ChEg 356
Spring 2005
Multiphase mass transfer problems

This problems given here are based on http://www.nd.edu/~mjm/mass_transfer/MT_multiphase.html or http://www.nd.edu/~mjm/MT_multiphase.nb, if you like Mathematica notebooks. So you will need to refer to these as you are solving the problems.

Note that you don't need to make one m-file to do everything. You just need to solve the questions that are asked.

1. **Solid- liquid mass transfer. (Make sure you also read the "Overview").**

If we have a situation where the area is constant and a pure solid is dissolving in a liquid, then the driving force will change as more solid dissolves. The equation to solve is

$$V^I \frac{dC_A{}^I}{dt} = -K_m\, a\,(C_A{}^I - C_{As}{}^I).$$

I show in the notebook that this has an analytical solution.

a. Use my numbers to solve this problem numerically
b. Plot your numerical solutions on the same plot as the analytical solution and comment on any difference.

2. Liquid-liquid extraction.

This problem is based on 8.8 from Russell and Denn's notes.

I want you to solve simultaneously, the component mass balances for octanoic acid in water and in xylene. To track the concentration as a function of time in both phases. Note that you may have already solved this analytically by substituting and getting one equation. I want you to avoid doing the substitution and just solve both equations together. Use the K_m a, and all other numbers you need from the problem.

a. Plot and compare the results of your calculation with the analytical solution.

b. Explain why you need to solve only the two "component" mass balances for this problem, that is, why don't you need the overall balance for either phase?

3. **Sugar dissolving problem.** This is based on the Mathematica notebook and HTML as given above.

Start by using my numbers for T = 25C.

a. Solve simultaneously the balance for the sugar phase and the concentration of sugar in the water phase. (Just as I have done with the "magic" integrator). You can use Euler integration or one of the ODE solvers in Matlab (e.g., ODE45), if you can figure it out.
b. Plot the results for concentration versus time and volume versus time. If you can, make these subplots of the same window!
c. Repeat your calculation, but now assume the sugar is "pelletized" and you are dissolving 10 kg of spherical pellets of sugar with a radius of 1 cm, into 10 Kg of water. Use the <u>best</u> numbers for K_m and other quantities you can get from the discussion I give in the HLML or Mathematica.
d. Compare the timescale of your calculation with the estimated time scale that I show in some of my calculations. Does it match? Comment on this.
e. Explain why you need to solve this one numerically, even if problem **2** could have been solved analytically.

4. Salt dissolving.

You wish to continuous produce a salt brine at 30C that is 90% by weight of saturation. The mass flow rate of the brine should be 100 kg/min.

a. Specify a tank size if the feed is "rock salt". You can stir it if you wish. Give rationale for your solution.
b. If the salt is available as granular table salt, how big would you make the tank? Explain the difference.

5. Solve the problems at the end of the tumor calculations notebook, Kill_tumor_2.nb, http://www.nd.edu/~mjm/cheg_356/kill_tumor_2.nb