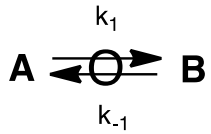
ChE-403 Problem Set 3.3

Week 12

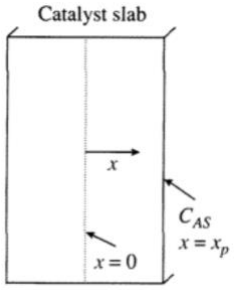
Problem 1

Consider the following first order reversible reaction in a continuous reactor.



With $K = \frac{k_1}{k_{-1}}$ and $C_A(initial) = C_{A,0}$ and $C_B(initial) = 0$

The catalyst pellets are the form of slabs:

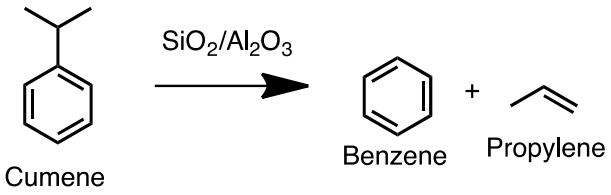


Assume that we are at low conversion and that there is no external mass transfer limitations so that $C_{A,0} = C_{AS}$.

a) Write the internal mass transfer balance for this reaction, determine the Thiele modulus after making putting it in dimensionless form and propose appropriate boundary conditions.
*Hint: Here you want to write the rate as the simplest possible way in the form of r=cst*f(C_A). Choose C_A' according to the form of f(C_A).*

b) Solve this differential equation and give an expression for C_A.

Problem 2
Cumene cracking on silica-alumina is a pseudo-first order reaction:



The observed first order rate constant was measured to be 0.80 $cm^3/(s\ g_{cat})$. Is this value the true rate constant (or close to it) or is there significant effects of pore diffusion?

We have determined that external mass transfer can be ignored.

We have this additional data:

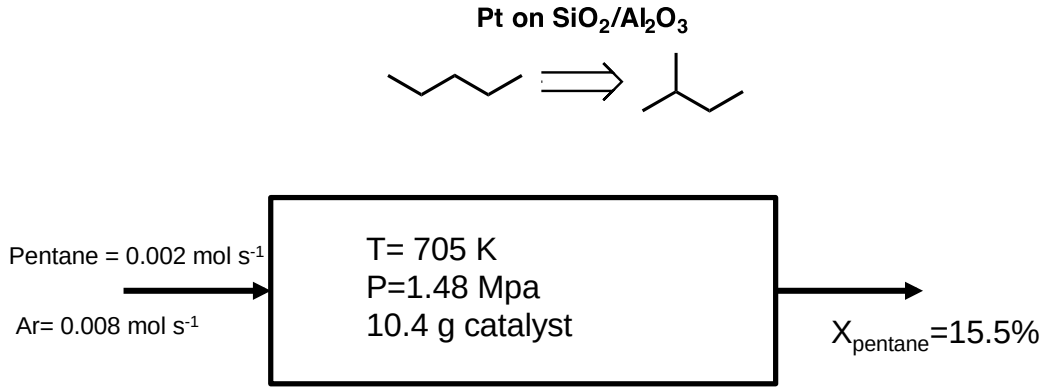
$R_p = 0.25\ cm$

$\rho = 1.2\ g_{cat}\ cm^{-3}$

$D_{TA}^{e} = 1\ 10^{-3} cm^2 s^{-1}$

Problem 3

The catalytic cracking of pentane to isopentane was accomplished in an isothermal continuous flow reactor containing a supported platinum catalyst on SiO_2/Al_2O_3:



The reaction has an effectiveness factor of 0.42.

Assuming the reaction is first-order in pentane and the diffusivity is primarily of the Knudsen type, estimate the tortuosity $\bar{\tau}$ of the perfectly spherical catalyst pellets that have a diameter of 3.2 mm. You can assume that the gases act ideally and that the catalyst has uniform cylindrical pores. You can also assume that the pentane concentration in the reactor is an average of the incoming and outgoing concentration and that external mass transfer can be neglected.

Additional data:

Pore volume of the catalyst: 0.48 $cm^3\ g^{-1}$
Surface area of the catalyst: 240 $m^2\ g^{-1}$
Pellet density: 1.332 $g\ cm^{-3}$
Pellet porosity: 0.59