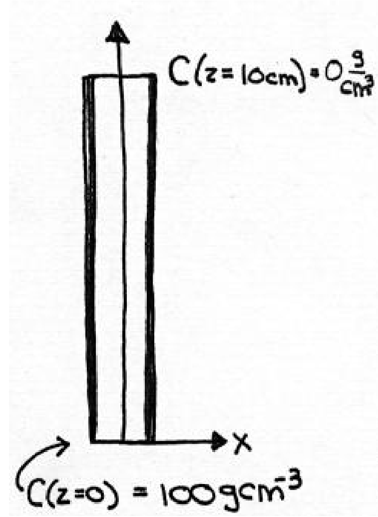
1.061 / 1.61 Transport Processes in the Environment
Fall 2008

Problem 1

A circular tube is filled with still water. The concentration at each end of the tube is maintained at a constant value. Estimate the magnitude and direction of mass flux through the tube. The cross-section is $A = 1\,cm^2$, and diffusion is molecular, $D = 10^{-5}\,cm^2 g^{-1}$.

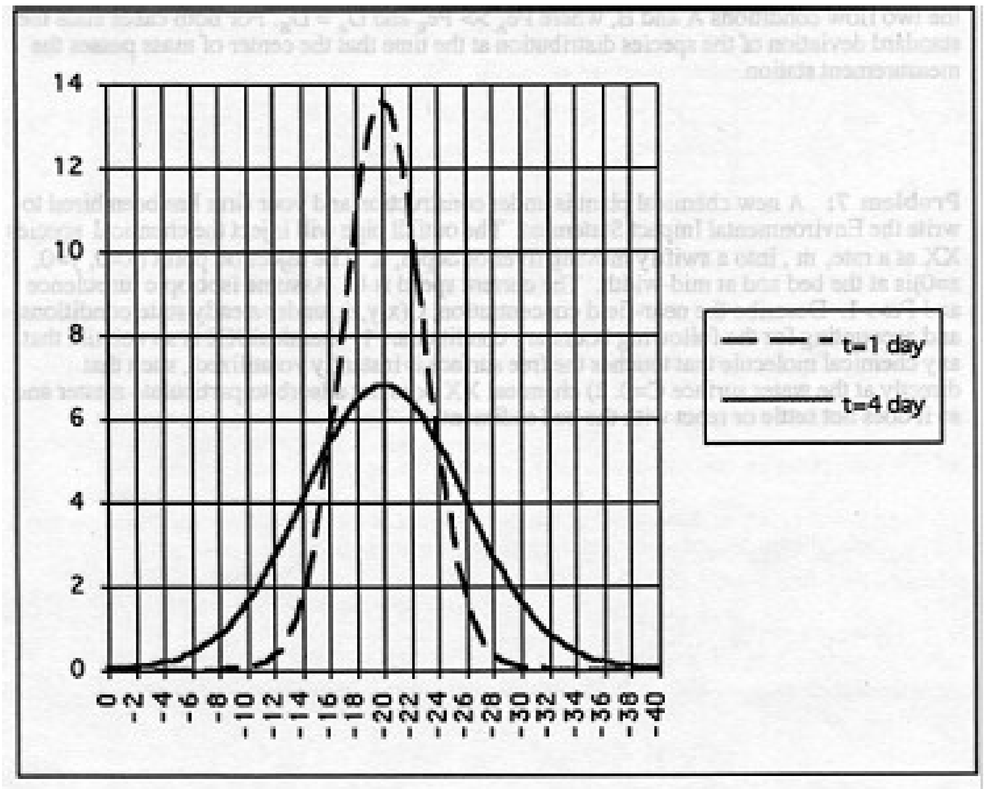


Problem 2

Based on the conceptual model for diffusion, how might molecular diffusivity, D, change with temperature and molecule size?

Problem 3

As part of a water quality study, you have been asked to access the diffusion of a new fluorescent dye. To accomplish this, you do a dye study in a laboratory tank (h = 40 cm). You release 100g of the dye at a depth of 20 cm (spread evenly over the area of the tank) and monitor its development over time. Vertical profiles of dye concentration in the tank are shown in the figure below; the x-axis represents depth and the y-axis represents the reading on your fluorometer.



Question 1

Estimate the diffusion coefficient of the dye, D, based on the evolution of the dye cloud.

Question 2

Predict at what time the vertical distribution of the dye will be affected by the boundaries of the tank.

Problem 4

An infinitely long cylinder with a diameter of 10 cm is filled with a stationary fluid. A mass input ($M = 0.1\, g\, CO_2$) is introduced instantaneously at $t = 0$ and uniformly at the center of the tube ($x = 0$). Find the time for the CO_2 to reach a concentration (mass fraction) of 1 ppm at $x = 50\, cm$ for

i) Molecular diffusion in air.

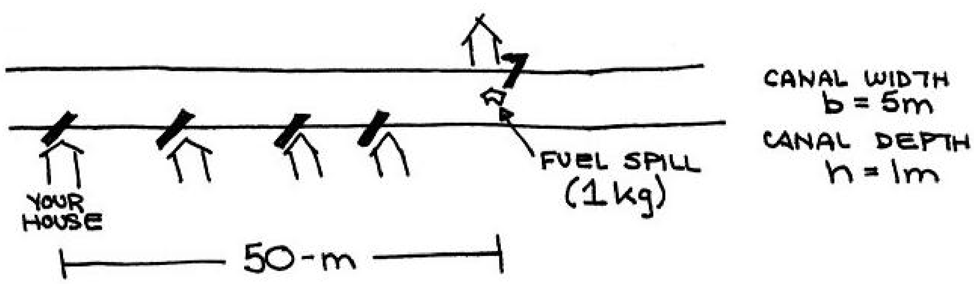
ii) Molecular diffusion in water.

Note:

(a) the densities of air and of water are 1.23 and 1000 kg/m^3 *respectively*

(b) the diffusion coefficient of gaseous carbon dioxide is $0.14\, cm^2/s$ *in air and* $1.71 \times 10^{-5}\, g/cm^3$ *in water*

Problem 5



You own a house and dock along a long boat canal. One day your neighbor has a small fuel spill. Due to the boat traffice, the diffusivity in the canal is quite high, $D = 0.01\, m^2/s$. The current in the canal is negligible, such that the fuel is transported to your house by diffusion only. Assume the fuel mixes rapidly across the width and depth.

A) How long does it take for the spilled fuel to reach your house?

B) For the time found in A), what is the concentration at your house?

C) What is the maximum concentration at your house?