Advanced Transport Phenomena 1

ChE 862 **April 24, 2019** **Spring 2019**

Due: May 1, 2019

The removal of a problem species "A" from a gas stream can often be accomplished in a spray tower by absorption into the individual droplets. In this exercise we will examine the removal of SO_2 *from a gas stream; liquid droplets are formed by spray nozzles at the top of the column and the gas is introduced at the bottom. The water droplets are spheres with* $R=0.2$ *cm and the diffusivity of* SO_2 *in water is about* $1.9\text{x}10^{-5}$ cm^2/s*. The solubility of* SO_2 *in the absorbent liquid is about 213 g/liter.*

In the interior of the spherical droplet the concentration of the absorbate will be governed by

$$\frac{\partial C_A}{\partial t} = D_{AB}\left[\frac{\partial^2 C_A}{\partial r^2} + \frac{2}{r}\frac{\partial C_A}{\partial r}\right].$$

We will ignore several important complications in our analysis: the diffusivity in this system is pH-dependent, a droplet this size will not be perfectly spherical, motion relative to the gas stream will induce circulation inside the droplet, the interfacial composition will not be the same as the solubility, the absorption process is slightly exothermic, and it is possible that contaminants will significantly hinder mass transfer. See Hixson and Scott (*Industrial and Engineering Chemistry*, 27:307, 1935) for a historical perspective of SO_2 absorption in spray towers.

Determine the *total uptake* of SO_2 by an individual droplet as a function of exposure time in the column; present your results in a graph illustrating the total gmols absorbed per droplet versus time. If 1000 droplets per second are introduced into the top of the column, and each droplet spends 30 s exposed to the gas flow, how much SO_2 will be removed per hour? Obviously the capture of SO_2 could be increased by constructing a taller column. Would you recommend this?