Ch 9.8 - Diffusion

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author: Clayton Johnson

date:

autosize: true

Cylinder

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Now, we want to relate the concentration at equilibrium in a linear geometry,

$$

\frac{d^2C}{dx^2} = 0,

$$

to cylindrical geometries:

$$

\frac{d}{dr} \left( r \frac{dC}{dr} \right) = 0.

$$

Note that $r$ is present since the area through which diffusion occurs changes with the distance from the center in this cylindrical geometry.

Spherical

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Following similar logic as the movement from a linear to cylindrical geometry, we see the addition of another factor of $r$ for spherical geometries.

$$

\frac{d}{dr} \left( r^2 \frac{dC}{dr} \right) = 0.

$$

What happens if we add an additional source/sink of particles into the system at distance $r$ from the center of the sphere?

Volumetric Mass Source

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Assuming volumetric mass source at distance $r$ from the center, we have that

$$

D \frac{1}{r^2} \frac{d}{dr} \left( r \frac{dC}{dr} \right) + M(r) = 0,

$$

where $D$ is the diffusion coefficient and $M(r)$ is the rate of the 'production' of mass, in $\frac{kg}{m^3 s}$.

Note that $M(r) \gt 0$ and $M(r) \lt 0$ with the addition and removal of mass, respectively.