# Department of Chemical Engineering

## CHL -122 Chemical Reaction Engineering-I

**Date: - 30/04/08 (Wednesday)**
**Marks: - 40**
**Venue: - WS 209 & WS 213** **Time: -1-3 p.m.**

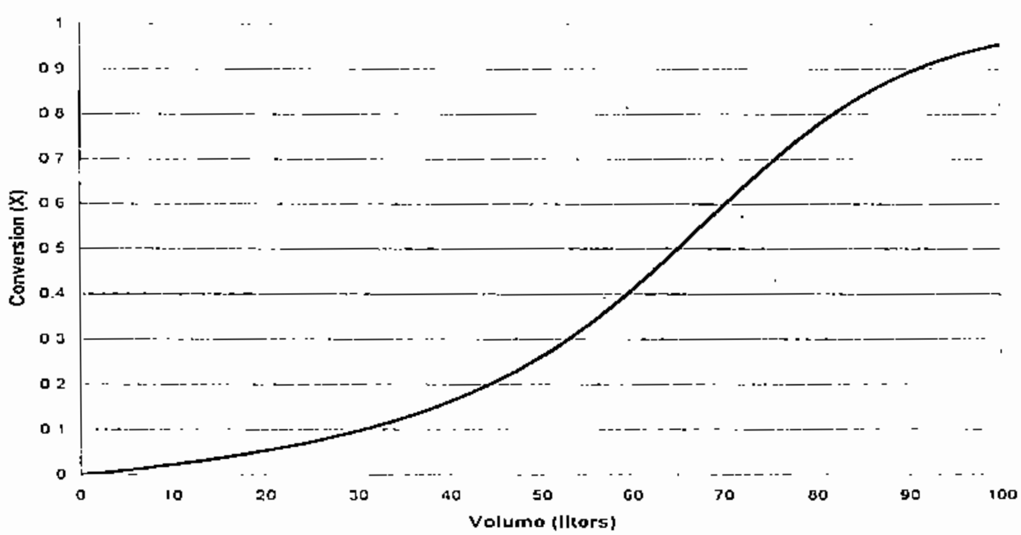
1. The first-order reaetion $A \rightarrow B$, is taking place in a Packed bed reactor. The reaction rate and the rate constant are given by:

$$-r_A = kp_A \quad \frac{\text{mol}}{\text{kg cat-h}}$$

$$k = 0.75 \frac{\text{mol}}{\text{atm-kg cat-h}}$$

A is fed to the reactor with 50% inerts at 327°C and 1 atmosphere. Feed rate of A is 37.5 moles/h. The pressure drop parameter $\alpha = 0.0045 \text{kg}^{-1}$. $P = P_0(1 - \alpha W)^{1/2}$ . Obtain an expression that relates the conversion in the reactor to the weight of the catalyst used. What conversion can be obtained with 100 kg of the catalyst? 8

2. The gas-phase reaction $A \rightarrow \frac{B}{2}$ is taking plaec in a PFR. Pure A enters the reaetor at a pressure of 4 atmospheres and 350 K. The heat of reaction, whieh ean be assumed to be independent of temperature, is -27 kJ/mol of A. Specific heat of A is 30 J/mol-K. The rate constant at 350 K is 0.2 $s^{-1}$ and the activation energy is 18 kJ/mol. The volumetric flow rate is 10 liters/s. When the conversion of A is plotted versus the reactor volume, the following plot is obtained. Determine the temperatures, concentrations and reaction rates of A in the reactor at the mid point (V=50 litre) and at the exit of the reactor (V=100 litre). 8

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3. The following second-order liquid-phase reaction is taking place in a CSTR.

$$A + B \rightarrow C + D$$

A and B are fed to the reaetor at rates of 4 mol/min and 2 mol/min respectively at a temperature of 300 K. The volumetric flow rate is 10 liters/min. Specifie heats (in J/mol-K) of A, B, C and D are 125, 100, 130 and 135 respeetively. The reactor is jacketed by water at a temperature of $40^0$C. The overall heat transfer eoefficient has been estimated at 200 J/($m^2$.min.K), while the heat transfer area is 0.5 $m^2$. The heats of formation of A, B, C and D are -45 kJ/mol, -30 kJ/mol, -50 kJ/mol and -60 kJ/mol respectively. The rate constant at 300 K is 0.1 $\frac{\text{lit}}{\text{mol-min}}$ and the activation energy is 30,000 J/mol. Find the steady-state temperature in the reactor for 90% consumption of the limiting reactant. What is the volume of the reactor to achieve this conversion? 10

4. Consider the following system of gas-phase reactions:

$A \rightarrow X \quad r_X = k_1 \quad k_1 = 0.0005$ kg mol/$m^3$.min.
$A \rightarrow B \quad r_B = k_2 C_A \quad k_2 = 1\ min^{-1}$.
$A \rightarrow Y \quad r_Y = k_3 C_A^2 \quad k_3 = 60\ m^3$/kg mol. min.

Where, B is the desired product, and X and Y are foul pollutants that are expensive to get rid off.

(a) What kind of combined reactor system (CSTR/PFR) would you recommend for this reaction scheme?
(b) Calculate the size of the reactors involved to achieve a 90 % conversion of A for a feed rate of 1 kg mol of pure A per minute. The reactor is operated at 4 atm and $225^0$C. 8

5. Develop an expression for the concentration and residence time distribution (RTD) in a tubular reactor using Tank in series model. 6