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

PRINCE OF SONGKLA UNIVERSITY

FACULTY OF ENGINEERING

Final Examination : Semester I

Academic year : 2007

Date : 2 October 2007

Time : ~~13.30 - 16.30~~ 9.00 - 12.00 pm

Subject : 230-620 Advance Chemical Engineering Kinetics and Reactor Design

Room: R200

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	20	
4	30	
รวม	**100**	

Please note that the exam consist of 13 pages (including this pages)

Good luck and do your best on the exam

Assoc. Prof. Dr. Charun Bunyakan

September 27, 2007

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1. (20 points)

Answer the following questions

1.1 What if someone had used the false kinetics? Would their catalyst weight be over design or under design? Clearly state your reasons. (10 points)

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1.2 From an example "Reducing Nitrous Oxides in a Plant Effluent" which discussed in class, what if the gas velocity were increased? How would your reactor length change? Explain what other effects would cause it to become larger and what would cause it to become smaller. (5 points)

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1.3 From example "Determining the Controlling Resistance" which discussed in class, what if the temperature were increased. Explain, how would the relative resistance in the slurry reactor change? (5 points)

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2 (30 points)

The first order reaction $A \longrightarrow B$ is carried out in packed bed reactor (5 cm ID tube packed with porous solid). The reactions were conducted at different molar flow rates (F_{TO} = 1,5 and10 mol/s) and particle sizes (d_p =1,2 and 3 cm). The results are shown in Figure 2a and 2b. The feed temperature and pressure were 800 K. There is no pressure gradient along the reactor.

2.1 Determine the limiting step of the reaction.

2.2 Given that the Thiele modulus of catalyst with d_p = 1 cm is 12.5, estimate the Thiele modulus and the internal effectiveness factor for each particle size.

2.3 For the catalyst pellet with particle size of 2 cm in diameter, if the concentration at the external catalyst surface is 100 mol dm^{-3}, calculate the concentration at r=R/2 inside the porous catalyst.

2.4 For the catalyst pellet with particle size of 3 cm, If the internal surface area of catalyst (S_a), the reaction rate constant (k) and the volumetric flow rate of A were 500 m^2/g, 4.1×10^{-3} $m^3 m^{-2} s^{-1}$ and 2×10^{-4} m^3 s^{-1}, respectively, calculate the overall effectiveness factor and the weight of catalyst necessary to obtain 90% conversion of A. (Additional data: bed porosity = 0.7, kinematic viscosity=1.45×10^{-8} $m^2 s^{-1}$, D_{AB} = gas phase diffusivity = 2.55×10^{-8} $m^2 s^{-1}$, bulk density of bed = 1.2×10^6 g m^{-3}, density of catalyst = 3.2×10^6 g m^{-3})

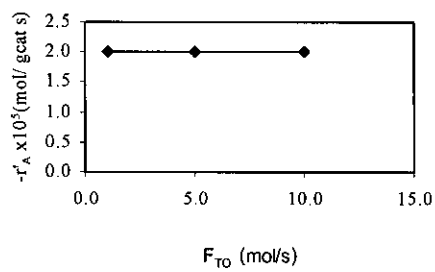

Figure 2a $-r_A'$ vs. F_{TO} at 800 K

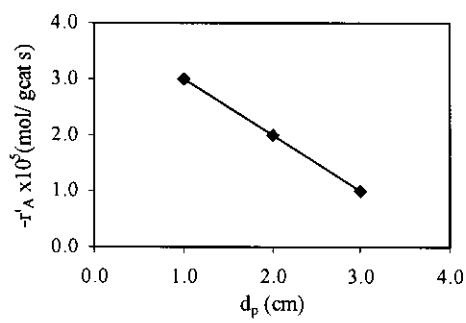

Figure 2b $-r_A'$ vs. d_p at 800 K

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3 (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

3.1 Determine the limiting step

3.2 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.

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4. (30 points)

The hydrolysis of A was carried out in a trickle bed reactor packed with 0.8 cm diameter spherical catalyst particles

$$A(g) + H_2O(l) \longrightarrow B(l)$$

The mixture of gas A in an inert gas in equimolar portions is fed into the reactor at the total pressure of 10 atm, temperature of 400 K and the total molar rate of 5 mol s^{-1}. The reactor diameter is 0.5 m. The superficial liquid mass velocity is 2 kg m^{-2} s^{-1}. The concentration of water is constant. The reaction can be assumed as first order reaction. The pseudo first-order specific reaction rate constant at 400 K is $2x10^{-3}$ m^3 kg cat^{-1} s^{-1}. The pressure drop in reactor is negligible. If the diffusion and reaction in the catalyst pellet is a limiting step, calculate the catalyst weight necessary to achieve 60% conversion of A.

Additional data:

Diffusivity of A in water = $2.5x10^{-8}$ m^2s^{-1}

Solubility of A in water = 0.005 kmol m^{-3} atm^{-1}

Pellet porosity = 0.7

Pellet density = 1500 kg m^{-3}

Tortuosity =1.2, constriction = 0.6