PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Final Examination: Semester I — Academic Year: 2004

Date: October 1, 2004 — Time: 9:00-12:00

Subject: 230-620 Advanced Engineering Kinetics and Chemical Reactor Design — Room: R300

- อนุญาตให้นำเอกสารและเครื่องคำนวณทุกชนิดเข้าห้องสอบได้
- ทุจริตในการสอบโทษขั้นต่ำคือปรับตกในรายวิชาที่ทุจริตและพักการศึกษา 1 ภาคการศึกษา

Part I

Please do all 2 questions. Show all your work to receive full or partial credit. Total score is 50.

Question #	Total Score	Score
1	20	
2	30	
Total	**50**	

สุกฤทธิรา (บุญเรือง) รัตนวิไล

1. The catalytic reaction $A \rightarrow B$ takes place within a fixed bed containing spherical porous catalyst. Figure 1 shows the overall rates of reaction at a point in the reactor as a function of temperature for various entering total molar flow rates, F_{T0}. (20 points)

   a. Is the reaction limited by external diffusion?

   b. If your answer to part (a) is "yes" under what conditions (T, F_{T0}) is the reaction limited by external diffusion?

   c. Is the reaction 'reaction rate limited'?

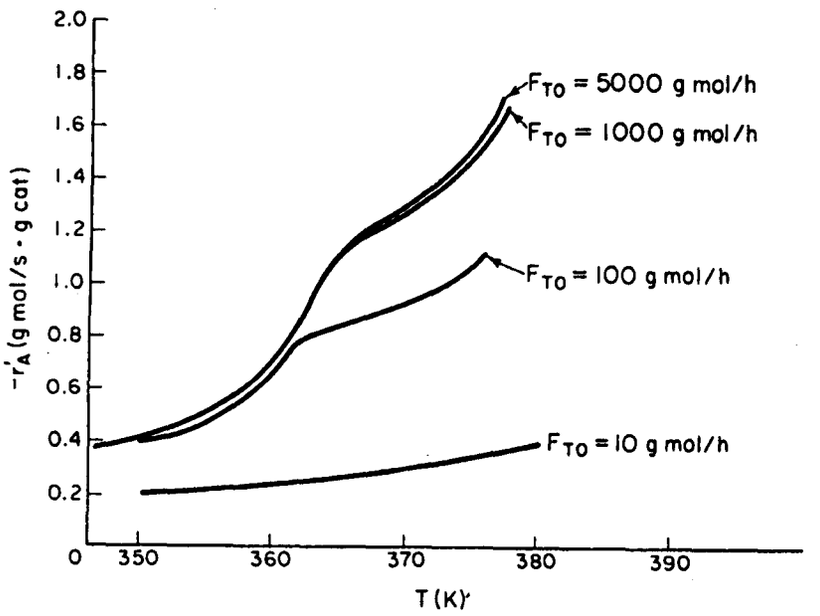
   d. If your answer to part (c) is "yes" under what conditions (T, F_{T0}) is the reaction limited by the rate of surface reactions?

   e. Is the reaction limited by internal diffusion?

   f. If your answer to part (e) is "yes" under what conditions (T, F_{T0}) is the reaction limited by the rate of internal diffusion?

   g. For a flow rate of 10 g mole/h, determine the overall effectiveness factor, Ω, at 360 K.

   h. Estimate the internal effectiveness factor, η, at 360 K



2. A second order, gas phase reaction $2A \rightarrow P$ occurs in a catalyst pellet with rate coefficient and constant parameters; (30 points)

$\rho_p k$	= 6.86 m^3/kmol s	P	= 1 atm
T	= 600 K	D_{AP}	= 0.1 cm^2/s
M_A	= 60	r_o (sphere)	= 9 mm
τ	= 3	S	= 100 m^2/g
ε	= 0.6	ρ_p	= 1.2 g/cm^3

a. Estimate the effective diffusivity if

$D_k = 9.7 \times 10^3 (r_p) T^{1/2} M_A^{-1/2}$ cm^2/s

r_p = mean pore radius, cm

T temperature, K

b. Determine if there are pore diffusion limitations.

c. If part (b) shows pore diffusion limitations, what can be done to eliminate them? Prove, with quantitative calculations that you have eliminated them?

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Midterm Examination Semester I
Date : October 1, 2004
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ทุจริตในการสอบโทษขั้นต่ำคือปรับตกในรายวิชาที่ทุจริตและพักการศึกษา 1 ภาคการศึกษา

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Part II. Non-isothermal Reactor Design

Read instruction carefully before working on your exam

- All documents (i.e., text book, lecture note, home work and old exam) and calculator are allowed
- Exam paper consists of 2 problems with a total points of 80
- Do all problems in provided answer book
  USE YELLOW ANSWER BOOK FOR PART II
- Show all your work to receive full or partial crdit
- The exam paper are not allow to leave the exam room

Problem No.	Total Points	Student achieved Point
1	30	
2	50	
Total	**80**	

1. (30 points)
The endothermic liquid phase reaction

$$A + B \longrightarrow 2C$$

is carried out to **complete conversion** in a CSTR with a steam jacket. From the following data, **calculate the steady state reactor temperature**:

Data: Reactor volume: 125 gal
Steam jacket area: 10 ft^2
Steam temperature: 365.9 °F
Overall heat-transfer coefficient of jacket, U: 150 Btu/h ft^2 °F
Agitator shaft horsepower: 25 hp (= 63,525 Btu/hr)
Heat of Reaction ΔH_R (independent of temperature)= +20,000 Btu/lbmol of A

Other data

	Component		
	A	B	C
Feed (lbmol/hr)	10	10	0
Feed temperature (°F)	80	80	-
Specific heat (Btu/ lbmol °F) independent of temperature	51	44	47.5
Molecular weight	128	94	-
Density (lb/ft^3)	63	67.2	65

2. (50 points)

The elementary irreversible 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. The concentration of A in feed is 0.1 $kmol/m^3$. The additional information are given below:

$H_A^o(298) = -20\,kcal/mol$

$H_B^o(298) = -15\,kcal/mol$

$H_C^o(298) = -41\,kcal/mol$

$C_{PA} = C_{PB} = 15\,cal/mol\,K$ *

$C_{PC} = 30\ cal/mol\,K$ * *** independent of temperature**

$k = 0.01\frac{dm^3}{mol\,s}$ *at* $300K$, $E = 10{,}000\,cal/mol$

a) Calculate the CSTR volume necessary to achieve 85% conversion
b) Calculate the PFR volume necessary to achieve 85% conversion

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End

Good luck and do your best
Charun Bunyakan
September 27, 2004