Separative Transport

(Chapter 3—01/28/2015)

1. Transport is drive by equilibrium

2. Mechanical and molecular transport:

Mechanical driving force = $-\frac{dp}{dx}$ **, where p stands for potential energy**

Molecular driving force = $-\frac{d\mu}{dx}$ **, where μ stands for chemical potential**

Newton's law: F = am

3. Molecular transport

Newton's law: **F = am**

$$M\frac{d^2x}{d^2t} = -\frac{d\mu}{dx} - f\frac{dx}{dt}$$, where M is molecular weight (Single molecule)

Note that d^2x/d^2t is effectively zero under most circumstance because of the strong friction force.

f = 6πη a, where a is radius of a particle: (Stokes Law; Stokes' drag)

$$-\frac{d\mu}{dx} = f\frac{dx}{dt}$$

Description of Multiple Molecular Transport

J = U c, U is mean molecular velocity and c is for concentration

J is flux density.

$$\overline{U} = \overline{\frac{dx}{dt}} = -\frac{1}{f}\frac{d\mu}{dx}$$

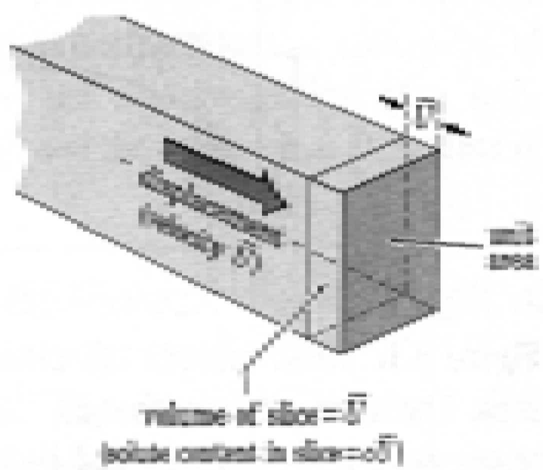


Figure 3.2. For tube of unit cross section, all solute within the slice of volume Ū is swept out of the tube in 1 s.

$$\mu = \mu^{ext} + \mu^{0} + RT \log c$$

J = U c – D (dc/dx), **U designates the mean displacement volocity caused by the external fields and chemical potential (internal).**

D = RT/f Nernst-Einstein equation.

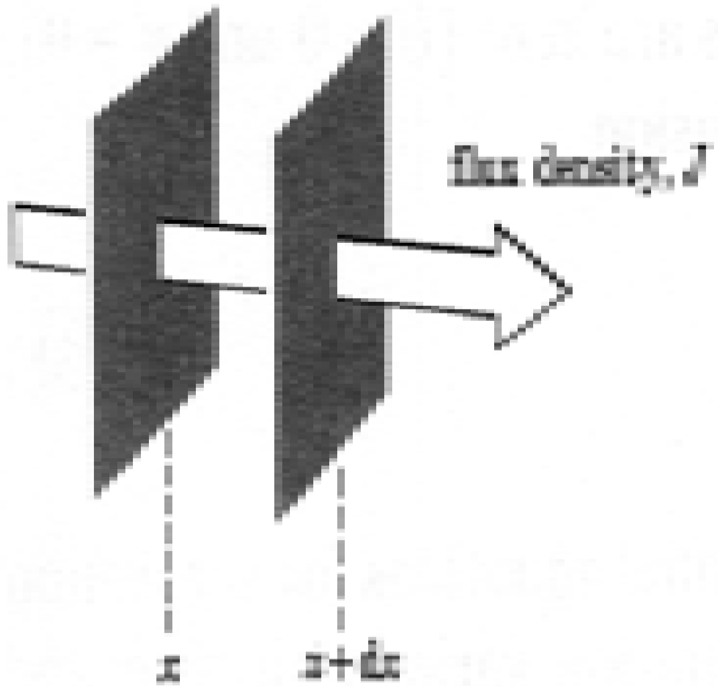
4. Transport with Flow

J = (U+v) c – D (dc/dx),

v: flow rate

J = D (dc/dx), Fick's fist law (diffusion)

J = (U+v) c – D (dc/dx),



$$\frac{dc}{dt} = -W\frac{dc}{dx} + D\frac{d^2c}{d^2x} = -(U+v)\frac{dc}{dx} + D\frac{d^2c}{d^2x}$$

Figure 3.3. Movement of solute a
planes of unit area.

$J_x - J_{x+dx}$ = molecules gained /s,

Summary

• **Molar flux density:**

$J = W c - D(dc/dx)$,

where **$W \equiv U + v$**. (Quantity W is simply the sum of all direct displacement velocities– those caused by bulk displacement at velocity v plus those caused by chemical potential gradients which impel solute at velocity U .

$J = D (dc/dx)$, Fick's fist law (diffusion)

• **Concentration Changes:**

$dc/dt = -W (dc/dx) + D(d^2c/dx^2)$

$dc/dt = D(d^2c/dx^2)$ **Fick's second law (diffusion)**

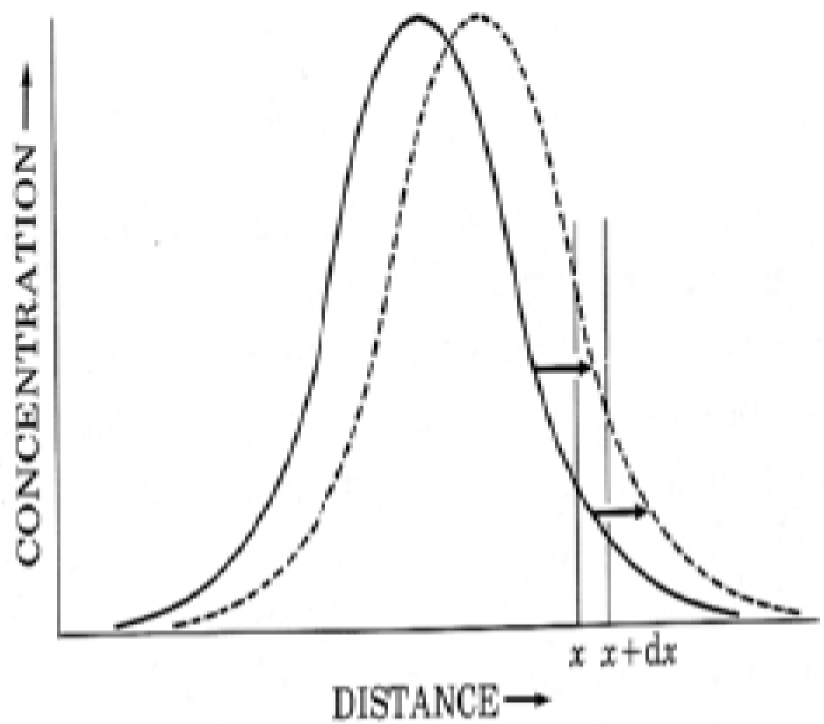


Figure 3.4. Bell-shaped concentration curve and its displacement right d
and/or field-induced drift at velocity *W*. The displacement of solute in :
region *dx* is shown by arrows.

Homework: Chapter 3.8

Estimate the molecular weight of bushy stunt virus, density 1.35 g/cm^3.
Its diffusion coefficient in water at 20 ^oC is 1.15 x 10^{-7} cm^2/s. At this temperature the viscosity of water is 0.0100 poises. Assume that the virus is spherical in shape.

Homework: Chapter 3.9

Hemoglobin, MW 68,000, diffuses into water at a rate governed by
D = 6.90 x 10^{-7} cm^2/s at 20 ^oC, at which temperature water's viscosity is 0.0100 poises.

(1)What is the Stokes' law radius of the molecule?
(2)What is the radius calculated on the basis that the molecule is sphere whose density of 1.33 g/cm^3
(3)If the discrepancy in (a) and (b) were due to a hydration shell moving along with the hemoglobin molecule, what would the shell thickness be? What would the MW of the total cluster be, assuming the hydration shell to have unit density.