1. Your plant has two liquid streams available containing solutes that are not profitably marketable at the present time. The first contains solute A, the second solute B.

   Two possible reactions may occur between these species. The stoichiometric equations and rate expressions are given below.

   $$A + B \rightarrow V \text{ (valuable product)}, \quad r_V = k_1 C_A C_B C_V^{1/2} + k_2 C_A C_B$$

   $$A + B \rightarrow U \text{ (undesirable product)}, \quad r_U = k_3 C_A C_B$$

   (a) You have two beakers containing samples of the two streams and desire to carry out a small-scale laboratory experiment in which you maximize the formation of V. In what manner would you carry out this experiment; that is, how would you mix the reactants and at what rate? (5%)

   (b) If you desire to produce V in a flow reactor, what type of reactor and operating conditions do you recommend? and why? (5%)

   (c) If the activation energies for the rate constants k_1, k_2, and k_3 are 30, 25 and 25 kJ/mole, respectively, what additional statement can you make regarding recommended operating conditions? (5%)

2. CT Consulting Firm has been asked to scale up an existing process to obtain an increased production capacity for compound B. At present the process is carried out in two CSTRs in series. The reaction involved has the flowing stoichiometry.

   $$2A \rightarrow B + C \text{ (liquid phase reaction)}$$

   Unfortunately, the data from which the rate constants were originally determined have been lost. The CT Firm believes that he can determine a rate constant from measurements on the plant's present system for manufacturing compound B.

   Data:

Volume of first CSTR	30 gal
Volume of second CSTR	40 gal
Feed to first CSTR	pure A
Fraction conversion of A in first CSTR	0.60
Overall fraction conversion of A by the two CSTRs in series	0.80
Volumetric feed rate to first CSTR	900 gal/hr

   The reaction is known to be second-order in A.

   (a) Is it possible for the CT Firm to determine a rate constant for the reaction from these data? If not, what additional data does he need? (10 %)

   (b) The plant production capacity is to be tripled and two CSTRs in series are to be used in the new layout. The overall conversion of species A is to remain the same. It has been suggested that the 40-gal CSTR be used in the new layout as the first tank in series. What will be the size of the second CSTR? (8%)

(背面仍有題目,請繼續作答)

3. t-Butyl alcohol (TBA) was produced by liquid-phase hydration (W) of isobutene (I) over a solid catalyst. The reaction mechanism is believe to be

$$I + S \leftrightarrow I \cdot S$$
$$W + S \leftrightarrow W \cdot S$$
$$W \cdot S + I \cdot S \leftrightarrow TBA \cdot S + S$$
$$TBA \cdot S \leftrightarrow TBA + S$$

Derive a rate law assuming:

(a) The surface reaction is rate-limiting. (12%)

(b) Isobutene (I) and water (W) are absorbed on different sites

$$I + S_1 \leftrightarrow I \cdot S_1$$
$$W + S_2 \leftrightarrow W \cdot S_2$$

TBA is not on the surface, and the surface reaction is rate-limiting. (12%)

4. For a first-order gas-solid (catalyst) reaction,

$$A(g) \rightarrow prodcut(s)$$

Show that the (isothermal) overall effectiveness (η_0) is related to the catalyst effectiveness factor (η) by

$$\frac{1}{\eta_0} = \frac{k_A}{k_{Ag}} + \frac{1}{\eta}$$

Where k_A is the reaction rate constant, and k_{Ag} is the gas-film mass transfer coefficient. (9%)

5. An ideal gas mixture is charged to a tubular reactor at the rate of 10 kmoles/hr. The reactor is operated isothermally at 500K and the pressure is 6atm. The reactor is 10 cm in inner diameter. The second-order irreversible reaction

$$A + B \rightarrow D$$

that is taking place in the reactor has a specific reaction rate of 6 m^3/mole/hr at 500K. The feed composition is: 40% A, 40% B and 20% inert.

(a) Derive the design equation for this reactor.

(b) What reactor length is necessary for 80% conversion? (24%)

6. Generally speaking, the volume of a plug flow reactor is smaller than that of a CSTR to carry out most reactions under the same feed and exit conditions. (10%)

(a) Give the explanation with your own words, not any equation or figure.

(b) Even so, give the reason that the CSTRs are still applied in industry.

(c) Give two possibilities that the volume of a plug flow reactor is larger than that of a CSTR.