FDE 307
Mass Transfer and Unit Operations

CONVECTIVE MASS TRANSFER

- Convective mass transfer involves the transport of material between a boundary surface and a moving fluid or between two immiscible moving fluids separated by a mobile interface.
- There are two different cases of convective mass transfer:

1. Mass transfer takes place only in a single phase either to or from a phase boundary, as in sublimation of naphthalene (solid form) into the moving air.
2. Mass transfer takes place in the two contacting phases as in extraction and absorption.

- The rate equation for convective mass transfer, generalized in a manner analogous to Newton's law of cooling, is

$$N_A = k_c \Delta C_A$$

- where N_A, is the molar-mass flux of species A, Δc_A is the concentration difference between the boundary surface concentration and the average concentration of the diffusing species in the moving fluid stream, and k_c is the convective mass-transfer coefficient.

CONVECTIVE MASS TRANSFER COEFFICIENTS

- If there is a solute which dissolves into a moving fluid, the convective mass transfer coefficient can be defined as

$$N_A = k_c (C_{As} - C_A)$$

- where N_A represents the moles of solute A leaving the interface per unit time and unit interfacial area, c_{AS} represents the composition of the solute in the fluid at the interface, and the quantity c_A represents the composition at some point within the fluid phase. The convective mass transfer coefficient k_c is a function of geometry of the system and the velocity and properties of the fluid similar to the heat transfer coefficient, h.

- Since the concentration can be defined in terms of mole fraction for a liquid or a gas and in terms of pressure for a gas, the equation for convective fluxcan be rewritten in several ways.
- For gases:

$$N_A = k_c^{'}(C_{A1} - C_{A2}) = k_G^{'}(p_{A1} - p_{A2}) = k_y^{'}(y_{A1} - y_{A2})$$

- For liquids:

$$N_A = k_c^{'}(C_{A1} - C_{A2}) = k_L^{'}(C_{A1} - C_{A2}) = k_x^{'}(X_{A1} - X_{A2})$$

- For the case of A diffusing through stagnant B ($N_B=0$) for steady state conditions;

$$N_A = \frac{k_c^{'}}{X_{BM}}(C_{A1} - C_{A2}) = k_c(C_{A1} - C_{A2})$$

- For gases:

$$N_A = k_c(C_{A1} - C_{A2}) = k_G(p_{A1} - p_{A2}) = k_y(y_{A1} - y_{A2})$$

- For liquids:

$$N_A = k_c(C_{A1} - C_{A2}) = k_L(C_{A1} - C_{A2}) = k_x(X_{A1} - X_{A2})$$

Table. Conversions between mass transfer coefficients

Gases	$k_c' C = k_c' \frac{P}{RT} = k_c \frac{p_{BM}}{RT} = k_G' P = k_G p_{BM} = k_y y_{BM} = k_y' = k_c y_{BM} c = k_G y_{BM} P$
Liquids	$k_c' C = k_L' C = k_L X_{BM} C = k_L' \rho / M = k_x' = k_x X_{BM}$ ρ:density of liquid M:molecular weight

Table. Units of mass transfer coefficients

	SI Units	Cgs Units	English Units
$k_c, k_L, k_c^{'}, k_L^{'}$	m/s	cm/s	ft/h
$k_x, k_y, k_x^{'}, k_y^{'}$	$\frac{kgmol}{s \cdot m^2 \cdot molfrac}$	$\frac{gmol}{s \cdot cm^2 \cdot molfrac}$	$\frac{lbmol}{h \cdot ft^2 \cdot molfrac}$
$k_G, k_G^{'}$	$\frac{kgmol}{s \cdot m^2 \cdot Pa}$ or $\frac{kgmol}{s \cdot m^2 \cdot atm}$	$\frac{gmol}{s \cdot cm^2 \cdot atm}$	$\frac{lbmol}{h \cdot ft^2 \cdot atm}$