Code No: RR410802 **Set No.1**

IV B.Tech. I Semester Regular Examinations, November -2005
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. The following readings represent a continuous response to a delta function input into a closed vessel to be used as a reactor. Plot E(θ) Vs θ and estimate the variance : [16]

Time, min.	Con. of tracer g/lit
0	0
5	3
10	5
15	5
20	4
25	2
30	1
35	0

2. A large tank (860liters) is used as a gas-liquid contactor. Gas bubbles up through the vessel and out of the top, liquid flows in at one part and out the other at 5liters/s. To get an idea of the flow pattern of liquid in this tank a pulse of tracer (M=150gm) is injected at the liquid inlet and measured at the outlet, as shown in given Figure2.

   (a) Is this a properly done experiment?

   (b) If so, find the liquid fraction in the vessel.

   (c) Determine the E curve for the liquid.

   (d) Qualitatively what do you think is happening in the vessel? [16]

3. (a) Define the following terms:

      i. Micro fluid

      ii. Macro fluid

      iii. Degree of segregation

      iv. Earliness of mixing

   (b) Explain the difference in behaviour of micro fluids and macro fluids in mixed flow reactor. [8+8]

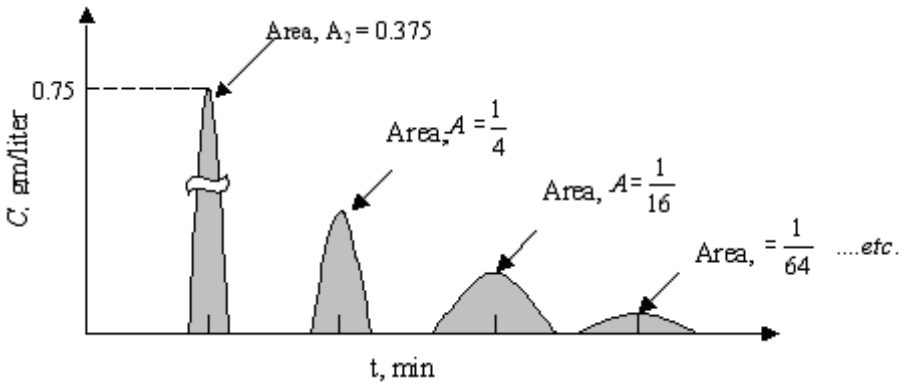

Figure 1:

4. For a particle which reacts under "Ash diffusion" control, what is the ratio of the time required for the radius of unreacted solid to be reduced to R/2 to that required for complete reaction. Sketch the concentration profiles. [16]

5. A batch of solids of uniform size is treated by gas in a uniform environment solid is converted give a non flaking product according to the shrinking core model conversion is about 7/8 for a reaction time of one hour, conversion is complete in two hours. What mechanism is rate controlling. [16]

6. (a) Mention the three reasons for which heterogeneous fluid-fluid reactions are made to take place. Give examples wherever possible.

   (b) With the help of a neat diagram describe the double mixed reactor and write its particular features. Explain how it can be used to obtain the clues to the kinetic regime from experiments in fluid-fluid reactions. [6+10]

7. How much catalyst is needed in a packed bed reactor for 80% conversion of $1000 m^3/hr$ of pure gas $A(C_{A0} = 100 mol/m^3)$ for the reaction, $A \rightarrow R$, whose rate expression is

   $-r_A = \frac{50\, C_A}{1+\ 0.02\, C_A}\, mol/kg.hr$ [16]

8. For the solid catalyzed reaction A + B $\rightleftarrows$ R + S, develop an expression for rate equation, if desorption of S is controlling the overall reaction. A, R and S are chemisorbed while B is in gas phase. [16]

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Code No: RR410802 **Set No.2**

IV B.Tech. I Semester Regular Examinations, November -2005
CHEMICAL REACTION ENGINEERING-II
(Chemical Engineering)

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

Answer any FIVE Questions
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1. The first order reaction

   A → B

   Is carried out in a 10-cm-diameter tubular reactor 6.36m in length. The specific reaction rate is 0.25 min^{-1}. Following are the results of a tracer test carried out in this reaction

t(s)	0	1	2	3	4	5	6	7	8	9	10	12	14
C(mg/liter)	0	1	5	8	10	8	6	4	3	2.2	1.5	0.6	0

   Calculate conversion using

   (a) the closed vessel dispersion model

   (b) the tanks-in-series model. [10+6]

2. A pulse test on a piece of reaction equipment gave the following results: The output concentration rose linearly from zero to $0.5\mu mol/m^3$ in 5 min, then fell linearly to zero in 10 min after reaching the maximum value.

   (a) Calculate in tabular form the values of E(t) and F(t) at 1 min intervals.

   (b) If the reactor were plug flow with the same flow and volume, what would be the conversion ? [10+6]

3. (a) Derive the general equation for determining conversion for macro fluid in mixed reactors.

   (b) Deduce the above equation for a first order reaction and show that the degree of segregation has no effect on conversion for first order system. [8+8]

4. Two small samples of solids are introduced in to a constant environment oven and kept there for one hour under these conditions, 4 mm particles are 58% converted and 2 mm particles are 87.5% converted. Find the rate controlling mechanism for the conversion of solids and the time needed for complete conversion of 1 mm particles. [16]

5. A batch of solids of uniform size is treated by gas in a uniform environment solid is converted give a non flaking product according to the shrinking core model conversion is about 7/8 for a reaction time of one hour, conversion is complete in two hours. What mechanism is rate controlling. [16]

6. CO_2 is to be removed from air by counter-current contact with water at 25^oC.

   (a) What are the relative resistances of gas and liquid films for this operation?

   (b) What simplest form of rate equation would you use for tower design?

   (c) For this removal operation would you expect reaction with absorption to be helpful? Why?

   From the literature we have for CO_2 between air and water:
   $k_g a = 80 mol/hr.lit.atm$
   $k_l a = 25/hr$
   H = 30 atm.lit/mol [16]

7. The following kinteic data on the reaction $A - - - - - \rightarrow R$ are obtained in an experimental packed bed reactor using various amounts of catalysts and a fixed feed rate, F_{A0} = 10 kg.mol/hr.

W,kg. Cat	1	2	3	4	5	6	7
X_A	0.12	0.20	0.27	0.33	0.37	0.41	0.44

   (a) Find the reaction rate at 40 % conversion.

   (b) In designing a large packed bed reactor with feed rate F_{A0}= 400 kmol/hr. How much catalyst would be needed for 40% conversion.

   (c) How much catalyst would be needed if the reactor is a mixed flow reactor?

   [8+8]

8. For the solid catalyzed reaction A + B $\rightleftarrows$ R + S, develop an expression for rate equation, if surface reaction is controlling the overall reaction. All species are chemisorbed. [16]

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Code No: RR410802 **Set No.3**

IV B.Tech. I Semester Regular Examinations, November -2005
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(Chemical Engineering)

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

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1. A reactor with a number of dividing baffles is to be used to run the reaction

   A → R with - r_A = 0.05 C_A mol / liter.min

   A pulse tracer gives the following output curve

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

   (a) How many tanks in series is this vessel equivalent to?

   (b) Calculate $X_A$assuming the tanks-in-series model. [10+6]

2. A large tank (860liters) is used as a gas-liquid contactor. Gas bubbles up through the vessel and out of the top, liquid flows in at one part and out the other at 5liters/s. To get an idea of the flow pattern of liquid in this tank a pulse of tracer (M=150gm) is injected at the liquid inlet and measured at the outlet, as shown in given Figure2.

   (a) Is this a properly done experiment?

   (b) If so, find the liquid fraction in the vessel.

   (c) Determine the E curve for the liquid.

   (d) Qualitatively what do you think is happening in the vessel? [16]

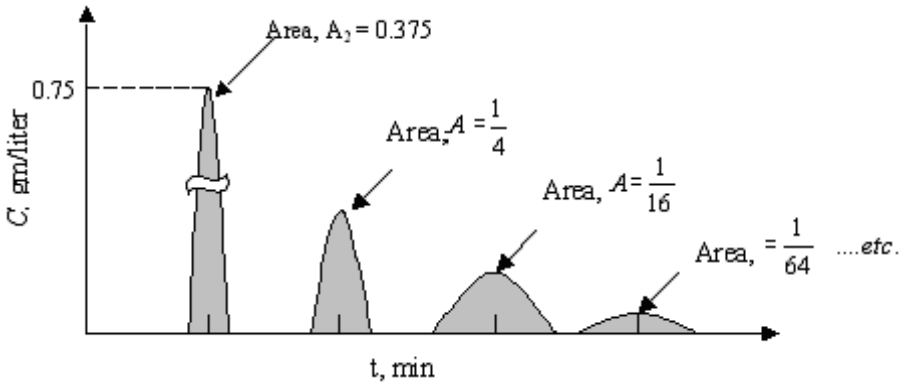

Figure 2:

3. (a) Define the following terms:
   i. Micro fluid
   ii. Macro fluid
   iii. Degree of segregation
   iv. Earliness of mixing
   (b) Explain the difference in behaviour of micro fluids and macro fluids in mixed flow reactor. [8+8]

4. Two small samples of solids are introduced in to a constant environment oven and kept there for one hour under these conditions, 4 mm particles are 58% converted and 2 mm particles are 87.5% converted. Find the rate controlling mechanism for the conversion of solids and the time needed for complete conversion of 1 mm particles. [16]

5. Spherical particles of zinc blende of radius 1 mm are roasted in an 8% oxygen stream at 900C and 1 atm. The reaction is
   $2ZnS + 3O2 \rightarrow 2Zno + 2SO2$
   Assuming that the reaction proceeds by shrinking core model and neglecting the film resistance.

   Calculate the time needed for complete conversion of a particle and the relative resistance of ash layer during this operation.
   Data:Density of solid = $4.13Kg/m^3$
   Rate constant = 0.02 m/s
   Effective diffusivity = $0.08Cm^2/S$. [16]

6. Derive a rate equation for fast reaction with a second-order rate between A and B, fluid-fluid reaction
   $A(gas) + bB(liquid) \rightarrow product$
   And sketch the concentration profiles assuming a two film theory. [16]

7. Discuss the role of the following on heterogeneous catalytic reaction:
   (a) Pore size
   (b) Pore size distribution
   (c) Surface area
   (d) Pellet size [4× 4]

8. For the solid catalyzed reaction A $\rightleftarrows$ R + S, develop an expression for rate equation, if adsorption of A is controlling the overall reaction. Only A and R are adsorbed while S is in gas phase. [16]

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Code No: RR410802 **Set No.4**

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CHEMICAL REACTION ENGINEERING-II
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Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
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1. The following readings represent a continuous response to a delta function input into a closed vessel to be used as a reactor. Plot E(θ) Vs θ and estimate the variance : [16]

Time, min.	Con. of tracer g/lit
0	0
5	3
10	5
15	5
20	4
25	2
30	1
35	0

2. Calculations show that a plug flow reactor would give 99.9% conversion of reactant which is in aqueous solution. However, our rector has an RTD somewhat as shown in Figure3. If $C_{AO} = 1000$, what outlet concentration can we expect in our reactor if reaction is first order? Use dispersion model. From mechanics $\sigma^2 = a^2/24$ for a symmetrical triangle with base a, rotating about its center of gravity. From mechanics [16]

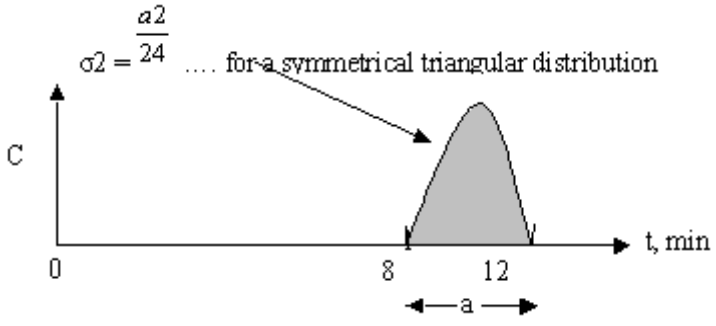

Figure 3:

3. Device a sketch to illustrate the difference in performance of second order reactions as a function of RTD, degree of segregation and earliness of mixing. [16]

4. Derive an equation to estimate the conversion for a mixture of particles of different but unchanging sizes under the condition of plug flow of solids and uniform gas

composition. Highlight the effect of time for complete conversion of individual particles of different sizes and average conversion of the mixture. [16]

5. Spherical particles of pure carbon are burning. The process is controlled by mass transfer of Oxygen to carbon surface. The mass transfer coefficient obeys an equation of the form
$\frac{k_m d}{D} = A\mathrm{Re}^{0.5} Sc^{0.34}$
What is the ratio of the time required for the radius of the particles to be halved to that required for complete combustion? [16]

6. Derive a rate equation for an instantaneous reaction of any order between A and B, fluid-fluid reaction
$A(gas) + bB(liquid) \rightarrow product$
And sketch the concentration profiles assuming a two-film theory. [16]

7. Write short notes on:
   (a) Experimental methods of finding rates of solid catalyzed reactions
   (b) Experimental determination of pore size and surface area of catalyst. [8+8]

8. For the solid catalyzed reaction A + B $\rightleftarrows$ R + S, develop an expression for rate equation, if desorption of R is controlling the overall reaction. All components are adsorbed. [16]

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