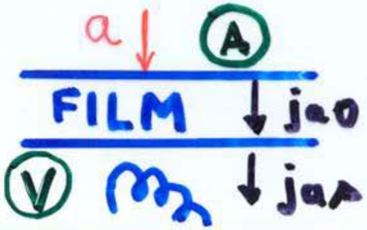
$\boxed{A + CHR}$

$z = 0,\ c_{a0}$

$z = \delta,\ c_{a\delta}$



$a + n_b b \rightarrow n_c c$

$(c_a \rightarrow 0)$

$$\boxed{-D_a \frac{d^2 c_a}{dz^2} = r_a,\quad -r_a = k^+ c_b c_a,\quad c_b = c_{bs}}$$

PSEUDO 1. Ř.

$$\frac{d^2 c_a}{dZ^2} - H^2 c_a = 0,\quad Z = \frac{z}{\delta},\quad H^2 = \frac{k^+ c_{b\delta} D_a}{k_L^2},\quad k_L = \frac{D_a}{\delta}$$

$$\beta^2 - H^2 = 0,\quad \beta_{1,2} = \pm H \qquad \text{HATTA}$$

$$\sinh x = \frac{e^x - e^{-x}}{2}$$

$$c_a = B_1 e^{HZ} + B_2 e^{-HZ}$$

$$\left.\begin{aligned} Z=0 &\quad c_{a0} = B_1 + B_2 \\ Z=1 &\quad c_{a\delta} = B_1 e^{H} + B_2 e^{-H} \end{aligned}\right\} \quad \begin{aligned} B_1 &= \frac{c_{a\delta} - c_{a0} e^{-H}}{2\sinh H} \\ B_2 &= \frac{c_{a0} e^{H} - c_{a\delta}}{2\sinh H} \end{aligned}$$

$Z = 1 \quad A j_{a\delta} = V k^+ c_{b\delta} c_{a\delta}$

$$j_{a\delta} = -\frac{D_a}{\delta} \left.\frac{dc_a}{dZ}\right|_{Z=1} = -\frac{D_a H}{\delta}\left(B_1 e^{H} - B_2 e^{-H}\right)$$

$$c_{a\delta} = \frac{c_{a0}}{\cosh H + (V/A\delta) H \sinh H}$$

$$\cosh x = \frac{e^x + e^{-x}}{2}$$

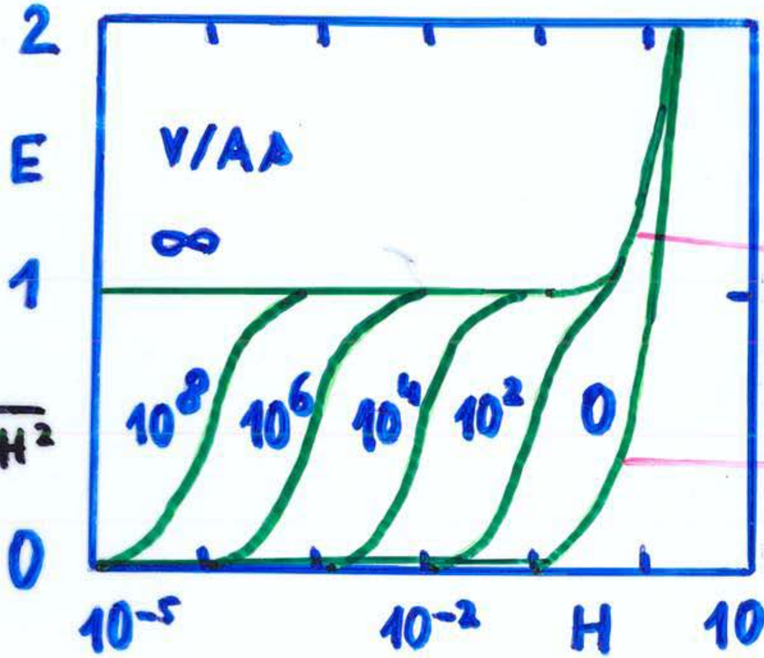
$$c_a = f(Z, H, V/A\delta)$$

$$\frac{V}{A\delta} = \frac{V_L - A\delta}{A\delta} = \frac{\varphi_L}{a\delta} - 1$$

$$j_{a0} = -\frac{D_a}{\delta}\left.\frac{dc_a}{dZ}\right|_{Z=0} = -\frac{D_a H}{\delta}(B_1 - B_2) = -\frac{D_a H}{\delta}\,\frac{c_{a\delta} - c_{a0}\cosh H}{\sinh H}$$

$$E = \frac{j_{A0}}{k_L c_{A0}} = \frac{H}{\sinh H}\left[\cosh H - \frac{1}{\cosh H + \frac{V}{A_S} H \sinh H}\right]$$

$$E = 1 - \frac{1}{1 + \frac{V}{A_S} H^2}$$



$H \to \infty$ $\longrightarrow$ $E = H$

$E = H \operatorname{ctgh} H$

$E = H \operatorname{tgh} H$

NEHYB.

(2. Ř)

POMALÉ
V JÁDŘE

RYCHLÉ
VE FILMU

$$\sinh x = \frac{e^x - e^{-x}}{2} = x + \frac{x^3}{3!} + \dots \qquad \operatorname{tgh} x = \frac{e^x - e^{-x}}{e^x + e^{-x}} = x - \frac{x^3}{3} + \dots$$

$$\cosh x = \frac{e^x + e^{-x}}{2} = 1 + \frac{x^2}{2!} + \dots \qquad \operatorname{cotgh} x = \frac{e^x + e^{-x}}{e^x - e^{-x}} = \frac{1}{x} + \frac{x}{3} - \frac{x^3}{45} + \dots$$

REAKČNÍ FAKTOR

$$E=\frac{-D_a\frac{dc_a}{dz}\Big|_0}{\frac{D_a}{\delta}c_{a0}}=\frac{j_{a0}}{k_L c_{a0}}$$

$$=\frac{\frac{dc_a}{dz}\Big|_0}{\frac{c_{a0}-0}{0-\delta}}$$

ZÁV. NA φ_L

② $H^2\to 0 \quad (k\to 0)$

$$j_{a0}=j_{a\delta}=\frac{D_a}{\delta}(c_{a0}-c_{a\delta}), \quad E=1-\frac{1}{1+\Theta}, \quad \Theta=\frac{H^2V}{A\delta}$$

$\Theta=0,\ E=0\ ;\ \Theta\to\infty,\ E=1$

$z=0\ ,\ c_{a0}$

$z=1\ ,\ dc_a/dz=0$

③ $V/A\delta=0 \quad (V=0)$

$z=1,\ 0=H(B_1e^{H}-B_2e^{-H})$ $\quad B_1=\frac{c_{a0}e^{-H}}{2\cosh H},\ B_2=\frac{c_{a0}e^{H}}{2\cosh H}$

$$c_a=f(z,H)=c_{a0}\frac{\cosh[H(1-z)]}{\cosh H}$$

$E=f(H)=H\,\mathrm{tgh}\,H$ $\quad \mathrm{tgh}\,x=\frac{\sinh x}{\cosh x}=\frac{1}{\mathrm{ctgh}\,x}$

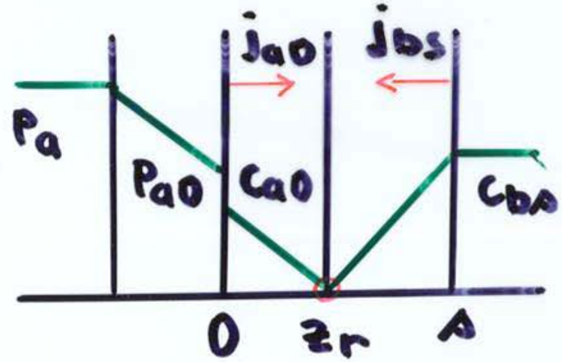
⑥ $c_{a\delta}=0$

$E=f(H)=H\,\mathrm{ctgh}\,H$ (NEZÁV. NA φ)

$H\to\infty\ ,\ E=H$

OKAMŽITÉ

$a + n_b b \to n_c c$



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$z=0$ — c_{a0}

$$\frac{d^2 c_a}{dz^2} = 0$$

z_r — $c_a = c_b = 0$

$$\frac{d^2 c_b}{dz^2} = 0$$

Δ — c_{bs}

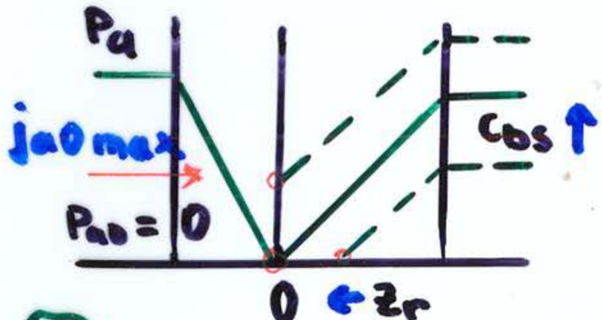
$$j_{a0} = D_a \frac{c_{a0}}{z_r} \quad 6 \Rightarrow \quad \frac{z_r}{\Delta} = \frac{1}{E_0}$$

$$n_b j_{a0} = -j_{bs}$$

$$j_{bs} = -D_b \frac{c_{bs}}{\Delta - z_r} \quad 2 \Rightarrow \quad z_r = \Delta - \frac{D_b c_{bs}}{n_b j_{a0}}$$

$$j_{a0} = \frac{D_a c_{a0}}{\Delta} \underbrace{\left(1 + \frac{D_b c_{bs}}{n_b D_a c_{a0}}\right)}_{E_0 \neq f(H)} = E_0 k_L c_{a0}$$

k_L



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$z_r = 0$, $c_{a0} = 0$

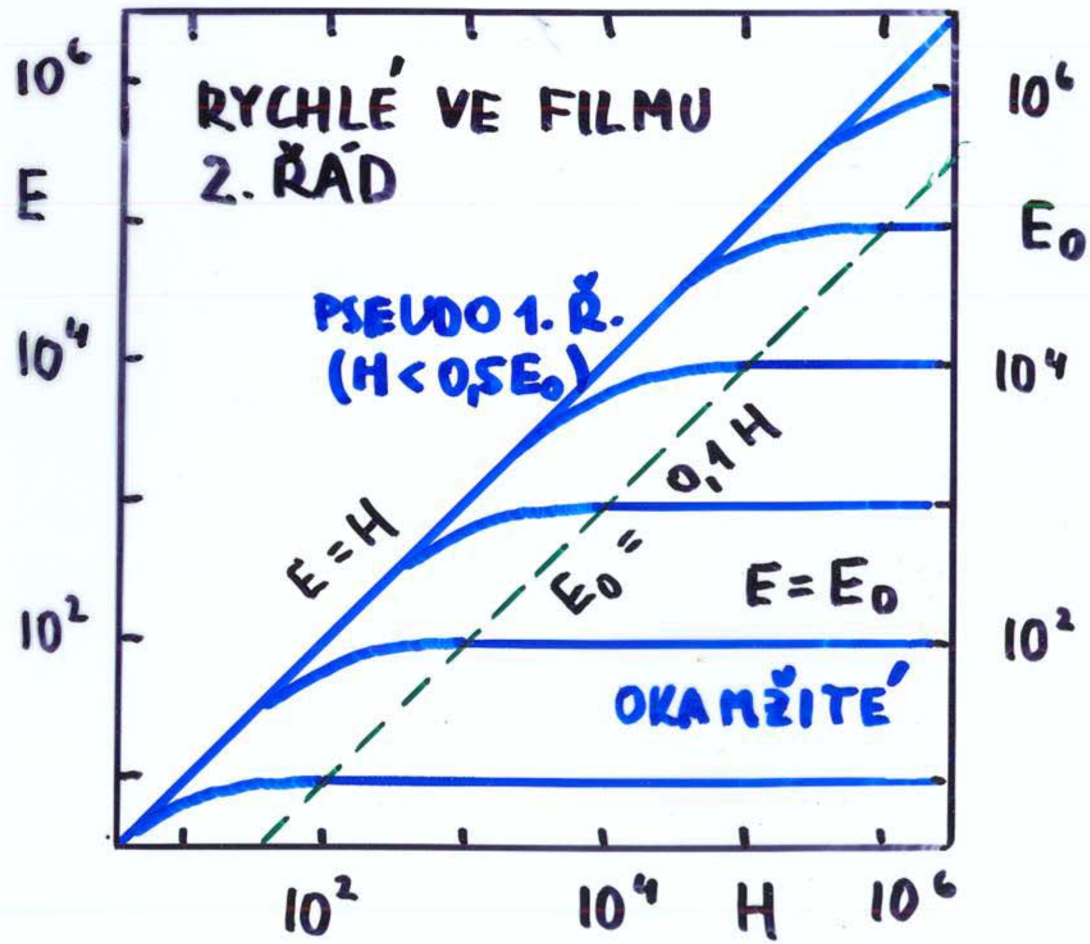
$j_{a0\,max} = k_p p_a$, $E_0 \to \infty$

$$c_{bs} = \frac{n_b k_p p_a \delta}{D_b}$$

k_{bL}

$$E = 1 + (E_0 - 1)\left[1 - \exp\left(-\frac{(1+H^2)^{1/2} - 1}{E_0 - 1}\right)\right]$$

$$E_0 = 1 + \frac{D_b}{n_b D_a} \frac{c_{bs}}{c_{a0}}$$



ODPOR V g

$$p_{a0} = H'_a c_{a0}$$

$$j_{a0} = k_p (p_a - p_{a0}) = E k_L c_{a0}$$

$$\frac{j_{a0}}{k_p} = p_a - p_{a0} \Big| \frac{1}{H'_a} \Rightarrow j_{a0} \frac{1}{H'_a k_p} = \frac{p_a}{H'_a} - c_{a0}$$

$$\frac{j_{a0}}{E k_L} = c_{a0} \qquad \Rightarrow j_{a0} \frac{1}{E k_L} = c_{a0}$$

$$j_{a0} = \frac{\frac{p_a}{H'_a}}{\frac{1}{k_p H'_a} + \frac{1}{E k_L}}$$

$E k_L \to \infty \Rightarrow j_{a0} = k_p p_a$

$k_p H'_a \to \infty \Rightarrow j_{a0} = E k_L c_{a0}$

VRATNÁ CHR

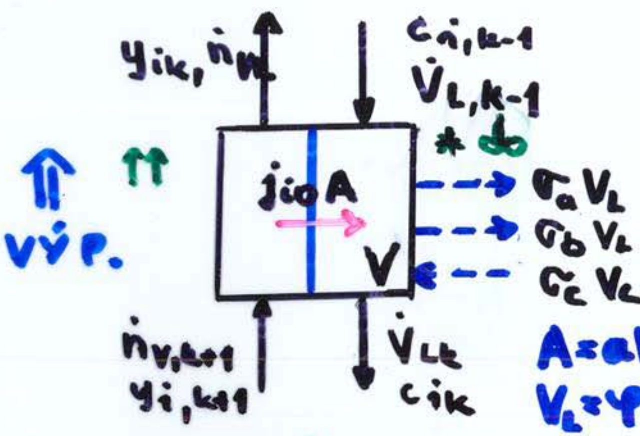
$$a + b \rightleftarrows c$$

$$-r_a = k^+ c_a c_b - k^- c_c \qquad K_R = \frac{k^+}{k^-} = \frac{c_c}{c_a c_b}$$

$$D_a \frac{d^2 (c_a - c_{ae})}{dz} = k^+ c_{bs} (c_a - c_{ae})$$

$$c_b = c_{bs}, \; c_c = c_{cs} \Rightarrow c_{ae} = \frac{1}{K_R} \frac{c_{cs}}{c_{bs}}$$

STUPŇOVÝ ABSORBÉR



$A = aV$

$V_L = \varphi V$

$a + n_b b \rightarrow n_c c$

BIL.:

(1) $\dot{n}_{v,k+1} y_{i,k+1} = \dot{n}_{vk} y_{ik} + j_{io} a V$

(2) $\dot{n}_{v,k+1} = \dot{n}_{vk} + j_o a V$

(3) $\dot{V}_{L,k-1} c_{i,k-1} + j_{io} a V = c_{ik} \dot{V}_{Lk} - \sigma_i \varphi V$

ZJEDN.

$j_{bo} = j_{co} = 0$

$c_{a,k-1} = c_{ak} = 0$

$\dot{V}_{L,k-1} = \dot{V}_{Lk} = \dot{V}_L$

DANCKWERTS - NÁVRH:

ODHAD c_{in}

$\vdots$

k ZNÁMO: $\underline{y_{i,k+1}}, \dot{n}_{v,k+1}, c_{ik}, \dot{V}_L$

ODHAD $\overline{c_i} \Rightarrow k_L, a, \varphi, c_{bo}$

ODHAD $\overline{y_i} \Rightarrow k_p, H_a, c_{a0}$

TEORIE $\Rightarrow$ E, j_{a0}

(1), (2) $\Rightarrow y_{ik}, \dot{n}_{vk}$

(3), $i = a \Rightarrow \sigma_a = -j_{a0} \frac{a}{\varphi}$ (<0)

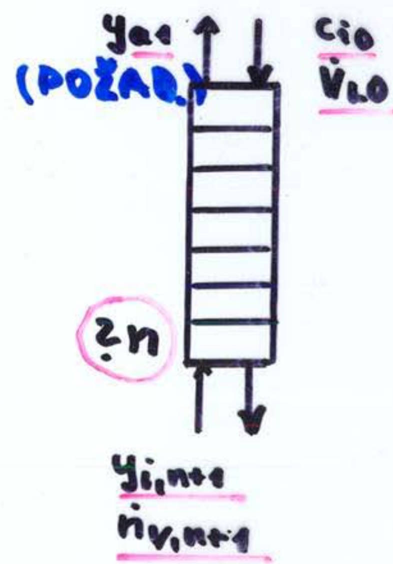
STECH. $\Rightarrow \sigma_b = n_b \sigma_a$, $\sigma_c = -n_c \sigma_a$

(3), $i = b, c \Rightarrow c_{i,k-1}$

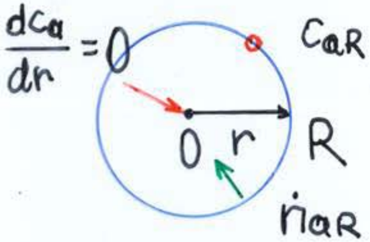
$\vdots$

n $y_{i1}, \dot{n}_{v1}, c_{i0}$

DÁNO:



UST. DIFUZE + CH.R. V ČÁSTICI KAT.



$$D_a\left(\frac{d^2c_a}{dr^2} + \frac{2}{r}\frac{dc_a}{dr}\right) = k^+ c_a$$

$$u = c_a r \qquad \frac{du}{dr} = \frac{dc_a}{dr} r + c_a$$

$$\frac{d^2u}{dr^2} = \frac{d^2c_a}{dr^2} r + \frac{dc_a}{dr} + \frac{dc_a}{dr}$$

$$\frac{d^2u}{dr^2} - \frac{k^+}{D_a} u = 0 \qquad B^2 - \frac{k^+}{D_a} = 0 \qquad \frac{1}{r}\frac{d^2u}{dr^2} = \frac{d^2c_a}{dr^2} + \frac{2}{r}\frac{dc_a}{dr}$$

$$c_a = \frac{b_1}{r} e^{Br} + \frac{b_2}{r} e^{-Br} \qquad B_{1,2} = \pm\sqrt{\frac{k^+}{D_a}} = \pm B$$

$$\left.\frac{dc_a}{dr}\right|_0 = \lim_{r\to 0}\left[\frac{b_1}{r^2}\left(Bre^{Br} - e^{Br}\right) + \frac{b_2}{r^2}\left(Bre^{-Br} - e^{-Br}\right)\right] =$$

$$\lim_{r\to 0} \frac{B^2}{2}\left(b_1 e^{Br} + b_2 e^{-Br}\right) = 0 \qquad b_1 + b_2 = 0$$

$$c_{aR} = \frac{b_1}{R}\left(e^{BR} - e^{-BR}\right) \qquad b_1 = -b_2 = \frac{c_{aR} R}{2\sinh(BR)}$$

$$c_a = f\left(\phi, \frac{r}{R}\right) = c_{aR} \frac{R}{r} \frac{\sinh(\phi r/R)}{\sinh\phi} \qquad BR = \phi = \sqrt{\frac{k^+ R^2}{D_a}} \quad \text{THIELE}$$

$$Br = \phi r/R$$

$$\dot{n}_{aR} = -4\pi R^2 D_a \left.\frac{dc_a}{dr}\right|_R \qquad \left.\frac{dc_a}{dr}\right|_R = \frac{c_{aR}}{R}\left[\phi \coth\phi - 1\right]$$

$$\dot{n}_{r0} = -\frac{4}{3}\pi R^3 k^+ c_{aR}$$

$$E_a = \frac{\dot{n}_{aR}}{\dot{n}_{r0}} = f(\phi) = \frac{3}{\phi^2}\left(\phi\coth\phi - 1\right)$$

$$R_e = 3V/A$$

TERMODIFUZE

$(c=2,\ [p],\ \vec{F}_i = 0)$

FOURIER DUFOUR

$$-\vec{J}_e = \lambda \nabla T + c D_a^D \nabla x_a$$

$$-\vec{J}_a = \frac{D_a^T}{T} \nabla T + c D_{ab} \nabla x_a$$

SORET FICK

$(\vec{J}_b,\ \nabla x_b$ Lin. záv.$)$

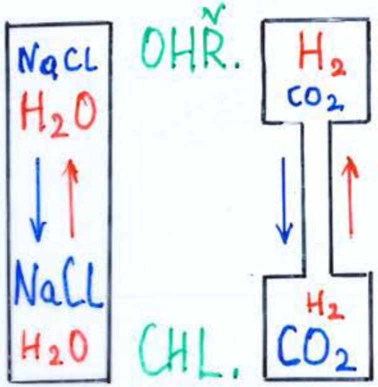
$$-\vec{J}_a = c D_{ab} \left(\nabla x_a + \underbrace{\frac{D_a^T}{c D_{ab}}}_{k^T} \frac{\nabla T}{T} \right)$$

$$k^T = \alpha^T x_a x_b = \sigma^T T x_a x_b$$

T-D POMĚR, T-D FAKTOR (G), SORET (L)

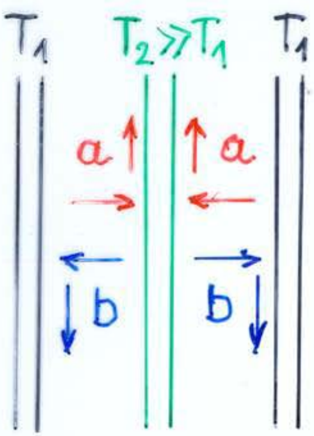
$$\boxed{-\vec{J}_a = c D_{ab} \left(\nabla x_a + \alpha^T x_a x_b \frac{\nabla T}{T} \right)}$$

σT (L)



SORET (1879)

CHAPMAN DOOTSON (1917)



$\alpha^T(a) < 0$

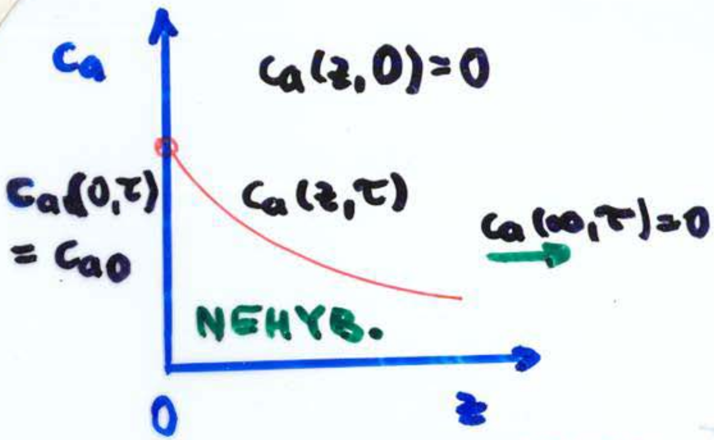
$\alpha^T(b) > 0$

G, $\vec{J}_a^n = 0$:

$$\int_{x_{a1}}^{x_{a2}} \frac{dx_a}{x_a(1-x_a)} = -\alpha^T \int_{T_1}^{T_2} \frac{dT}{T}$$

$$\ln \frac{x_{a2}/x_{b2}}{x_{a1}/x_{b1}} = \alpha^T \ln \frac{T_1}{T_2}$$

PRO $T_{stř.}$



POLONEKON.
VRSTVA

NEUST. DIFUZE

$$\frac{\partial c_a}{\partial \tau} = D_{ab} \frac{\partial^2 c_a}{\partial z^2}$$

LAPLACE

$$\frac{d^2 \hat{c}_a}{d z^2} - \frac{p}{D_a} \hat{c}_a = 0$$

$$m^2 = \frac{p}{D_a}, \quad m = \pm \sqrt{\frac{p}{D_a}}$$

$$\hat{c}_a = B_1 \exp\left(z\sqrt{\frac{p}{D_a}}\right) + B_2 \exp\left(-z\sqrt{\frac{p}{D_a}}\right)$$

$$z \to \infty, \ \hat{c}_a = 0 \Rightarrow 0 = B_1 e^{\infty} + B_2 e^{-\infty} \Rightarrow B_1 = 0$$

$$z = 0, \ \hat{c}_a = \frac{c_{a0}}{p} \Rightarrow \frac{c_{a0}}{p} = B_2$$

$$\hat{c}_a = \frac{c_{a0}}{p} \exp\left(-z\sqrt{\frac{p}{D_a}}\right)$$

$$\mathcal{L}^{-1}\left[\frac{1}{p} e^{-b\sqrt{p}}\right] = \operatorname{erfc} \frac{b}{2\sqrt{\tau}}$$

$$b = z/\sqrt{D_a}$$

$$\operatorname{erfc} x = 1 - \operatorname{erf} x = 1 - \frac{2}{\sqrt{\pi}} \int_0^x e^{-u^2} du$$

$$\boxed{\frac{c_a}{c_{a0}} = \operatorname{erfc} \frac{z}{2\sqrt{D_a \tau}}}$$

$$\hat{j}_{a0} = -D_a \frac{d\hat{c}_a}{dz}\Big|_0 = D_a \frac{c_{a0}}{p} \sqrt{\frac{p}{D_a}} = c_{a0} \sqrt{\frac{D_a}{p}}$$

$$\mathcal{L}^{-1}\left[\frac{1}{\sqrt{p}}\right] = \frac{1}{\sqrt{\pi \tau}}$$

$$\boxed{j_{a0} = c_{a0} \sqrt{\frac{D_a}{\pi \tau}}}$$

$$\frac{1}{\tau} \int_0^\tau \tau^{-1/2} d\tau = \frac{2}{\tau} \left[\tau^{\frac{1}{2}}\right]_0^\tau$$

$$\bar{j}_{a0} = \frac{1}{\tau} \int_0^\tau j_{a0} \, d\tau = 2 c_{a0} \sqrt{\frac{D_a}{\pi \tau}}$$