ชื่อ ............................ รหัสประจำตัว ..............

# PRINCE OF SONGKLA UNIVERSITY
## FACULTY OF ENGINEERING

Final Examination: Semester I — Academic Year: 2006
Date: 3 October 2006 — Time: 9.00-12.00
Subject: 230-620 Advanced Chemical Engineering Kinetics and Chemical Reactor Design — Room: A400

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- ข้อสอบมี 5 ข้อ จำนวน 10 หน้า ต้องทำทุกข้อ คะแนนเต็ม 120 คะแนน
- ควรใช้เวลาทำข้อสอบโดยเฉลี่ย 1.5 นาที/คะแนน

| ข้อที่ | คะแนนเต็ม | ได้คะแนน |
|---|---|---|
| 1 | 40 | |
| 2 | 20 | |
| 3 | 20 | |
| 4 | 25 | |
| 5 | 15 | |
| **รวม** | **120** | |

- ขอให้นักศึกษาทำข้อสอบในที่ว่างซึ่งได้เตรียมไว้สำหรับข้อสอบแต่ละข้อ โดยอาจใช้เนื้อที่ด้านหลังทำข้อสอบเพิ่มเติมได้
- อนุญาตให้นำหนังสือ เอกสาร เครื่องคำนวณ และอุปกรณ์อื่นๆ เข้าห้องสอบได้

**ทุจริตในการสอบ โทษขั้นต่ำคือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียน 1 ภาคการศึกษา**


สุธรรม สุขมณี

สุกฤทธิรา รัตนวิไล

ผู้ออกข้อสอบ


24 กันยายน 2549

1) (Sukritthira Ratanawilai) (40 points)

A first-order, irreversible gas phase reaction takes place in a CSTR reactor charged with spherical catalyst particles. The catalyst pores are sufficiently large that it can be safely assumed that the mass transport mechanism is one of ordinary diffusion. The reaction stoichiometry is

$$A \rightarrow 5B$$

and the feed is pure A. Estimate the effectiveness factor when the reactor is operating at the 15% conversion level using

a) The effectiveness factor ratios for first order kinetics on spherical catalyst pellets in Figure 12-6 in Foglor. (15 points)

b) The generalized Thiele modulus. (25 points)

*Additional data:*

Catalyst particle radius = 0.125 cm

$D_A^e = 0.25\ cm^2/s$

$\rho_p K$ = first order rate constant per unit particle volume = 576 $sec^{-1}$

$D_{KA}$ is very large

$$\int \frac{xdx}{1+ax} = \frac{x^2}{2(1+ax)}$$

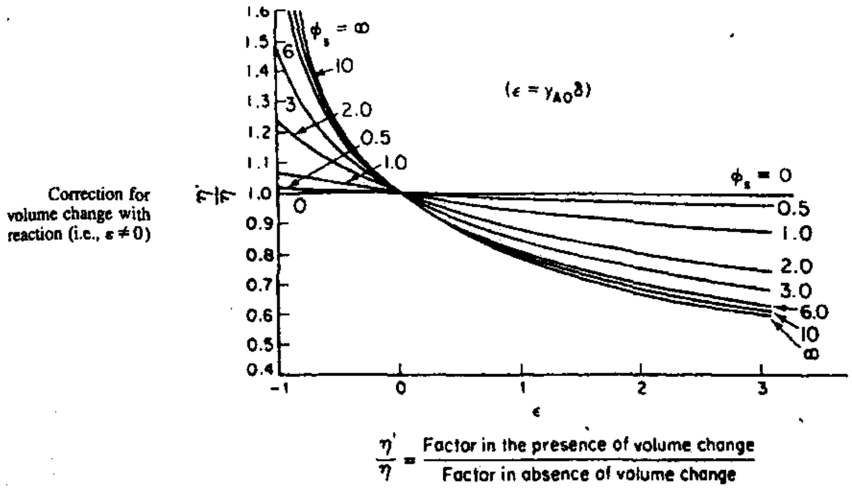


**Figure 12-6** Effectiveness factor ratios for first-order kinetics on spherical catalyst pellets for various values of the Thiele modulus, $\phi_s$, as a function of volume change. [From V. W. Weekman and R. L. Goring, *J. Catal.*, *4*, 260 (1965).]

2) (Sutham Sukmanee) (20 points)

Reactant A decomposes by three simultaneous reactions to form three products, one that is desired, S, and two that are undesired, R and T.

$$2A \xrightarrow{k_1} R \qquad r_R = 0.01037 C_A \frac{\text{mole}}{\text{dm}^3 \cdot \text{min}}$$

$$A \xrightarrow{k_2} S \qquad r_S = 0.08642 C_A^2 \frac{\text{mole}}{\text{dm}^3 \cdot \text{min}}$$

$$A \xrightarrow{k_3} 2T \qquad r_T = 0.02881 C_A^3 \frac{\text{mole}}{\text{dm}^3 \cdot \text{min}}$$

These liquid-phase reactions, along with the appropriate rate laws are carried out in the CSTR at 330 K with an entering concentration of A of 2.0M. Find the space-time of the reactor and exit concentration of A and S from the reactor to maximize the selectivity of S.

3) (Sutham Sukmanee) (20 points)

For the elementary reactions

$$A \xrightarrow{k_1} R \xrightarrow{k_2} S$$

$$A \xrightarrow{k_3} T$$

Show for CSTR reactor that the space time ($\tau$) to maximize exit concentration of R from the reactor is:

$$\tau_{opt} = \frac{1}{\sqrt{k_2(k_1 + k_3)}}$$

4) (Sutham Sukmanee) (25 points)

The elementary reversible organic liquid-phase reaction

$A + B \rightarrow C$

is carried out adiabatically in a flow reactor. An equal molar feed in A and B enters at 27 °C, and the volumetric flow rate is 2 $dm^3/s$ and $C_{A0} = 0.1$ $mol/dm^3$.

(a) What is the maximum inlet temperature one could have so that the boiling point of the liquid (550 K) would not be exceeded even for complete conversion (5 points)

(b) Calculate the CSTR volume necessary to achieve 85% conversion. (10 points)

(c) Approximate the PFR volume necessary to achieve 85% conversion. (10 points)

*Additional data:*

$\Delta H_A^0 = -20\ \frac{\text{kcal}}{\text{mol}}$ $\quad \Delta H_B^0 = -15\ \frac{\text{kcal}}{\text{mol}}$ $\quad \Delta H_C^0 = -41\ \frac{\text{kcal}}{\text{mol}}$ $\quad T_R = 273$ K

$C_{P_A} = 15\ \frac{\text{cal}}{\text{mol-K}}$ $\quad C_{P_B} = 15\ \frac{\text{cal}}{\text{mol-K}}$ $\quad C_{P_C} = 30\ \frac{\text{cal}}{\text{mol-K}}$

$k = 0.01\ \frac{\text{dm}^3}{\text{mol} - \text{s}}$ at 300 K $\quad E = 10000\ \frac{\text{cal}}{\text{mol}}$ $\quad R = 1.987\ \frac{\text{cal}}{\text{mol-K}}$

5) (Sutham Sukmanee) (15 points)

The first-order irreversible exothermic liquid-phase reaction

$A \rightarrow B$

is to be carried out in a jacketed CSTR. Species A and an inert I are fed to the reactor in equimolar amounts. The molar feed of A is 80 mol/min. Find the reactor temperature for a feed temperature of 450 K.

*Additional data:*

| | |
|---|---|
| Heat capacity of the inert: 30 cal/mol-°C | $\tau = 100$ min |
| Heat capacity of A and B: 20 cal/mol-°C | $\Delta H_{Rx} = -7500$ cal/mol |
| UA: 8000 cal/min-°C | $k = 6.6 \times 10^{-3}$ min$^{-1}$ at 350 K |
| Ambient temperature, $T_a = 300$ K | $E = 40000$ cal/mol |