A First Course on Kinetics and Reaction Engineering

Activity 39.1

Suppose that pure gas phase A reacts with a solid, non-porous, spherical particle of B (radius 0.5 cm, 0.3 mol cm^{-3}), yielding porous solid product Z, as in equation (1). Further assume that the porosity of Z and the effective diffusion coefficient for diffusion of A through Z are constants. If the gas phase concentration of A is 0.01 mol L^{-1} and its effective diffusion coefficient in Z is 3 x 10^{-7} cm^2 s^{-1}, show how to calculate the radius of the unreacted core of B as a function of time if the reaction is effectively instantaneous and the pseudo steady state assumption applies.

$$A_{(g)} + B_{(s)} \rightarrow Z_{(s)} \qquad (1)$$

Problem Solution

Read through the problem statement and each time you encounter a quantity, assign it to the appropriate variable.

Will the concentration of B in the core change over time? Why (not)?

Knowing that the concentration of B in the core is constant, use geometry to relate the total moles of B in the core to the radius of the core

Use that relationship to relate the rate of change in the total moles of B in the core to the rate of change in the core radius

What initial condition is needed to solve this equation?

What quantities are needed in order to solve the equation and are they available?

How can the values of the missing quantities be calculated?

The flux of A, or equivalently the radial gradient in the concentration of A within the shell, can be found using a mole balance on A within the shell; write that mole balance making the pseudo steady state assumption

What are the boundary conditions needed to solve the mole balance on A in the shell?

What is needed to solve this equation, and is that information available?

If the mole balance on A in the shell cannot be solved independently, can it be solved simultaneously with the equation for the core radius? If so, describe how.