Problem 9.5

A small pond is h = 1 m deep with a surface area A. Three chemicals are spilled into the pond and rapidly mixed over the volume. The chemicals are the pesticide Lindane (w/ Henry's Law constant $H_L = 2.2 \times 10^{-5}$), the solvent Toluene ($H_T = 0.28$), and Napthalene ($H_N = 0.04$). Assume that mixing is sufficient to maintain a uniform concentration of each chemical within the bulk of the lake volume, i.e. below the laminar sub-layer at the surface.

Molecular diffusivity in air, $D_a = 10^{-5}\ m^2 s^{-1}$ for all chemicals

Molecular diffusivity in water, $D_w = 10^{-9}\ m^2 s^{-1}$ for all chemicals

Turbulent diffusivity in water, $D_{tw} = 10^{-3}\ m^2 s^{-1}$

Waterside laminar sub-layer, $\delta_w = 100\ \mu m$

Airside laminar sub-layer, $\delta_a = 10\ mm$

a) Sketch the profile of C (z) for each chemical. Indicate the concentration at z = 0, the air-water interface; at $z = -\delta_w$; at $z < -\delta_w$; and at $z = +\delta_a$. Assume that the atmosphere is a perfect sink for each chemical, such that $C_a = 0$ for $z > +\delta_a$.

b) Write an equation for the mass flux at the air-water interface for each chemical.

c) For each chemical determine the time at which only 5% of the original mass remains.

d) For which chemicals is the assumption of a uniform concentration within the bulk fluid appropriate?