BEH.360/10.449J
Fall 2002

Mass Transfer Notation

We will use a mass transfer notation that differs slightly from that presented in the handout from Cussler. Our notation is a bit more detailed and follows that used in the 10.302 text 'Fundamentals of Heat & Mass Transfer" by Incropera & Dewitt.

C_A = molar concentration of component *A*, (mol/L, mmol/L, etc.)

C = total molar concentration of all species = $\sum_{i=1}^{n} C_i$

x_A = mole fraction of component *A*

ρ_A = mass concentration of component *A* (gm/L, mg/mL, etc.) = $M_A C_A$

ρ = total mass concentration of all species = $\sum_{i=1}^{n} \rho_i$

m_A = mass fraction of component *A*

D_{AB} = diffusion coefficient of A in B (cm^2/s, m^2/s, etc.)

FICK'S LAW (DIFFUSIVE FLUX OF COMPONENT A)

Fick's law gives the diffusive flux relative to the average velocity of the fluid mixture. In the absence of any convective transport (velocity = 0), the diffusive flux and total flux are the same. Flux = rate of mass transfer per unit surface area normal to the direction of transport; units are mol/cm^2-s or gm/cm^2-s.

In terms of <u>molar</u> flux (mol/cm^2-s):	In terms of <u>mass</u> flux (gm/cm^2-s):
$J_A^* = -CD_{AB}\nabla x_A$	$j_A = -\rho D_{AB}\nabla m_A$
if C is constant: $J_A^* = -D_{AB}\nabla c_A$	if ρ is constant: $j_A = -D_{AB}\nabla \rho_A$
for one-dimensional diffusion: $J_A^* = -D_{AB}\dfrac{dc_A}{dx}$	for one-dimensional diffusion: $j_A = -D_{AB}\dfrac{d\rho_A}{dx}$

MASS FLUX RELATIVE TO STATIONARY COORDINATES

Fick's law applies to diffusion relative to the average velocity of the fluid.
Diffusion relative to stationary coordinates is as follows:

In terms of <u>molar</u> flux (mol/cm^2-s):	In terms of <u>mass</u> flux (gm/cm^2-s):
$N''_A = J^*_A + C_A v^* = -CD_{AB}\nabla x_A + C_A v^*$	$n''_A = j_A + \rho_A v = -\rho D_{AB}\nabla m_A + \rho_A v$
where v^* = molar average velocity of fluid:	where v = mass average velocity of fluid:
$v^* = x_A v_A + x_B v_B$	$v = m_A v_A + m_B v_B$
total molar flux relative to stationary coordinates:	total mass flux relative to stationary coordinates:
$N'' = N''_A + N''_B = Cv^* = C_A v_A + C_B v_B$	$n'' = n''_A + n''_B = \rho v = \rho_A v_A + \rho_B v_B$

DIFFERENCES BETWEEN THIS NOTATION AND THAT OF CUSSLER

Cussler uses the following notation, which I find a bit more vague

J_1 = diffusive molar mass transfer rate, mol/s (NOT a flux! even though it says so in the book). The "1" subscript denotes it is for the 1-dimensional case (the "1" does not help us figure out which direction"

j_1 = diffusive molar mass flux, mol/cm^2-s (Note -- a flux is a rate per unit area, so the statement in Cussler that j_1 is a "flux per unit area" is semantically flawed.)

n_1 = total molar or mass transfer rate relative to stationary coordinates

v = mass average velocity of fluid

v* = molar average velocity of fluid

CORRECTION OF LIQUID DIFFUSION COEFFICIENTS FOR TEMPERATURE

$D_{AB,Temp2} = D_{AB,Temp1}\frac{T_2\mu_1}{T_1\mu_2}$ where μ_1 and μ_2 are the solvent viscocities at temperatures T_1 and T_2.