

PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Midterm Examination: Semester I

Academic Year: 2006

Date: August 3, 2006

Time: 9:00-12:00

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

Room: A401

อนุญาตให้นำเอกสารและเครื่องคำนวณทุกชนิดเข้าห้องสอบได้
ทุจริตในการสอบโทษขั้นต่ำคือปรับตกในรายวิชาที่ทุจริต
และพักการศึกษา 1 ภาคการศึกษา

Please do all 4 questions. Show all your work to receive full or partial credit.
Total score is 160. (Total page 3, including first page)

Question #	Total Score	Score
1	50	
2	40	
3	40	
4	30	
Total	160	

สุกฤทธิรา รัตนวิไล
ผู้ออกข้อสอบ

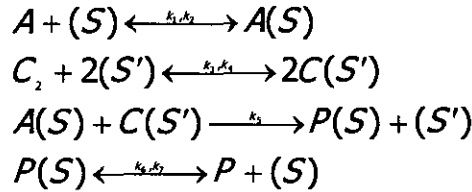
Micro kinetics and Catalysis

1. Propose the mechanisms and find out reaction rate for the following reaction:
Please define all parameters that you need (50 scores)

1.1 $A \rightarrow B + C$:Using Langmuir Hinshelwood Model (10 scores)

1.2 $A + 2B_{(g)} \rightarrow C$:Using Eley-Rideal Mechanism Model (10 scores)

1.3 Using Pseudo Steady State Hypothesis: (10 scores)



S and S' are different active sites

k_1, k_3, k_5, k_6 as forward reaction rate constant

k_2, k_4, k_7 as backward reaction rate constant

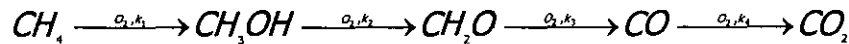
1.4 $A \rightarrow B + C$:Propose **ONE mechanism** which can explain reaction rate of A at both low and high pressures (20 scores)

a. at low pressure, $r_A = k[A]^2$

b. at high pressure, $r_A = k'[A]$

Macro kinetics and analysis data

2. A study of methane oxidation over iron phosphate with hydrogen present in a feed gas. High selectivity to methanol was observed under these conditions at low conversions. The role of H₂ was thought to be in generation of new surface sites active for methanol formation. (40 scores)



Oxygen is a feed gas in all reactions. Consider only data taken in the presence of hydrogen, propose and defend a reaction network for all species in a plug flow reactor. Using data in Tables A evaluate all of the parameters in the first reaction at 713 K.

Table A. Effect of methane partial pressure on methane conversion rate, T = 713K, Pressure of H₂ = 50 kPa, Pressure of O₂ = 8.4 kPa, W/F = 0.208 g h/dm³.

Pressure of CH ₄ (kPa)	Rate x 10 ³ mol (g h) ⁻¹
8.3	2.0
12.4	2.5
17.2	2.8
25.5	4.1
34.5	4.7
42.8	5.3

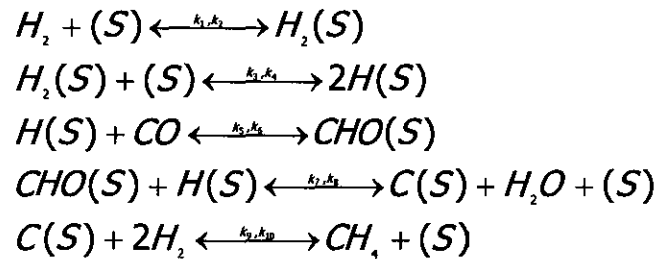
Catalyst and reaction rate

3. Using differential reactor to study the formation of methane from H₂ and CO over nickel catalysts showed reaction rate as following: **(40 scores)**

$$r_{CH_4} = \frac{0.0183 P_{H_2}^{0.5} P_{CO}}{1 + 1.5 P_{H_2}} \text{ mole/(g.cat s)}$$

Propose a mechanism and rate determination step that is consistent with experimental data. Reactor is desired to produce 20 tons/day of CH₄. Calculate the catalyst weights necessary to achieve 80% conversion in CSTR. The feed consists of 75% H₂ and 25% CO at a temperature of 500°F and a pressure of 10 atm.

Suggested mechanism is:



k₁, k₃, k₅, k₇, k₉ as forward reaction rate constant

k₂, k₄, k₆, k₈, k₁₀ as backward reaction rate constant

Conceptual knowledge

4. Answer the following questions in THAI LANGUAGE based on your understanding: **(30 scores)**

4.1 In class, we discussed a lot about how to find out an actual reaction rate from experimental data. Now you have a bimolecular molecule reaction in a batch reactor and would like to correct data to get reaction rate parameter. Please suggest:

- How you correct the data from experiment?
- Which analytical method you expect to use?
- How do you solve for these parameters?
- Can I use method of half-lives to solve? Explain **(20 scores)**

4.2 Write an algorithm for determining reaction mechanism and rate-determining step **(10 scores)**