

PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Midterm Examination: Semester I

Academic Year: 2005

Date: August 3, 2005

Time: 9:00-12:00

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

Room: A401

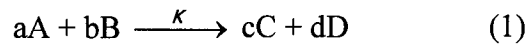
อนุญาตให้นำเอกสารและเครื่องคำนวณทุกชนิดเข้าห้องสอบได้
ทุจริตในการสอบโทษขั้นต่ำคือปรับตกในรายวิชาที่ทุจริตและพักการศึกษา 1 ภาคการศึกษา

Please do all 5 questions. Show all your work to receive full or partial credit.
Total score is 100.

| Question # | Total Score | Score |
|--------------|-------------|-------|
| 1 | 15 | |
| 2 | 20 | |
| 3 | 20 | |
| 4 | 25 | |
| 5 | 20 | |
| Total | 100 | |

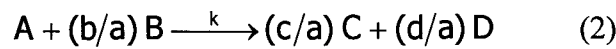
สุกฤทธิรา รัตนวิไล
ผู้ออกข้อสอบ

1. If the irreversible reaction was elementary as written,



the rate expression was $-r_A = kC_A^a C_B^b$

If take A as our basis and divide thoroughly equation (1) by the stoichiometric coefficient of A so that the equation is expressed as

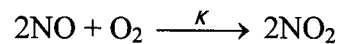


Will the kinetic rate expression then become? Explain in detail. (15 points)

$$-r_A = kC_A C_B^{b/a}$$

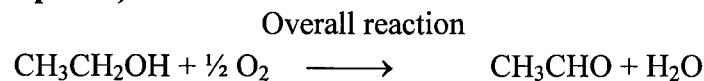
Macro kinetics

2. The gas phase homogeneous oxidation of nitrogen monoxide (NO) with oxygen (O₂) to nitrogen dioxide (NO₂) is known to have a form of third order kinetics which suggests that the reaction is elementary, at least for low partial pressure of nitrogen oxides. However, starting from the fact that an active intermediate species, NO₃, is sometimes observed. In addition, NO₃ is a participant in some other known reactions that involve oxides of nitrogen. What reaction mechanism is suggested based on the above information in reaction of nitrogen monoxide and oxygen? (20 points)

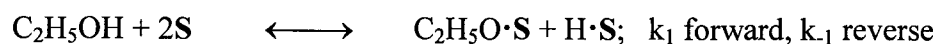


Micro kinetics and Catalysis

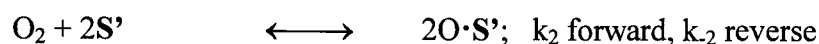
3. The catalytic oxidation of ethanol has been carried out over a tantalum oxide catalyst. (20 points)



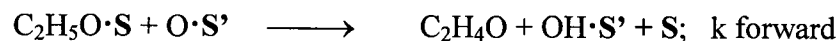
The overall reaction is believed to proceed by the following mechanism in which ethanol is adsorbed on one type of site, S, and oxygen is adsorbed on a different type of site, S'. Ethanol undergoes dissociative adsorption on two S sites:



Oxygen also undergoes dissociative adsorption on two S' sites:



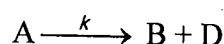
Assuming that the rate-limiting step is



2

Modeling diffusion with reaction

5. The elementary reaction as written,

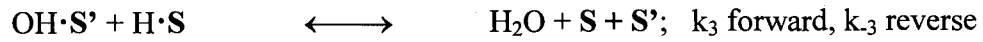


Species A is diffusing at steady state from the bulk fluid through the external surface of catalyst. Develop a mathematical model in term of differential equation based on concentration of A and distance Z for chemically reacting systems in which diffusional effects are important, develop only ODE, no need to solve. (20 points)

assume: mole fraction of A = $y_A = C_A/C_T$, C_T constant total concentration.

BULK

and the adsorbed hydroxyl may be converted into water by



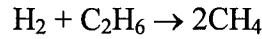
Show that the initial rate law is

$$-r_{A0} = \frac{K P_A^{1/2} P_{O_2}^{1/2}}{(1 + K_{O_2} P_{O_2}^{1/2})(1 + 2K_A^{1/2} P_A^{1/2})}$$

Note: $[\text{H}\cdot\text{S}] = [\text{A}\cdot\text{S}]$, where $\text{A} \equiv \text{C}_2\text{H}_5\text{OH}$, $\text{A}\cdot\text{S} \equiv \text{C}_2\text{H}_5\text{O}\cdot\text{S}$, $\text{W} \equiv \text{H}_2\text{O}$

Rate data

4. The ethane hydrogenolysis over a commercial nickel catalyst was studied in a stirred contained solids reactor. Only hydrogen and ethane are fed to reactor at 300°C

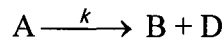


Determine the rate law parameter from the data below. (25 points)

| Total Pressure of Feed (atm) | Pressure Fraction of Ethane and Hydrogen in Feed Stream | | Reaction Rate (disappear of Ethane, g mole/h) -r Ethane |
|------------------------------|---|----------|--|
| | Ethane | Hydrogen | |
| 0.95 | 0.5 | 0.5 | 1.0625 |
| 0.93 | 0.5 | 0.5 | 1.0500 |
| 0.84 | 0.5 | 0.5 | 1.2000 |
| 0.84 | 0.4 | 0.6 | 0.6000 |
| 1.08 | 0.5 | 0.5 | 0.9375 |
| 0.94 | 0.6 | 0.4 | 2.0625 |

Modeling diffusion with reaction

5. The elementary reaction as written,



Species A is diffusing at steady state from the bulk fluid through the external surface of catalyst. Develop a mathematical model in term of differential equation based on concentration of A and distance Z for chemically reacting systems in which diffusional effects are important, develop only ODE, no need to solve.

(20 points)

assume: mole fraction of A = $y_A = C_A/C_T$, C_T constant total concentration.

