Seat No. ☐

King Mongkut's University of Technology Thonburi
Final Examination—2/2556
ChE 343 Chemical Engineering Kinetics & Reactor Design

Date:16 May 2014, 9:00-12:00

Notes:

1. This exam paper includes 5 problems (100 points) in a total of 9 pages.
2. Only one print textbook or one copied textbook is allowed.
3. A calculator is allowed.
4. Do not take any exam materials/papers out of the exam room.

This exam paper has been evaluated and approved by the Department of Chemical Engineering's Committee.

(Assoc. Prof. Dr. Piyabutr Wanichpongpan)
Departmental Chair

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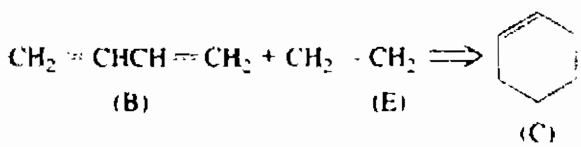
1. (20%)

Butadiene and ethylene can be reacted together to form cyclohexene as follows:



If equimolar butadiene and ethylene (C_B=C_E) at 450 °C and 1 atm are fed to a PFR operating abiabatically, what is <u>the space time</u> necessary to reach a fractional conversion of 0.1?

Data:

$k = 10^{7.5} \exp[-27{,}500/(R_g T)]$ L/mol/s

$\Delta H_r = -30000$ cal/mol

$C_{p_B} = 36.8$ cal/mol/K

$C_{p_E} = 20.2$ cal/mol/K

$C_{p_C} = 59.5$ cal/mol/K

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2. (20%)

The rate of product desorption can also influence the kinetics of a surface-catalyzed reaction. Consider the following simple catalytic cycle:

$$A + S \underset{}{\overset{K_1}{\rightleftarrows}} A \cdot S$$

$$A \cdot S \underset{}{\overset{K_2}{\rightleftarrows}} B \cdot S$$

$$B \cdot S \xrightarrow{k_3} B + S$$

If desorption of B from the surface is rate-determining, then all elementary steps prior to desorption are assumed to be quasi-equilibrated.

Show that the final rate expression of this reaction is as follow:

$$r = \frac{kK_1K_2[\mathrm{A}]}{1+(K_1+K_1K_2)[\mathrm{A}]}$$

3. (20%)

The double bond isomerization of 1-hexene to form 2-hexene was studied in a laboratory reactor containing rhodium particles supported on alumina at 150°C and atmospheric pressure.

$$H_2C{=}CH-CH_2-CH_2-CH_2-CH_3 \Rightarrow H_3C-CH{=}CH-CH_2-CH_2-CH_3$$

The reaction was found to be first order in 1-hexene with a rate constant of 0.14 s^{-1}. The pore radius of the alumina is 10 nm, and D_{AB} is 0.050 $cm^2 s^{-1}$ and the porosity and tortuosity are assumed to be 0.5 and 4, respectively. The molecular weight of hexene (84 g mol^{-1}).

Find the largest pellet size that can be used in an industrial reactor to achieve 70 percent of the maximum rate.

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4. (20%)

In a multiple reaction

$$A = P \qquad R_P = 1.0\ C_A\ (kmol/m^3s)$$

$$2A = S \qquad R_S = 0.5\ C_A^2\ (kmol/m^3s)$$

If the conversion of 98% is desired and the feed contains C_{A0}= 1, C_{P0}=0 (kmol/ms).

Determine the concentration of P (C_P) and the space time in the following cases by keeping the instantaneous yield as high as possible:

4.1) CSTR

4.2) PFR

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5. (20%)

In an experiment of gas solid reaction, we found that the reaction followed the unreacted shrinking core model. If the particle size was doubled ($R \rightarrow 2R$) then the time for complete conversion (t^*) was increased three times ($t^* \rightarrow 3t^*$).

Find the contribution of ash diffusion to the overall resistance in these cases:

5.1 $\dfrac{\text{Ash } \textit{Resistance} \; (\textit{if particle size} = R)}{\textit{Overall resistance} \; (\textit{if particle size} = R)}$

5.2 $\dfrac{\text{Ash } \textit{Resistance} \; (\textit{if particle size} = 2R)}{\textit{Overall resistance} \; (\textit{if particle size} = 2R)}$