Sardar Beant Singh State University, Gurdaspur
Department of Chemical Engineering & Bio Technology

Tutorial Sheet No.1

Subject: Chemical Reaction Engineering-I

Topic: Stoichiometric , Non Elementary & Activation Energy

Q1. A reaction has the stoichiometric equation ***A + B = 2R.*** What is the order of reaction?

Q2. Given the reaction $\boldsymbol{2NO_2 + 0.5O_2 = N_2O_5}$, what is the relation between the rates of formation and disappearance of the three reaction components?

Q3. The pyrolysis of ethane proceeds with an activation energy of about 300 kJ/mol. How much faster is the decomposition at 650^0C than at 500^0C?

Q4. An 1100-K n-nonane thermally cracks (breaks down into smaller molecules) 20 times as rapidly as at 1000 K. Find the activation energy for this decomposition.

Q5. Show that the following scheme proposed by R. Ogg, J. Chem. Phys., 15, 337 (1947) is consistent with, and can explain, the observed first-order decomposition of N205.

$$N_2O_5 \underset{k_2}{\overset{k_1}{\rightleftharpoons}} NO_2 + NO_3^*$$

$$NO_3^* \xrightarrow{k_3} NO^* + O_2$$

$$NO^* + NO_3^* \xrightarrow{k_4} 2NO_2$$

Tutorial Sheet No.2

Subject: Chemical Reaction Engineering-I

Topic: ***Interpretation of Batch Reactor Data***

Q1. If $-r_A = -(dC_A/dt) = 0.2$ mol/liter.sec when $C_A = 1$ mol/liter, what is the rate of reaction when CA = 10 mol/ liter? Note: the order of reaction is not known.

Q2. Liquid A decomposes by first-order kinetics, and in a batch reactor 50% of A is converted in a 5-minute run. How much longer would it take to reach 75% conversion?

Q3. Repeat the previous problem for second-order kinetics.

Q4. A 10-minute experimental run shows that 75% of liquid reactant is converted to product by a ½ order rate. What would be the fraction converted in a half-hour run?

Q5. In a homogeneous isothermal liquid polymerization, 20% of the monomer disappears in 34 minutes for initial monomer concentration of 0.04 and also for 0.8 mol / liter. What rate equation represents the disappearance of the monomer?

Q6. After 8 minutes in a batch reactor, reactant (C_{AO} = 1 mol/ liter) is 80% converted; after 18 minutes, conversion is 90%. Find a rate equation to represent this reaction.

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Tutorial Sheet No.3
Subject: Chemical Reaction Engineering-I

Topic: ***Design & Performance of Batch and Continuous Reactor***

Q1. Consider a gas-phase reaction 2A →R +2 S with unknown kinetics. If a space velocity of 1/min is needed for 90% conversion of A in a plug flow reactor, find the corresponding space-time and mean residence time or holding time of fluid in the plug flow reactor.

Q2. In an isothermal batch reactor 70% of a liquid reactant is converted in 13 min. What space-time and space-velocity are needed to effect this conversion in a plug flow reactor and in a mixed flow reactor?

Q3. We are planning to operate a batch reactor to convert A into R. This is a liquid reaction, the stoichiometry is A → R, and the rate of reaction is given in Table How long must we react each batch for the concentration to drop from C_{A0} = 1.3 mol/liter to C_{Af} = 0.3 mol/liter?

C_A, mol/liter	$-r_A$, mol/liter·min
0.1	0.1
0.2	0.3
0.3	0.5
0.4	0.6
0.5	0.5
0.6	0.25
0.7	0.10
0.8	0.06
1.0	0.05
1.3	0.045
2.0	0.042

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Tutorial Sheet No.4
Subject: Chemical Reaction Engineering-I

Topic: Design of Single reactions

Q1. At present 90% of reactant A is converted into product by a second-order reaction in a single mixed flow reactor. We plan to place a second reactor similar to the one being used in series with it.
(a) For the same treatment rate as that used at present, how will this addition affect the conversion of reactant?
(b) For the same 90% conversion, by how much can the treatment rate be increased?

Q2. The reactor setup consists of three plug flow reactors in two parallel branches. Branch D has a reactor of volume 60 liters followed by a reactor of volume 30 liters. Branch E has a reactor of volume 50 liters. What fraction of the feed should go to branch D?

Q3. 100 liters/hr of radioactive fluid having a half-life of 20 hr is to be treated by passing it through two ideal stirred tanks in series, V = 40 000 liters each. In passing through this system, how much will the activity decay?

Q4. The kinetics of the aqueous-phase decomposition of A is investigated in two mixed flow reactors in series, the second having twice the volume of the first reactor. At steady state with a feed concentration of 1 mol A/ liter and mean residence time of 96 sec in the first reactor, the concentration in the first reactor is 0.5 mol A/ liter and in the second is 0.25 mol A/ liter. Find the kinetic equation for the decomposition.

Q5. 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 of the two mixed flow reactors in series, each having a volume of 400 cm3. The color change occurs in the first reactor for a steady-state 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.

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Tutorial Sheet No.5

Subject: Chemical Reaction Engineering-I

Topic: **Design for Multiple Reactions**

Q1. Substance A in the liquid phase produces R and S by the following reactions:

$$A \rightarrow R, \quad r_R = k_1 C_A^2$$
$$A \rightarrow S, \quad r_S = k_2 C_A$$

The feed (C_{A0} = 1.0, C_{R0} = 0, C_{S0} = 0.3) enters two mixed flow reactors in series (τ_1 = 2.5 min, τ_2 = 10 min). Knowing the composition in the first reactor (C_{A1} = 0.4, C_{R1} = 0.2, C_{S1}, = 0.7), find the composition leaving the second reactor.

Q2. Liquid reactant A decomposes as follows:

$$A \rightarrow R, \quad r_R = k_1 C_A^2, \quad k_1 = 0.4 \text{ m}^3/\text{mol·min}$$
$$A \rightarrow S, \quad r_S = k_2 C_A, \quad k_2 = 2 \text{ min}^{-1}$$

A feed of aqueous A (C_{A0} = 40 mol/m^3) enters a reactor, decomposes, and a mixture of A, R, and S leaves. Find C_R, C_S and τ for X_A = 0.9 in a plug flow reactor.

Q3. Consider the parallel decomposition of A of different orders

$$A \rightarrow R, \quad r_R = 1$$
$$A \rightarrow S, \quad r_S = 2C_A$$
$$A \rightarrow T, \quad r_T = C_A^2$$

Determine the maximum concentration of desired product obtainable in (a) plug flow, (b) mixed flow

R is the desired product and C_{A0} = 2.

S is the desired product and C_{A0} = 4.

T is the desired product and C_{A0} = 5.