CHEG 321: Chemical Reaction Engineering I Due: 10/19/07

Homework #6: Reaction and Diffusion Analysis

1. Reaction and Diffusion in a Spherical Pellet w/ External Mass Transfer Limitations

(a) Derive the relationship between dimensionless concentration and position for the case of reaction and diffusion in a spherical catalyst with finite external mass transfer.
(b) Plot concentration within the pellet for ϕ = 0.1, 0.2, 0.5, 1, 2, 5, 10 if Bi_m = 100.
(c) Plot concentration within the pellet for ϕ = 0.1, 0.2, 0.5, 1, 2, 5, 10 if Bi_m = 10.
(d) Plot concentration within the pellet for ϕ = 0.1, 0.2, 0.5, 1, 2, 5, 10 if Bi_m = 1.
(e) Plot effectiveness as a function of ϕ, for Bi_m = 100, 10, 1.

2. Reaction and diffusion within a Cartesian slab with non-elementary kinetics.

Consider reaction and diffusion within a Cartesian slab following unimolecular reaction following Langmuir-Hinshelwood kinetics,

$$r = \frac{kA}{1+KA}, \qquad D_e \frac{dA^2}{dx^2} = r(A).$$

(a) Derive the dimensionless differential relationship between concentration and position, assuming steady-state reaction and diffusion.
(b) Assuming symmetry within the catalyst and negligible external mass transfer resistance, and p = 2, KA_o = 5, solve for the concentration profile within the pellet. You may use any numerical solver you wish – Matlab, Polymath, or even Excel.
(c) Using your solution from part (b), calculate the catalyst effectiveness.
(d) Repeat parts (b,c), if ϕ = 0.1.

Consider reaction and diffusion within a Cartesian slab following power-law kinetics of order [-1].

(a) Derive the dimensionless differential relationship between concentration and position, assuming steady-state reaction and diffusion.
(b) Assuming symmetry within the catalyst and negligible external mass transfer resistance, solve for the concentration profile within the pellet if ϕ = 1.
(c) Using your solution from part (b), calculate the catalyst effectiveness.