

PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Midterm Examination: Semester I

Academic Year: 2004

Date: August 5, 2004

Time: 9:00-12:00

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

Room: Chemical
engineering's Meeting
Room

อนุญาตให้นำเอกสารและเครื่องคำนวณทุกชนิดเข้าห้องสอบได้

ทุจริตในการสอบโทษขั้นต่ำคือปรับตกในรายวิชาที่ทุจริตและพักการศึกษา 1 ภาคการศึกษา

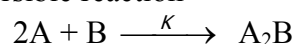
Please do all 6 questions, including bonus. Show all your work to receive full or partial credit. Total score is 120.

Question #	Total Score	Score
1	20	
2	15	
3	15	
4	20	
5	25	
6	25	
Total	120	

ศุภฤทธิรา (บุญเรือง) รัตนวิไล
ผู้ออกข้อสอบ

Macro kinetics

1. The irreversible reaction



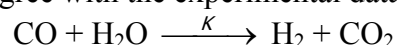
has been studied kinetically, and the rate of formation of product has been found to be well corrected by the following rate equation:

$$r_{A_2B} = \frac{0.72C_A^2C_B}{1 + 2C_A}$$

What reaction mechanism is suggested by this rate expression if the chemistry of the reactions that the intermediate consists of an association of reactant molecules and that a chain reaction does not occur? **(20 points)**

Micro kinetics and Catalysis

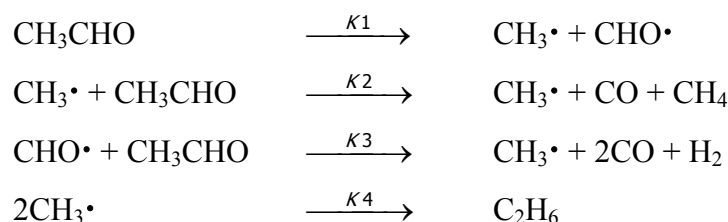
2. CO reacts with H₂O over Fe₂O₃ catalyst to form H₂ and CO₂. The rate has been found to agree with the experimental data and is shown below.



$$-r_{CO}' = \frac{k_1 P_{CO} P_{H_2O} - k_2 P_{H_2} P_{CO_2}}{(1 + k_3 P_{CO} + k_4 P_{H_2O} + k_5 P_{CO_2} + k_6 P_{H_2})^2}$$

Propose an adsorption surface reaction-desorption mechanism (micro-kinetics) and specify the rate-limiting step that will explain rate law. **(15 points)**

3. The pyrolysis of acetaldehyde is believed to take place according to the following sequence **(15 points)**:



- a. Derive the rate expression for the rate of disappearance of acetaldehyde
b. Under what conditions does it reduce to

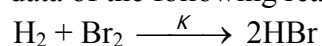
$$-r_{CH_3CHO} = k[CH_3CHO]^{3/2}$$

Conceptual knowledge

4. Answer the following questions in THAI LANGUAGE based on your understanding: **(5 points for each question)**
- What are promoters and inhibitors?
 - What is homopolymer and copolymer? And also classified types of the copolymer.
 - What is the most common types of reversible inhibition occurring in enzymatic reaction please explain and also compare among each type by using graph [graph plots between (-1/r_s) and (1/S), S = substrate]
 - What are the advantages and disadvantages of recirculation transport reactor?

Rate data

5. Initial rate data of the following reaction are in table 1. **(25 points)**



Using some of the data explore the kinetics of a reaction only for

- Over all order of reaction
- Reaction order with respect to individual reactants

Table 1 Initial rate data

$[\text{H}_2]_0$, mol/l	$[\text{Br}_2]_0$, mol/l	$(-r_{\text{H}_2}) \times 10^3$
0.900	0.900	10.9
0.675	0.675	8.19
0.450	0.450	4.465
0.225	0.225	1.76
0.5637	0.2947	4.48
0.3103	0.5064	3.28
0.2881	0.1517	1.65
0.1552	0.2554	1.267

External diffusion

6. A_2 diffuses at steady state from a bulk solution to a catalytic surface, where it dissociates instantaneously to form 2A. Species A then diffuses back into the bulk solution, which contains only A and A_2 . **(25 points)**
- From a differential mole balance on A_2 , derive a differential equation in terms of W_{A_2} . State the appropriate boundary conditions.
 - After determining the proper relationship between W_{A_2} and W_{A} , use expression for a molar flux to substitute for W_{A_2} in the differential equation derived in Part (a)
 - Obtain concentration profile for A_2 .

Solution Problem #4

a. Promoter as a substance added during the preparation on a catalyst which improves activity or selectivity or stabilizes the catalytic agent so as to prolong its life.

Inhibitor is the opposite of a promoter. When added in small amounts during catalyst manufacture, it lessens activity, stability, or selectivity. Inhibitors are useful for reducing the activity of a catalyst for an undesirable side reaction.

b.

1. Homopolymer คือ polymer ซึ่งในโซ่มีหน่วยที่ซ้ำๆกันเพียงชนิดเดียวเท่านั้น เช่น polyethylene, polystyrene

2. Copolymer คือ polymer ซึ่งในโซ่มีหน่วยที่ซ้ำๆกัน 2 ชนิด หรือมากกว่า 2 ชนิด

Copolymer ที่มีหน่วยที่ซ้ำๆกัน 2 ชนิด อาจแบ่งตามลักษณะการจัดเรียง โมเลกุลของหน่วยที่ซ้ำๆกัน ออกได้เป็น

1. Alternating copolymer -A-B-A-B-A-B -A-B-A-B-A-

2. Block copolymer -A-A-A-A-B-B-B-B-A-A-A-

3. Random copolymer -A-A-B-A-B-B-A-B-A-B-B-

4. Graft copolymer -A-A-A-A-A-A-A-A-A-A-
-B-B-B-B-B-B-B-B-

c.

The **three most common types** of reversible inhibition occurring in enzymatic reactions

I. Competitive inhibition: the substrate and inhibitor are usually similar molecules that compete for the same site on the enzyme.

II. Uncompetitive Inhibition: the inhibitor deactivates the enzyme-substrate complex by attaching itself to both the substrate and enzyme molecules of the complex.

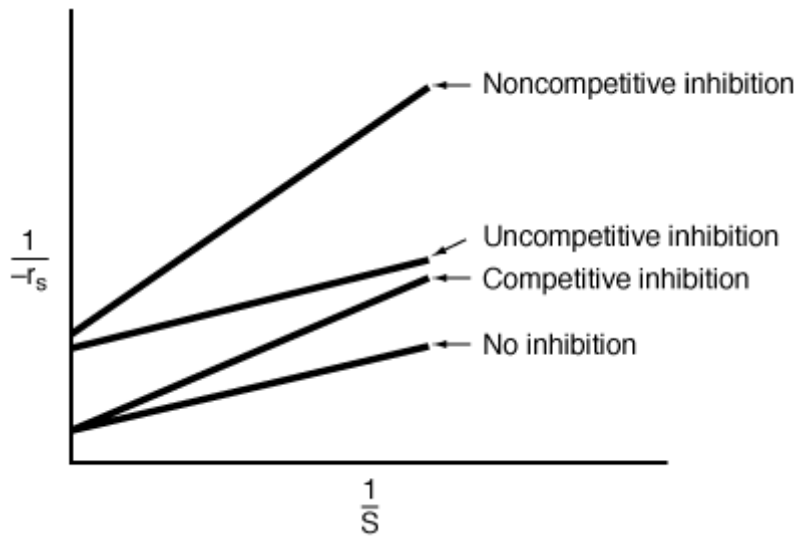
III. Noncompetitive Inhibition: Enzymes containing at least two different types of sites. The inhibitor attaches the only one type of site and the substrate only to the other.

Graph

1. In *competitive inhibition* the slope increases with increasing inhibitor concentration while the intercept remains fixed.

2. In *uncompetitive inhibition* the *y*-intercept increases with increasing inhibitor concentration while the slope remains fixed.

3. In *noncompetitive inhibition* both the intercept and slope will increase with observe the following relationships: increasing inhibitor concentration.



- d. ข้อดี
- ให้ คอนเวอร์ชันสูง
 - ประหยัดตัวเร่งใหม่ที่ใช้
 - มีการสัมผัสกันของตัวเร่งและสารป้อนดีมาก
 - สามารถศึกษาในระดับห้องปฏิบัติการแล้วนำไป
 - ประยุกต์ใช้ ได้ง่ายเนื่องจากมีความคล้ายคลึงกัน และมีข้อมูลทางจลนพลศาสตร์ที่น่าเชื่อถือ
- ข้อเสีย
- ใช้กลไกที่ยุ่งยากกว่า STTR
 - มีค่าใช้จ่ายเกี่ยวกับโครงสร้างและการติดตั้งที่สูงกว่า STTR โดยจะมีส่วนของ recirculating pump หรือ recirculating jet เพิ่มขึ้น
 - อาจพบปัญหาเกี่ยวกับการไหล เช่น มีการอุดตัน