. Calculate the dispersion coefficient.

      ii. Calculate the conversion for a first order reaction in which k = 0.02 sec^{-1}. [8+8]

7. In slurry reactor reactant gas is bubbled through the liquid to reach the surface of solid. Thus to reach the surface of solid the reactant which enters the liquid must diffuse through the liquid film into the main body of liquid, and then through the film surrounding the catalyst particle. At the surface of the particle reactant yields product according to 1st order kinetics. Sketch the concentration profile of the gaseous reactant A. List out the resistances offered to the over all rate of reaction. [16]

8. A gaseous feed (10% C_4H_{10} - 90% inerts, P_t = 10 atm,T =555^{0}C) flows (τ' = 1.1 kg.hr/m^3) through a packed bed of aluminum chromia catalyst. The butane decomposes by first order reaction

   $C_4H_{10} \rightarrow C_4H_8 \rightarrow$ carbon
   $\searrow$ Othergases

   and the behavior with time is as follows:

t hrs	0	1	2	3	4	5
X_A	0.89	0.78	0.63	0.47	0.34	0.26

   Examination of the 0.55mm pellets shows the same extent of carbon deposition at the entrance and the exit of the reactor, suggesting concentration independent deactivation. Develop rate equations for reaction an deactivation. [16]

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Code No: 07A60803 **R07** **Set No. 3**

III B.Tech II Semester Examinations,December 2010
CHEMICAL REACTION ENGINEERING - II
Chemical Engineering

Time: 3 hours Max Marks: 80

Answer any FIVE Questions
All Questions carry equal marks
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1. (a) Explain the difference in behavior of microfluids and macrofluids in a mixed flow reactor.
   (b) Derive the expression for a zero order reaction of a macrofluid in a mixed flow Reactor. [8+8]

2. (a) Write about dispersion model and mention its applications and limitations.
   (b) An injected slug of tracer material flows with its carrier fluid down a long, straight pipe in dispersed plug flow. At point A in the pipe the spread of tracer is 16m. At point B, 1 kilometer downstream from A, its spread is 32m. What do you estimate its spread to be at a point C, which is 2 kilometers downstream from point A? [8+8]

3. (a) Give a brief account of E, the exit age distribution and the experimental methods for finding E curve.
   (b) A liquid macrofluid reacts according to A → R as it flows through a vessel. Find the conversion of A for the flow pattern shown in the figure 3, with the given data. C_{A0} = 6 mol/liter, -r_A = k, k = 3 liter/mol.min [8+8]

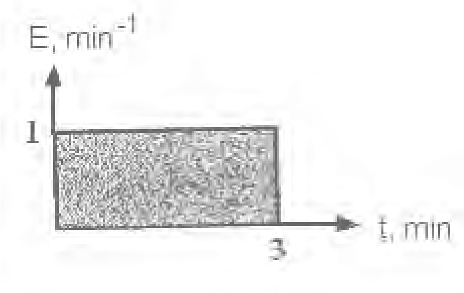

Figure 3

4. Derive an expression for the effectiveness factor of a porous catalyst slab of thickness 2L that has an effective pore diameter = $4\in/\rho_c$ S with a first order reaction r" = k" C_A. can you justify $d_e = 4\in\rho_c s$. [16]

5. Calculate the time needed to burn to completion particles of graphite (R_o = 5mm, ρ_B = 2.2gm/cc, K_S = 20 cm/s.) in an 8% oxygen stream. For high gas velocity used assume that film diffusion doesnot offer any resistance to transfer and reaction. Reaction temperature is 900^0C. [16]

6. (a) A small diameter pipe 32m 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" rose is produced(8 bottles). Because of some construction in the winery the pipeline length will have to be increased to 50m. For the same flow rate of wine, how many bottles of rose may we now expect to get each time we switch the flow?

(b) Discuss briefly about the tanks-in-series model. [8+8]

7. The following data on an irreversible reaction are obtained with decaying in a batch reactor (batch-solids, batch-fluid). What can you say about the kinetics and find the decay constant. [16]

t hrs	0	0.25	0.5	1	2	α
C_A, mol/lit	1	0.802	0.675	0.532	0.422	0.363

8. Develop the overall rate equation for the reaction A $\Leftrightarrow$B taking steps below into account:

(a) Adsorption rate of A

$$r = K_1 \left(P_a\theta_v - \theta_a/K_2\right)$$

(b) Desorption rate of B

$$r = K_3 \left(\theta_b/K_4 - P_t\theta_v\right)$$

(c) Surface reaction rate

$$\mathrm{r = K_5(\theta_a - \theta_b/K_6)}$$

θ_a and θ_b are the fractions of the surface covered by species A and B. θ_v is uncovered surface (θ_v = 1 - θ_a - θ_b). [16]

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