Name.....Student ID.....

PRINCE OF SONGKLA UNIVERSITY

FACULTY OF ENGINEERING

Final Examination : Semester II | Academic year : 2007

Date : February 19, 2007 | Time : 9.00 – 12.00 am

Subject : 231-322 Chemical Engineering Kinetics and Reactor Design II | Room: R300

ทุจริตในการสอบ โทษขั้นต่ำปรับตกในรายวิชานั้น และพักการเรียน 1 ภาคการศึกษา โทษสูงสุด ให้ออก

1. The exam are not allow to leave an exam room
2. All books, notes, and all computing devices (i.e., calculator and computer) are allowed
3. Do not discuss or ask any person during taking an exam
4. Do all problems, the mark of each problem is listed below

Problem No.	Total Points	Point obtained
1	20	
2	30	
3	15	
4	20	
5	15	
รวม	**100**	

Please note that the exam must consist of 11 pages (including this pages)

Good luck and do your best on the exam

Assoc. Prof. Dr. Charun Bunyakan

Feb 15, 2007

Student ID.....

1. (20 points)

The elementary irreversible organic liquid phase reaction

$$A + B \longrightarrow C$$

is carried out in an existing adiabatic flow reactor. An equal molar feed in A and B enter at 27°C. The volumetric flow rate and C_{AO} are 2 dm^3/s and 0.1 mol/dm^3. The additional information are given below:

$H_A^o(298) = -20\,kcal/mol$, $H_B^o(298) = -15\,kcal/mol$, $H_B^o(298) = -15\,kcal/mol$

$C_{PA} = C_{PB} = 15\frac{cal}{mol\,K}$, $C_{PC} = 30\frac{cal}{mol\,K}$

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

1.1 Calculate the volume of CSTR necessary to achieved 85% conversion of A

1.2 Calculate the volume of PFR necessary to achieved 85% conversion of A

Student ID..... .....

2 (30 points)

The endothermic liquid-phase elementary reaction

$$A + B \longrightarrow 2C$$

proceeds, substantially, to completion in a single steam-jacketed CSTR. From the follow ng data, calculate the steady-state reactor temperature:

Reactor and reaction:

Reactor volume: 125 gal

Steam jacket area: 10 ft^2

Steam temperature: 365.9 °F

Overall heat-transfer coefficient of jacket, U: 150 Btu/(hr ft^2 °F)

Agitator shaft hose power: 25 hp (63,525 Btu/hr)

Heat of reaction, ΔH^o_{Rx} = +20,000 Btu/ lb mol of A (independent of temperature)

Feed condition and feed properties:

Items	Component		
	A	B	C
Feed (lb mol/hr)	10	10.0	0
Feed temperature (°F)	80	80	-
Specific heat Btu/ (lb mol °F)*	51	44	47.5
Molecular weight	128	94	222
Density (lb/ft^3)	63	67.2	65

* Independent of temperature

Student ID..... .....

3 (15 points)

The first order reaction $A \longrightarrow B$ is carried out in packed bed reactor packed with porous solid. The reactions were conducted at different particle sizes (d_p =1,2 and 5 cm). Given that the Thiele modulus of catalyst with d_p = 1 cm is 5

2.1 Estimate the Thiele modulus and the internal effectiveness factor for each particle size.

2.2 Explain what you had learned from the values of the Thiele modulus and the internal effectiveness obtained from 2.1

Given: Thiele modulus for first order reaction is define as

$$\phi_1 = R\sqrt{\frac{-r'_{As}\rho_c}{D_e C_{As}}}$$

Internal effectiveness factor

$$\eta = \frac{3}{\phi_1^2}(\phi_1 \coth\phi_1 - 1)$$

If $\phi_1 > 2$ then $\eta = \frac{3}{\phi_1^2}(\phi_1 - 1)$

If $\phi_1 > 20$ then $\eta = \frac{3}{\phi_1}$

Student ID..... .....

4 (20 points)

The catalytic hydrogenation of methyl linoleate to methyl oleate was carried out in a laboratory-scale slurry reactor in which hydrogen gas was bubbled up through the liquid containing spherical catalyst pellets. The pellet density is 2 g cm^{-3}. The following experiments were carried out at 25°C:

Run	Partial Pressure of H_2 (atm)	Solubility of H_2 (mol dm^{-3})	H_2 Rate of Reaction (mol $dm^{-3}min^{-1}$)	Catalyst Charge (g dm^{-3})	Catalyst Particle Size (μm)
1	3	0.007	0.014	3.0	12
2	18	0.042	0.014	0.5	50
3	3	0.007	0.007	1.5	50

4.1 What is the major resistance?

4.2 What should be taken to reduce such resistance?

Student ID..... .....

5 (15 points)

From problem 4, if the volume of the slurry reactor is 3 m^3, the molar feed rate of methyl linoleate is 0.5 kmol min^{-1}, the catalyst particle size is 80 μm, the partial pressure of H_2 is 15 atm and the reactor is considered to be well mixed, calculate the catalyst charge necessary to achieve 90% conversion of methyl linoleate.