Mass Transfer Coefficient Cheatsheet

Governing Eq. $N_A = k'_c \frac{1}{x_{\mathrm{Bm}}}(c_{A,1} - c_{A,2})$

① Geometry?

Parameters? μ, ρ, v, D_{AB}

② Calculate N_{Re} N_{Sc}

$$N_{\mathrm{Re}} = \frac{L_D v \rho}{\mu}$$

$$N_{\mathrm{Sc}} = \frac{\mu}{\rho D_{AB}}$$

③ Which Regime?

Gas? Liquid?
Laminar? Turbulent?

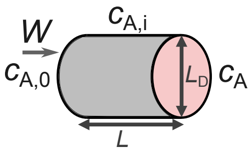
④ Which Equation?

N_{Sh} expression? → $k'_c = \frac{N_{\mathrm{Sh}} D_{\mathrm{AB}}}{L}$

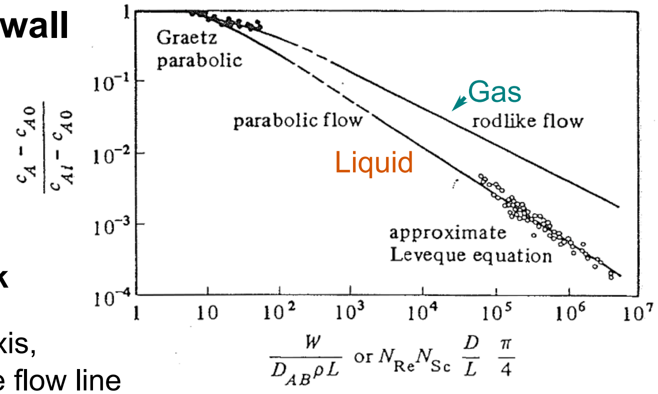
j_D expression? → $k'_c = j_{\mathrm{D}} v N_{\mathrm{Sc}}^{-\frac{2}{3}}$

$N_{\mathrm{Sh}} = j_{\mathrm{D}} N_{\mathrm{Re}} N_{\mathrm{Sc}}^{\frac{1}{3}}$

Pipe / Wetted-wall



Mass transfer from wall to bulk



Gas: Calculate x-axis,
go to Rod-like flow line

Liquid:

Parabolic

$N_{Re} < 2100;\ \frac{W}{D_{AB}\rho L} > 400$

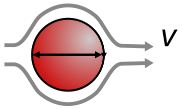
$$\frac{c_A - c_{A,0}}{c_{A,i} - c_{A,0}} = 5.5\left[\frac{W}{D_{AB}\,\rho\,L}\right]^{-\frac{2}{3}}$$

Turbulent

$N_{Re} > 2100;\ 0.6 < N_{Sc} < 3000$

$$N_{\mathrm{Sh}} = 0.023 N_{\mathrm{Re}}^{0.83} N_{\mathrm{Sc}}^{0.33}$$

Sphere



$L=L_D$ (diameter)

Low Reynolds: Gas & Liquid

$N_{\mathrm{Re}} << 2$ → $N_{Sh} = 2$

High Reynolds

Gas $N_{Sh} = 2 + 0.552 N_{Re}^{0.53} N_{Sc}^{1/3}$

$0.6 < N_{Sc} < 2.7$ $N_{Re} < 48000$

Liquid

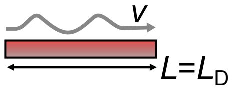
$N_{\mathrm{Re}} < 2000$

$$N_{Sh} = 2 + 0.95 N_{Re}^{0.5} N_{Sc}^{1/3}$$

$2000 < N_{\mathrm{Re}} < 17000$

$$N_{Sh} = 0.347 N_{Re}^{0.62} N_{Sc}^{1/3}$$

Flat surface



* *Use $L_D=L$ in Reynolds number*

Laminar flow (gas & liquid)

$N_{\mathrm{Re}} < 15{,}000$ → $j_D = 0.664 N_{Re,L}^{-0.5}$

Turbulent flow

Gas

$15{,}000 < N_{\mathrm{Re}} < 300{,}000$

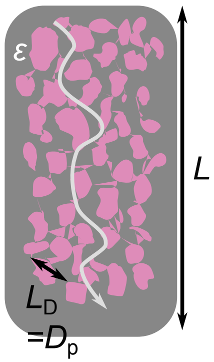
$$j_D = 0.036 N_{Re,L}^{-0.2}$$

Liquid

$600 < N_{\mathrm{Re}} < 50{,}000$

$$j_D = 0.99 N_{Re,L}^{-0.5}$$

Packed bed



Gas $10 < N_{\mathrm{Re}} < 10{,}000$

Liquid $10 < N_{\mathrm{Re}} < 1500$

$$j_D = \frac{0.4548}{\varepsilon} N_{Re}^{-0.4069}$$

Liquid $0.0016 < N_{\mathrm{Re}} < 55$
$165 < N_{\mathrm{Sc}} < 70{,}600$

$$j_D = \frac{1.09}{\varepsilon} N_{Re}^{-2/3}$$

Liquid $55 < N_{\mathrm{Re}} < 1500$
$165 < N_{\mathrm{Sc}} < 10{,}690$

$$j_D = \frac{0.250}{\varepsilon} N_{Re}^{-0.31}$$

Fluidized Beds of Spheres

Gas & Liquid

$10 < N_{\mathrm{Re}} < 4000$

$$j_D = \frac{0.4548}{\varepsilon} N_{Re}^{-0.4069}$$

Liquid

$1 < N_{\mathrm{Re}} < 10$

$$j_D = \frac{1.1068}{\varepsilon} N_{Re}^{-0.72}$$

ε: void fraction v': superficial velocity D_p: average particle size (sphere)