Qu 1 Show that for the reaction A + B → R + B → S being carried out in a batch/ plug flow reactor:

$$C_{R,\,max}/\ C_{A0} = (k_1/\ k_2)^{k2/\,(k2-k1)} \quad k_2 \neq k_1$$

$$C_{R,\,max}/\ C_{A0} = 1/\ e = 0.368 \quad k_2 = k_1$$

and if carried out in a CSTR

$$C_{R,\,max}/\ C_{A0} = 1/\ [1 + (k_2/\ k_1)^{1/2}]^2$$

Qu 2 Under appropriate conditions A decomposes as follows: A → R → S ($k_1$ = 0.1/ min, $k_2$ = 0.1/ min). R is to be produced from 1,000 liter/ hr of feed in which $C_{A0}$ = 1 mol/ liter, $C_{R0} = C_{S0} = 0$

a. What size of plug flow reactor will maximize the concentration of R, and what is that concentration in the effluent stream from this reactor?
b. What size of mixed flow reactor will maximize the concentration of R, and what is $C_{Rmax}$ in the effluent stream from this reactor?

Qu 3 Consider the following elementary reactions: A + B → R and R + B → S ( Rate constants are respectively $k_1$ and $k_2$)

a. One mole of A and 3 moles of B are rapidly mixed together. The reaction is very slow, allowing analysis of compositions at various times. When 2.2 moles B remain unreacted, 0.2 mole S is present in the mixture. What should be the composition of the mixture ( A, B, R and S) when the amount of S present is 0.6 moles?
b. One mole A is added bit by bit with constant stirring to 1 mole B. Left overnight and then analyzed, 0.5 mole S is found. What can we say about $k_1/\ k_2$?
c. One mole A and 1 mole B are thrown together and mixed in a flask. The reaction is very rapid and goes to completion before any rate measurements can be made. On analysis of the products of reaction 0.25 mole S is found to be present. What can we say about $k_2/\ k_1$?

Qu 4 A large fully automated municipal incinerator is being designed. A survey estimates the garbage load to be 1,440 tons/ day. This will be harvested by a fleet of compaction trucks which will disgorge their loads into an underground storage bin. A conveyor will then feed the garbage to the incinerator.

The proposed daily collection route is such that at the beginning of the working day ( 6 AM sharp) relatively large quantities of garbage ( average of 6 tons/ min) are returned from nearby commercial areas. Subsequently, the supply will diminish as more remote suburban areas are serviced. It is assumed that the collection rate is proportional to the amount of garbage still to be collected, the initial rate being one truckload/ min. The conveyor, on the other hand, will transport garbage at a uniform 1 ton/ min to the incinerator. At the beginning of the working day, the trucks will work faster than the conveyor, later in the day, slower. Thus, each day the bin will accumulate material, then lose material.

To evaluate this operation, we need information. Please help us with this.

a. At what time of day will the trucks have collected 95% of the day's garbage?
b. How much garbage would the storage bin be designed for?
c. At what time of day will the bin be fullest?
d. At what time of day will the bin be empty?

Qu 5 Chemical X, a powdered solid, is slowly and continuously fed for half an hour into a well stirred vat of water. The solid quickly dissolves and hydrolyses to Y, which then slowly decomposes to Z as follows $Y \rightarrow Z$, $-r_Y = kC_Y$, $k = 1.5\ hr^{-1}$

The volume of liquid in the vat stays close to 3 $m^3$ throughout this operation, and if no reaction of Y to Z occurred, the concentration of Y in the vat would 100 moles/ $m^3$ at the end of the half hour addition of X.

a. What is the maximum concentration of Y in the vat and at what time is this maximum reached?
b. What is the concentration of product Z in the vat after 1 hour?

Qu 6 Chemical A reacts to form R ($k_1 = 6\ hr^{-1}$) and R reacts away to form S ($k_2 = 3\ hr^{-1}$). In addition R slowly decomposes to form T ($k_3 = 1\ hr^{-1}$). If a solution containing 1.0 mol/ liter of A is introduced into a batch reactor, how long would it take to reach $C_{R,\ max}$ and what would be $C_{R\ max}$?

Qu 7 First order reactions: $A \rightarrow R \rightarrow S$ ( $k_1 = 10^9\ e^{-6000/T}$, $k_2 = 10^7\ e^{-4000/T}$); $R \rightarrow U$ ($k_3 = 10^8\ e^{-9000/T}$); $R \rightarrow U$ ($k_4 = 10^{12}\ e^{-12,000/T}$ are to be run in tow mixed flow reactors in series anywhere between 10 and 90 deg C. If the reactors may be kept at different temperatures, what should these temperatures be for maximum fractional yield of S? Find this fractional yield.

Qu 8 The reversible first order gas reaction $A \leftrightarrow R$ is to be carried out in a mixed flow reactor. For operations at 300 K the volume of reactor required is 100 liters for 60% conversion of A. What should be the volume of the reactor for the same feed rate and conversion but with operations at 400 K?

Data: k1 = $10^3$ exp (-2,416/ T); $\Delta C_p = C_{pR} - C_{pA} = 0$; $\Delta H_r = -8{,}000$ cal/ mol at 300 K; K = 10 at 300 K; Feed consists of pure A. Total pressure stays constant.