Mass Transfer Coefficient Cheatsheet

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

① Geometry?

Parameters? μ, ρ, v, D_{AB}

② Calculate N_{Re} N_{Sc}

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

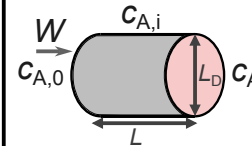$$N_{Sc} = \frac{\mu}{\rho D_{AB}}$$

③ Which Regime?

Gas? Liquid?
Laminar? Turbulent?

④ Which Equation?

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

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

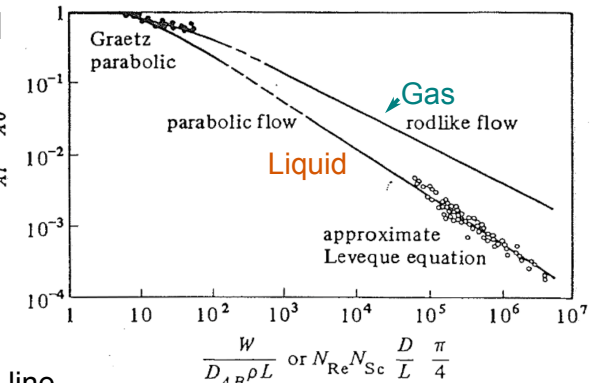$N_{Sh} = j_D N_{Re} N_{Sc}^{\frac{1}{3}}$

Pipe / Wetted-wall

Mass transfer **from wall to bulk**

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

Liquid:

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

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

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

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

Sphere
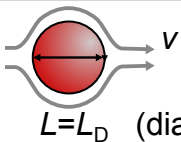
$L = L_D$ (diameter)

Low Reynolds: Gas & Liquid
$N_{Re} << 2$ → $N_{Sh} = 2$

High Reynolds
Gas $N_{Sh} = 2 + 0.552 N_{Re}^{0.53} N_{Sc}^{1/3}$
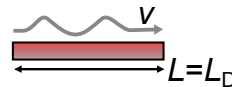$0.6 < N_{Sc} < 2.7$ $N_{Re} < 48000$

Liquid
$N_{Re} < 2000$
$N_{Sh} = 2 + 0.95 N_{Re}^{0.5} N_{Sc}^{1/3}$

$2000 < N_{Re} < 17000$
$N_{Sh} = 0.347 N_{Re}^{0.62} N_{Sc}^{1/3}$

Flat surface

$L = L_D$

Use $L_D = L$ in Reynolds number

Laminar flow (gas & liquid)
$N_{Re} < 15,000 \rightarrow j_D = 0.664 N_{Re,L}^{-0.5}$

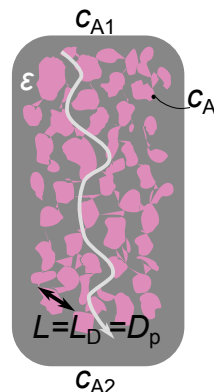**Turbulent flow**
Gas
$15,000 < N_{Re} < 300,000$
$$j_D = 0.036 N_{Re,L}^{-0.2}$$

Liquid
$600 < N_{Re} < 50,000$
$$j_D = 0.99 N_{Re,L}^{-0.5}$$

Packed bed

c_{A1}

c_{Ai}

ε

$L = L_D = D_p$

c_{A2}

Gas $10 < N_{Re} < 10,000$
Liquid $10 < N_{Re} < 1500$
$$j_D = \frac{0.4548}{\varepsilon} N_{Re}^{-0.4069}$$

Liquid $0.0016 < N_{Re} < 55$
$165 < N_{Sc} < 70,600$
$$j_D = \frac{1.09}{\varepsilon} N_{Re}^{-2/3}$$

Liquid $55 < N_{Re} < 1500$
$165 < N_{Sc} < 10,690$
$$j_D = \frac{0.250}{\varepsilon} N_{Re}^{-0.31}$$

Fluidized Beds of Spheres

Gas & Liquid
$10 < N_{Re} < 4000$
$$j_D = \frac{0.4548}{\varepsilon} N_{Re}^{-0.4069}$$

Liquid
$1 < N_{Re} < 10$
$$j_D = \frac{1.1068}{\varepsilon} N_{Re}^{-0.72}$$

Mass Balance
$$\ln\left(\frac{c_{Ai} - c_{A1}}{c_{Ai} - c_{A2}}\right) = \frac{A k_c}{Q} \quad A = \frac{6(1-\epsilon)}{D_p} V_b$$

ε: void fraction V_b: total volumn D_p: average size A: surface area Q: vol. flow rate