- High $T$, $Sc = 1$, $Re = 0$ (viscous stagnant gas surrounding particles)

\[ \text{Sh} = 2.0 \Rightarrow \text{Re} = \frac{2 \pi D_A}{\rho} \left( C_A - C_s \right) = -\frac{1}{S_e} \frac{dN_B}{dt} \]

\[ -\frac{S_B}{M_B} \frac{dR}{dt} = \frac{2 \pi D_A}{2R} \left( \frac{C_A - C_s}{\Delta} \right) / S \]

\[ t = \frac{S_B R_o^2}{2 \pi C_A D_A M_B} \left[ 1 - \left( \frac{R}{R_o} \right)^2 \right] \quad (R = 0, \ t = T) \]

\[ C = \frac{S_B R_o^2}{2 \pi C_A D_A M_B} \quad \text{i.e., } \quad C \propto R_o^2 \quad \left( = \frac{D_o^2}{k'} \right) \]

Example (Ex. 14.5, Turnes): Have a 70-μm particle burning in air at 1800 K and 1 atm, $S_B = 1900 \text{ kg/m}^3$ (no need to assume "mol wt of carbon gas is mixture at particle surface)."

\[ C_A = \frac{P_A}{RT} = \frac{0.21 \text{ atm}}{(82.06 \times 10^{-6} \text{ atm m}^3)/(1800 \text{ K})} = 1.42 \frac{\text{mol O}_2}{\text{m}^3} \]

\[ C = \frac{1900 \text{ kg C}/\text{m}^3}{(35 \times 10^{-6} \text{ m})^2} = 0.44 \text{ s} \]

\[ \left( 2 \times \frac{1 \text{ mol C}}{1 \text{ mol O}_2} \times \frac{1.42 \text{ mol O}_2}{\text{m}^3} \times \frac{1.54 \times 10^{-14} \text{ m}^2}{s} \times \frac{0.012 \text{ kg C}}{\text{mol C}} \right) \]

\[ (C + O_2 \rightarrow CO_2) \quad \text{vs.} \quad 2C + O_2 \rightarrow 2CO \]

Note: Can also define a transfer # for carbon, but not necessary...
- analogy with combustion (evaporation) of liquids!
- importance of RDS (mass transfer and chem. rxn in series...)
- remember handout "RDS"
- remember $t_D = D_0^2 / k$ for droplets

Fick's law of diffusion:

$$J_A = \frac{\delta}{k} \frac{(C_A - C_S)}{C_m}$$

Mass flux into the surface

Concentration gradient between bulk of fluid (gas) and external particle surface [mol A/cm^3]

with mass transfer as RDS

$$R_e = \frac{d}{d} \frac{(C_A - C_S)}{C_m} = \Lambda J_A$$

"diffusional rate constant"

Rate per unit external surface

mol B/cm^2/s

$[m]$ depends on fluid mechanics (momentum transport)

$$Sh = \frac{Re_d^{0.5} \cdot Sc}{D_A} = f(Re, Sc)$$

Schmidt # $= \frac{V}{D_A} = \frac{J}{SD_A}$

e.g.,

$$Sh = 2\left(1 + cRe^{0.5} \frac{1}{Sc}\right)$$

... analogy with $Nu = f(Re, Pr)$

(flow around objects ... ok)