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

III B.Tech II Semester Examinations,APRIL 2011
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 $-r_A = 0.05\ C_A$ 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]

2. What are the experimental devices used for collecting experimental data to estimate the kinetic parameters of a catalytic reaction. Explain the strategy of applications of those devices for different reactions. [16]

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. Denmark's longest and greatest river, the Gudenaa, certainly deserves study, so pulse tracer tests were run on various stretches of the river using radioactive Br-82. Find the axial dispersion coefficient in the upper stretch of the river, between Torring and Udlum, 8.7 km apart, from the following reported measurements. [16]

t,hr	C, arbitrary	t,hr	C, arbitrary
3.50	0	5.75	400
3.75	3	6.00	250
4.00	25	6.25	122
4.25	102	6.50	51
4.50	281	6.75	20
4.75	535	7.00	9
5.00	740	7.25	3
5.25	780	7.50	0
5.50	650		

5. Define the enhancement factor. Consider a fast instantaneous reaction between a Gaseous component and a liquid. Assuming a two film theory explain the Physical significance of the enhancement factor. [16]

6. Curves A, B and C in the figure 6 show the variations in reaction rate for three different reactions catalysed by solid pellets. What can you say about each reaction. [16]

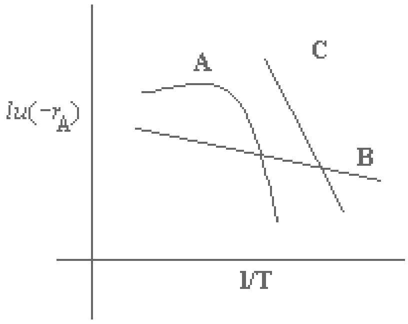

Figure 6

7. Consider a second-order reaction being can-led out in a real CSTR that can be modeled as two different reactor systems: In the first system a CSTR is followed by a PFR, in the second system the PFR precedes the CSTR. Let τ_s and τ_p each equal 1 min, let the reaction rate constant equal 1.0 m^3/kmol.min and let the initial concentration of liquid reactant, C_{AO}, equal 1 kmol/m^3. Find the conversion in each system. [16]

8. A pulse test on a piece of reaction equipment gave the following results: The output concentrations rose linearly from zero to 0.5 μmol/dm^3 in 5 min, then fell linearly to zero in 10 min after reaching the maximum value.

   (a) What is the mean residence time? If the flow rate were 150 gal/min, what would be the total reactor volume? A second order reaction with $kC_{A0} = 1.2$ min^{-1} is carried out in the system.

   (b) If the reactor were a CSTR with the same flow and volume, what would be the conversion? [16]

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

III B.Tech II Semester Examinations,APRIL 2011
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. Write briefly on:
   (a) Effect of temperature on surface diffusivity.
   (b) Effective thermal conductivity. [16]

2. What are the steps involved in shrinking core model? How the particle porosity effects its conversion. Give an industrially important reaction of this type. [16]

3. A liquid-phase reaction is currently carried out commercially in a series of three, equal volume, stirred tank reactors operating isothermally. It is planned to replace these reactors with a single, tubular flow reactor. To obtain the same conversion as in the stirred tank equipment, for the same V_t/Q, what degree of dispersion is necessary in the tubular reactor? That is, determine the value of D/uL if the flow in the tubular reactor could be represented by the dispersion model. [16]

4. (a) Give a brief account of the tanks-in-series model.
   (b) Given C_{in} and C_{out} as well as the location and spread of these tracer curves, as shown in the figure 4. Estimate the vessel E curve. We suspect that the tanks-in-series model reasonably represents the flow in the vessel. [8+8]

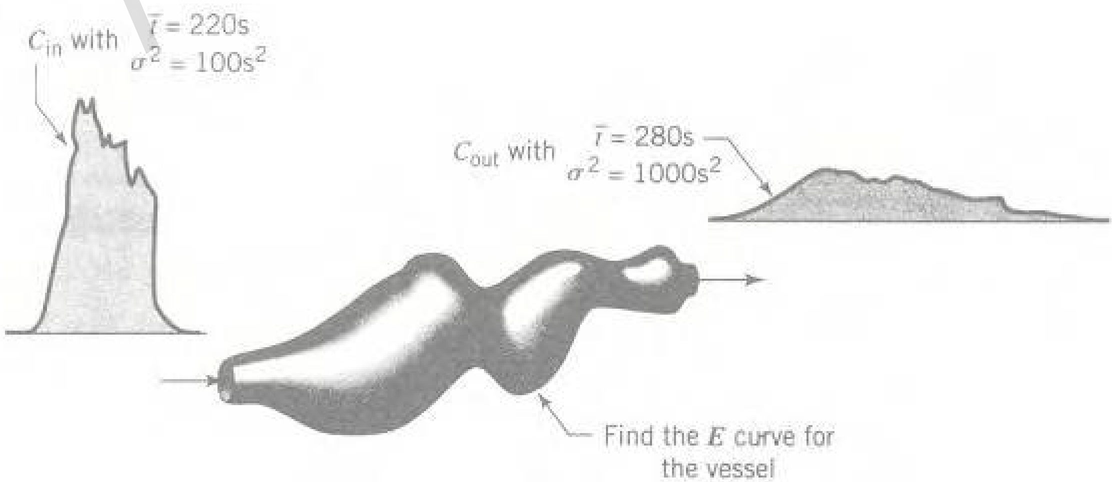

Figure 4

5. (a) Dispersed noncoalescing droplets containing reactant A pass through 3 ideal stirred tanks in series. The mean holding time in each tank is 1.5hr and the rate constant for the first-order decay reaction is 0.1 min^{-1}. Find the fractional conversion of A in the exit stream from the three reactors.

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

6. 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 ≥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 6. [16]

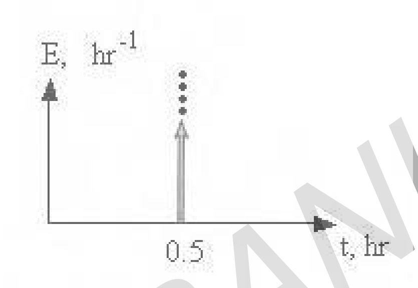

Figure 6

7. The decomposition of cumene to form benzene and propylene by catalytic reaction is $C_6H_5CH(CH_3)_2 \rightarrow C_6H_6 + C_3H_6$
Show a conceptual model depicting the sequence of steps in this platinum - catalyzed reaction and develop a rate equation for its decomposition. [16]

8. A reversible catalytic reaction $A <===> R$,$X_{AC} = 0.5$. proceeds with decaying catalyst in a batch reactor (batch-solids, batch-fluid). What can you say of the kinetics of reaction and deactivation from the following data: [16]

t hrs	0	0.25	0.5	1	2	α
C_A, mol/lit	1	0.901	0.830	0.766	0.711	0.684

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

III B.Tech II Semester Examinations,APRIL 2011
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. How do you distinguish between a differential reactor and an integral reactor. Compare and constract? [16]

2. 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]

3. (a) Define RTD and write about the experimental methods of determining RTD.
   (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} = 4 mol/liter, -r_A = k, k = 1 mole/litre.min [8+8]

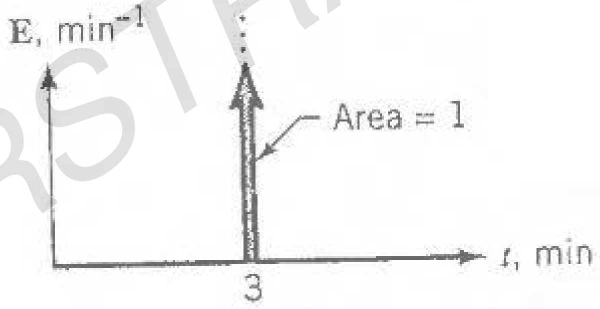

Figure 3

4. (a) Given C_{in} and C_{out} as well as the location and spread of these tracer curves, as shown in the figure 4a. Estimate the vessel E curve. We suspect that the tanks-in-series model reasonably represents the flow in the vessel.

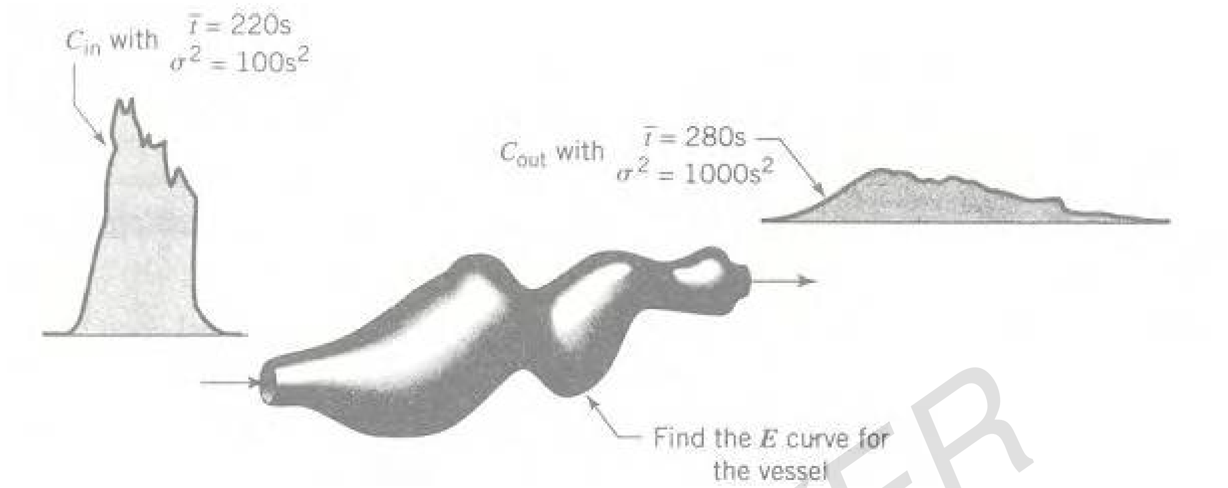

Figure 4a

(b) Briefly discuss about correlations for axial dispersion. [8+8]

5. Spray drying and other procedures for manufacturing small particles can produce Catalyst particles as smaller as 2 to 5 Microns .Calculate the surface area of non Porous Spherical particles of 2 microns diameter. What size particles would be necessary if the external surface is to be 100 m^2/g. The density of the particles is 2 g/cc. [16]

6. 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 1hr .conversion is complete in two hours. What mechanism is rate controlling? [16]

7. (a) Discuss about axial dispersion and the dispersion model. What are its limitations and applications?

   (b) RTD studies were carried in a tubular reactor (L = 1.21 m, 35 mm ID). A squirt of NaCl solution (5 N) was rapidly injected at the reactor entrance and mixing cup measurements were taken at the exit. From the following results calculate the vessel dispersion number, also the fraction of reactor volume taken up by the baffles. (ν = 1300 ml/min) [8+8]

t, sec	NaCl sample
0 - 20	0
20 - 25	60
25 - 30	210
30 - 35	170
35 - 40	75
40 - 45	35
45 - 50	10
50 - 55	5
55 - 70	0

8. (a) Find the expression for conversion of a macrofluid in two equal size MFR's for a second order reaction. If conversion is 99% for the microfluid, what is it for a macrofluid having the same reaction rate.
   (b) Discuss about the mixing of two miscible fluids. [8+8]

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

III B.Tech II Semester Examinations,APRIL 2011
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 is Henry's law? Discuss its role in gas-liquid reaction. If Henry's constants are 0.01 and 1000atm.lit/mol. What do you understand by them? [16]

2. (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 2, with the given data. C_{A0} = 6 mol/liter, -r_A = k, k = 3 liter/mol.min [8+8]

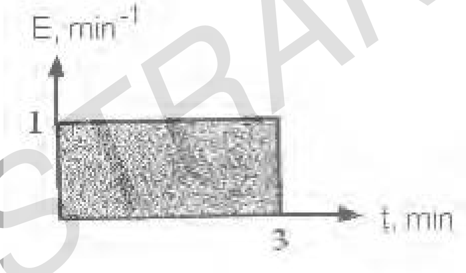

Figure 2

3. What is differential method of analysis? Discuss the procedure in detail to estimate the kinetic parameters using differential method and highlight the advantages over integral method. [16]

4. (a) Discuss briefly about fitting the dispersion model for small extents of deviation from plug flow.
   (b) A tubular reactor has been sized to obtain 98% conversion and to process 0.03 m^3/s. The reaction is a first order irreversible isomerization. The reactor is three meters long with a cross sectional area of 25 cm^2. After being built a pulse of tracer test on the reactor gave the following data: t_m = 10 sec and σ^2 = 65 sec^2. What conversion can be expected in the real reactor? [8+8]

5. (a) Dispersed noncoalescing droplets containing reactant A pass through 3 ideal stirred tanks in series. The mean holding time in each tank is 1.5hr and the rate constant for the first-order decay reaction is 0.1 min^{-1}. Find the fractional conversion of A in the exit stream from the three reactors.
   (b) Discuss about early and late mixing of fluids for idealized pulse RTD, exponential decay RTD and arbitrary RTD, in turn, for a single reacting fluid. [10+6]

6. Fluid flows at a steady rate through ten well-behaved tanks in series. A pulse of tracer is introduced into the first tank, and at the time this tracer leaves the system is measured giving

   maximum concentration = 100 mmol/litre

   tracer spread = 1 min

   If ten more tanks are connected in series with the original ten tanks,

   (a) What would be the maximum concentration of leaving tracer?

   (b) How does the relative spread change with number of tanks? [12+4]

7. Show that $\frac{C_A}{C_{AS}} = \frac{Cosh\, m\,(L-X)}{mL}$

   M = $\frac{\sqrt{K}}{D}$ C_A = Concentration of reactant A.

   C_{As} = Concentration of reactant in catalyst pore

   L = Length of a cylindrical pore of a catalyst

   X = any length of cylindrical pore. [16]

8. Gaseous reactant diffuses through a gas film and reacts on the surface of a solid according to a reversible first order rate - r'' = $k_s(C_s - C_e)$. Develop an expression for the rate of reaction accounting for both the mass transfer and reaction steps. Give the limitations of the equation. [16]

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