Szlovák

(Bukóci)

G-25

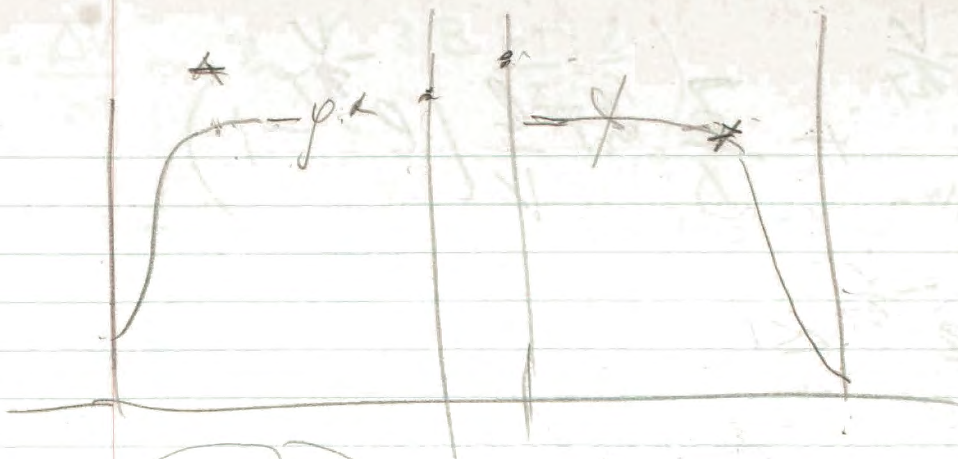
Standard

COMPOSITION BOOK

NARROW RULED MARGINAL

SIZE 11 x 8½

No. P-2713



$\boxed{W-V}$

$RT_1 \ln\frac{\rho^*}{\rho_1} = RT_1 \ln\frac{\rho^*}{\rho_0}\cdot\frac{\rho_0}{\rho_1} = RT_1 \ln\frac{\rho^*}{\rho_0} + W$

$= Q_1^*$

$RT_1 \ln\frac{\rho_0}{\rho_1} = W$

$W - Q_1^* = RT_1 \ln\frac{\rho_0}{\rho^*} = \Pi_1$

$RT_2 \ln\frac{\rho^*}{\rho_2} = RT_2 \ln\frac{\rho^*}{\rho_0}\cdot\frac{\rho_0}{\rho_2} = Q_2 = V_0$

$= RT_2 \ln\frac{\rho^*}{\rho_0} + W$

$W - Q_1 = \Pi_1$

$\Pi_1 - \Pi_2 = Q_2 - Q_1$

$\cancel{RT_2 \ln\frac{\rho_0}{\rho_2} = W}$ $(RT_1 - RT_2)\ln\frac{\rho_0}{\rho^*}$

Q_2

$\boxed{Q = W - \Pi}$

$$\overline{\rho_2} = \rho^* e^{-\frac{V}{kT}} + \frac{J}{D} kT \frac{l}{V} \left(e^{-\frac{V}{kT}} - 1\right)$$
$(x = l)$

neglect: $e^{-\frac{V}{kT}} \ll 1$

$$\overline{\rho_2} = \rho^* e^{-\frac{V}{kT}} - \frac{J}{D} kT \frac{l}{V}$$

$$\rho^* = \rho_2 e^{\frac{V_0}{kT}}$$

$$\overline{\rho_2} = \rho_2 e^{\frac{V_0 - V}{kT}} - \frac{J}{D} kT \frac{l}{V}$$

mult. $\overline{v_2}$ || $\overline{\rho_2 v_2} = J + S$ $\quad \rho_2 \overline{v_2} = S$

$$J + S = S e^{\frac{V_0 - V}{kT}} - \frac{J \overline{v_2}}{\frac{\overline{v_2}\lambda}{3}} kT \frac{l}{V}$$

$$J + S = S e^{\frac{V_0 - V}{kT}} - 3J \frac{l}{\lambda} \frac{kT}{V}$$

~~$S \ll J$~~

$$\frac{J}{S}\left(1 + \frac{3l}{\lambda} \frac{kT}{V}\right) + 1 = e^{\frac{V_0 - V}{kT}}$$

$\frac{J}{S} = B$

$$\boxed{\ln\left[B\left(1 + \frac{3l}{\lambda} \frac{kT}{V}\right) + 1\right] = \frac{V_0 - V}{kT}}$$

$$\vec{\rho}_2 = \rho_2 \cancel{e^{(V_0 - V)/kT}} - \frac{J}{D} \frac{kT l}{V} \left(e^{-V/kT} - 1\right)$$

$$\frac{\Delta V}{kT} \approx \ln\left(3B\frac{kT}{V_0}\frac{\ell}{\lambda}\right)$$ H

$$B = \frac{J}{S} \qquad S = 100\,T^2 e^{-W/kT}$$

B

$$\Delta V = kT\left\{\ln 3 \text{[illegible]} \frac{\ell}{\lambda} + \ln B - \ln \frac{V_0}{kT}\right\}$$

$$\Delta V = \qquad +$$

~~$10\ \text{amp} = 100\,T^2 e^{-\frac{W}{kT}}$~~

$\ln J - \ln AT^2 e^{-\frac{W}{kT}}$

$$B = \frac{10}{100\,T^2 e^{-\frac{W}{kT}}}$$

$$B = 10^{-7} e^{W/kT} = e^{-16} e^{10W}$$

$$\ln B = 10W - 16$$

$$\delta(\Delta V) \approx 10\,\delta W$$

$$\delta V_0 = \delta W$$

Current under influence of Force $\pm$

$$J = -\frac{\lambda v}{3}\frac{d\bar{\rho}}{dx} - \frac{\bar{\rho}\,\text{Force}\,\lambda}{mv} \qquad [\rho^* - \bar{\rho}_{?}]$$

Assume Force $= \frac{V}{\ell}$

$$\frac{J}{\frac{\lambda v}{3}} = -\frac{d\bar{\rho}}{dx} - \frac{\bar{\rho}}{kT}\frac{V}{\ell} \qquad D = \frac{\lambda v}{3}$$

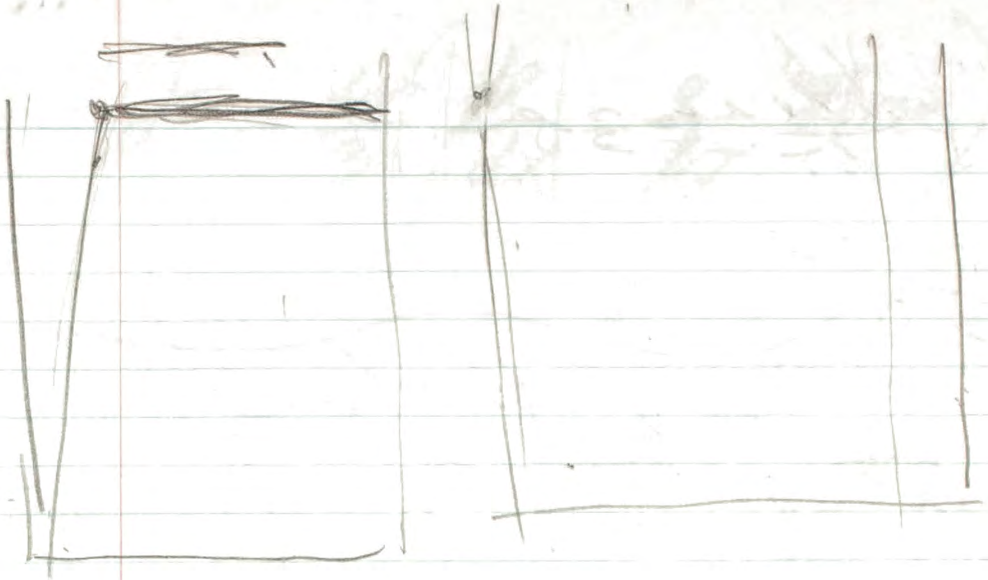
Integrated

$$\bar{\rho} = \rho^* e^{-\frac{V}{kT}\frac{x}{\ell}} + \frac{J}{D} kT \frac{\ell}{V}\left(e^{-\frac{V}{kT}\frac{x}{\ell}} - 1\right)$$

Ford; Borgemann

Wild night
~~The nights speaks~~ ~~the night~~
Freddy ~~night~~ morning,

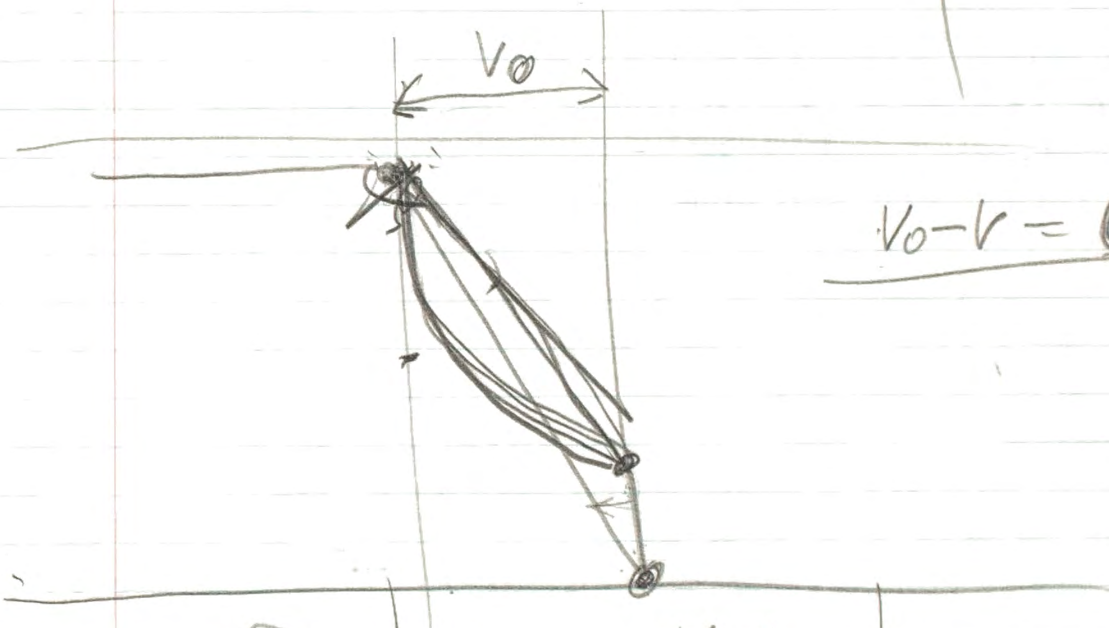
h



Kathode

$$I = S - \bar{v}_1 \bar{\rho}_1$$

$$I = \bar{\rho}_2 \bar{v}_2 - S$$



$$V_0 - V = C\, I$$

$\frac{d\rho}{dx}$ $\quad \frac{\rho^*}{l}$

$$\rho^* e^{-\frac{V}{kT}\frac{x}{l}}$$

$$-\frac{V}{kT}\frac{1}{l}\rho^*$$

$$j = \frac{\lambda v}{3}\left[+ \frac{V}{kT}\frac{1}{l}\rho^* - \frac{\bar{\rho}^*}{kT}\frac{V}{l} \right]$$

$$-\frac{d\rho}{d\frac{x}{\lambda}} - \rho\frac{V\hat{e}}{kT} = 3S$$

$$\rho_2 = \rho^* e^{-\frac{V}{kT}} - 3\frac{\partial}{\lambda V}\frac{kT}{V}\, l \left\{1 - e^{-\frac{V}{kT}}\right\}$$

solution

$$V < kT \ln\frac{\rho^*}{\rho_2}$$

Correct!

$$S = -\frac{\lambda}{3}\frac{d\rho}{dx} - \rho\left(1 - e^{-\frac{V}{kT}\frac{\lambda}{e}}\right)$$

as before

4

$$J = \frac{\lambda v}{3}\left(\left|\frac{d\rho}{dx}\right| - \frac{\rho}{RT}\,\text{Force}\right)$$

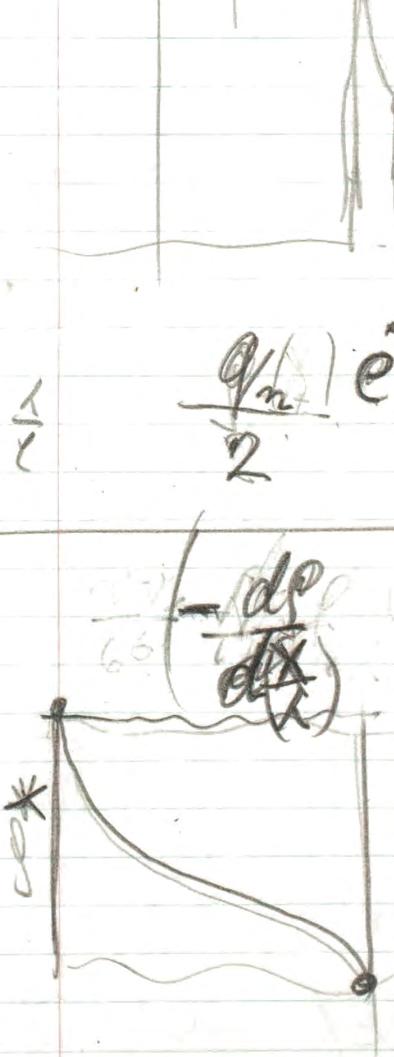
$$\left|\frac{d\rho}{dx}\right| > \frac{\rho^*}{\ell} \qquad J > \frac{\lambda v}{3}\left(\frac{\rho^*}{\ell} - \frac{\rho^*}{RT}\,\text{Force}\right)$$

$$J = \frac{\lambda v}{3\lambda}\left(-\frac{d\rho}{dx} - \rho\,\frac{V}{RT}\frac{\lambda}{\ell}\right)$$

$$J = \left\{-\frac{\lambda\,\rho}{dx} - \rho\left(1 - e^{-\frac{V}{RT}\frac{\lambda}{\ell}}\right)\right\}\frac{v}{3}$$

$$A = \frac{V}{RT}\frac{\lambda}{\ell} \qquad \frac{q_n}{2}\,e^{-\frac{V}{RT}\frac{\lambda}{\ell}} - \frac{q_{n+1}}{2} = J$$

$$\left(-\frac{d\rho}{dx/\lambda}\right) - \rho\,\frac{\Delta V}{kT} = 6\,\frac{J}{v} = 6\delta$$



If J is fixed
then at low temp V_2 goes
to zero. —

$$V_2 = V_0 - \cancel{kT} \ln B \left[1 + \frac{3}{\ln \left\{ \frac{\rho^*}{\frac{\delta + S}{v}} \right\}} \right]$$

$$B = \frac{J}{\cancel{S}}$$

$$\Pi_2 = W - V_2^\circ$$ H

$$V_2^\circ = kT_2 \ln \frac{\rho^*}{\rho_2} = kT_2 \ln \frac{\rho^*}{\rho_0} + W$$

Approx

$$\overline{V}_2 = kT_2 \ln \frac{\rho^*}{\frac{J+S}{v}}$$

$$\overline{\Pi}_2 = W - kT_2 \ln \frac{\rho^*}{\frac{J+S}{v}}$$

Correct

$$\overline{V}_2 = kT_2 \ln \frac{v\rho^*}{J\left(1+\frac{3kT}{V_2}\right)+S}$$

Subst from approx equation

$$\overline{V}_2 = kT_2 \ln \frac{v\rho^*}{J\left(1+\frac{3}{\ln \frac{\rho^*}{\frac{J+S}{v}}}\right)}$$

If J is a fixed multiple of S then at low temp $\overline{V}_2$ goes to W

$$\rho v - J/a = A e^{\frac{a}{\lambda} x}$$

$x=0$

$$S - J - \frac{J}{a} = A$$

$$A = S - J\left(1 + \frac{1}{a}\right)$$

$$\rho v = \frac{J}{a} + \left[S - J\left(1 + \frac{1}{a}\right)\right] e^{\frac{a}{\lambda} x}$$

$$\left(S - \frac{J}{a}\right)$$

$$\rho v = \frac{J}{a}\left(1 - e^{\frac{x}{\ell}}\right) + \cancel{S e^{x/\ell}}$$

$$\rho = \frac{J\ell}{\lambda v}\left(1 - e^{\frac{x}{\ell}}\right)$$

a

$$v\rho(\ell) = J$$

$$S_1 - v\rho(0) = J$$

$$\frac{S_1 - J}{v} = \rho(0)$$

$$\frac{S_1}{v} - \rho(0) = s$$

$$\rho_0 = \frac{S_1}{v} - s$$

$$S - \frac{J}{a} = J$$

$$\frac{J}{S} = 1 - \frac{J}{S}\frac{1}{a}$$

$$\frac{J}{S} = \frac{1}{1 + \frac{1}{a}}$$

$$S = J\left(1 + \frac{1}{a}\right)$$

$$\frac{J}{S} = \frac{1}{1 + \frac{1}{a}}$$

$$-\lambda \frac{d\rho}{dx} v + a\rho v = J$$

$$-\lambda \frac{d\rho}{dx} + a\rho = s$$

$$+\lambda \frac{d\rho}{dx} = -s + a\rho = a\rho - s = a\left(\rho - \frac{s}{a}\right)$$

$$\frac{d\rho}{dx} = \frac{a}{\lambda}\underbrace{\left(\rho - \frac{s}{a}\right)}_{y}$$

$$\frac{dy}{dx} = \frac{a}{\lambda} y$$

$$y = A e^{\frac{a}{\lambda} x}$$

$$\left(\rho - \frac{s}{a}\right) = A e^{\frac{a}{\lambda} x}$$

$$\boxed{\rho - \frac{J}{av} = A e^{\frac{\beta x}{\ell}}}$$

$x=0$

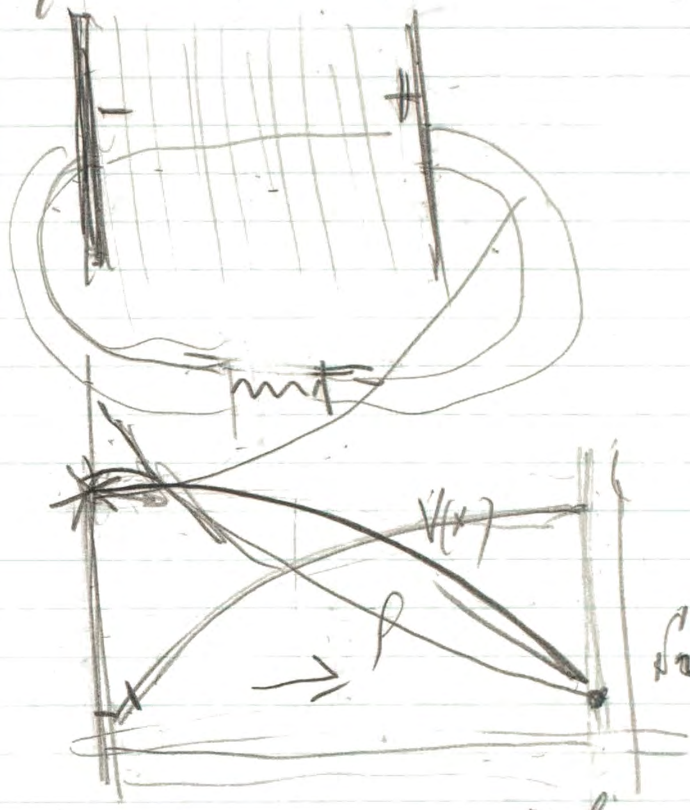
$$\rho_0 - \frac{s}{a} = A$$

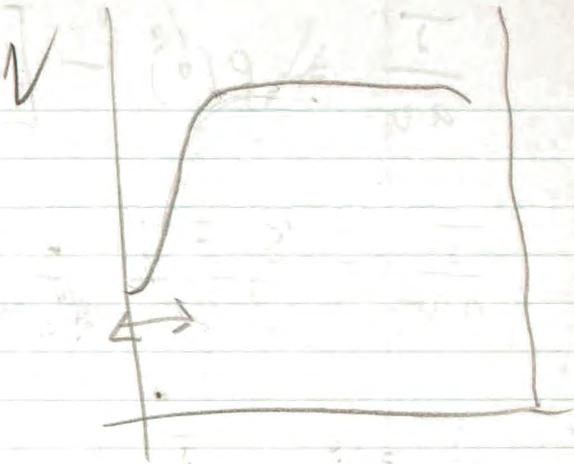
$$\frac{S_1}{v} - s\left(1 + \frac{1}{a}\right)$$

$$\rho = \frac{s}{a} + \left[\frac{S_1}{v} - s\left(1 + \frac{1}{a}\right)\right] e^{\frac{a}{\lambda} x}$$

$$\rho = \frac{S_1}{v} + \frac{s}{a}\left(1 - e^{\frac{a}{\lambda} x}\right) - s e^{\frac{a}{\lambda} x}$$

$W_1 > W_2$





$$\frac{V_0}{\frac{1}{2}mv^2} = \beta$$

$$e^{-\frac{\Delta V}{V_0}} \quad a = \frac{\lambda}{\ell}$$

$$V' = \frac{V_0}{\ell}$$

$$e^{-\frac{V(x)\lambda}{\ldots}}$$

$$e^{-\frac{\frac{V_0 \lambda}{\ell}}{\frac{1}{2}mv^2}}$$

$$\alpha\sqrt{V(\ell)}\,\rho(\ell) = J$$

$$\alpha\sqrt{V(0)}\,\rho(0) = J$$

$$\boxed{-\lambda \frac{d(\rho v)}{dx} + a\rho v = J}$$

$$(1+a)\rho(x)v(x) - \rho(x+\lambda)v(x+\lambda)$$

$$(1+c)\rho v|_x - \{(\rho v)_x - \tfrac{d}{dx}(\rho v)\lambda\}$$

$$\boxed{-\frac{d\rho}{dx}\lambda v - \rho \cancel{\frac{dv}{dx}}\lambda + a\rho v = J}$$

$$a = \beta\frac{\lambda}{\ell}$$

$$\frac{\lambda}{a}\frac{d\eta}{dx} = \eta$$

$$\eta = A e^{a/\lambda\, x}$$

$$-\frac{\lambda}{a}\frac{dy}{dx} + \alpha y = \frac{J}{a} \qquad \frac{\lambda}{a}\frac{dy}{dx} = \alpha y - \frac{J}{a}$$

$$(y - J/a) = A e^{\frac{a}{\lambda}x}$$

$$\frac{J}{av} = \rho(0) - \left[\frac{\rho(\ell) - \rho(0)}{e^{\beta}-1}\right]$$

$$\frac{J}{av} = \frac{S - J}{v} - \frac{\cancel{J} - S + \cancel{J}}{\cancel{v}(e^{\beta}-1)}$$

$$\frac{J}{a} = S - J + \frac{S}{e^{\beta}-1}$$

$$1 + \frac{1}{e^{\beta}-1}$$

$$\frac{e^{\beta}-1+1}{}$$

$$J\left(1 + \frac{1}{a}\right) = S\left(\frac{e^{\beta}}{e^{\beta}-1}\right.$$

$$\frac{y}{S} = \frac{e^{\frac{V_0}{4 m u^2}}}{e^{\beta}-1}\, a$$

$$v\rho(\ell) = S_1 - v\rho(0)$$ H

$$\rho - \frac{J}{av} = A e^{\beta x/e} \qquad -\lambda v \frac{d\rho}{dx} + a\rho v = J$$

$$\frac{d\rho}{dx} = \frac{\beta}{e} A e^{\beta x/e}$$

$$-v\frac{\lambda\beta}{e} A e^{\beta x/e} + \overset{\frac{\beta\lambda}{e}}{\cancel{av}}\left(A e^{\beta x/e} + \frac{J}{av}\right) \overset{?}{=} J$$

$$-v\frac{\lambda\beta}{e} A e^{\beta x/e} + \frac{\beta\lambda}{e} v A e^{\beta x/e}$$

$$\rho = A e^{\frac{\beta x}{e}} + \frac{J}{av}$$

$$\rho(0) = A + \frac{J}{av}$$

$$\rho(e) = A e^{\beta} + \frac{J}{av}$$

$$J = \varepsilon S_1$$

$$\rho(0) - \rho(e) = A(1 - e^{\beta})$$

$$A = \frac{\rho(0) - \rho(e)}{1 - e^{\beta}} = \frac{\rho(\ell) - \rho(0)}{e^{\beta} - 1}$$

$$\underline{\frac{J}{av}} = \rho(0) - A = \rho(0) - \frac{\rho(0) - \rho(e)}{1 - e^{\beta}} = \underline{\rho(0) - \frac{\rho(\ell) - \rho(0)}{e^{\beta} - 1}}$$

$$\rho = + \frac{\rho(e) - \rho(0)}{e^{\beta} - 1} e^{\frac{\beta x}{e}} + \rho(0) - \frac{\rho(\ell) - \rho(0)}{e^{\beta} - 1}$$

$$\rho = \rho(0) + \left[\frac{\rho(e) - \rho(0)}{e^{\beta} - 1}\right]\left(e^{\frac{\beta x}{\ell}} - 1\right)$$

Ohmic case

$$j = \frac{1}{l}\frac{V}{kT}\frac{\lambda v}{3}\rho$$

$$6\,10^{7}$$

$$j = \frac{1}{l}\, 6\,10^{7}\,\frac{10^{13}}{3}$$

$$= \frac{V}{l}\,\frac{2\,10^{20}\;5\,10^{-10}}{3\,10^{9}}\ \text{amps}$$

$$= \frac{1}{l}\,30\ \text{amps}$$

$$j = \frac{1}{l}\frac{V}{kT}\frac{10^{11}}{3}(10kT)^2$$

$$\boxed{j = \frac{1}{3l}\,V\,kT\,10^{13}}$$

$\cancel{\sigma = 10^{-14}\ \text{cm}^2}$

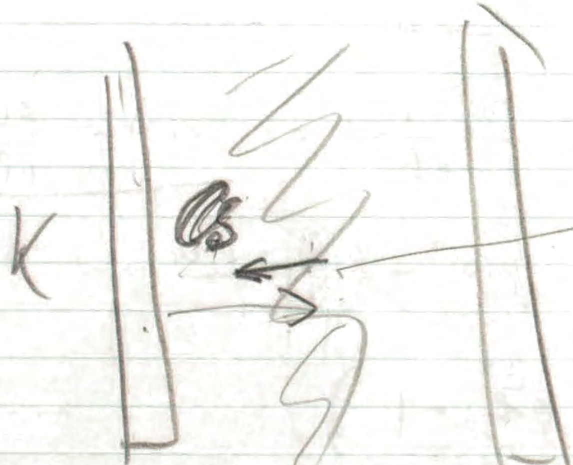
$\sigma = 10^{-13}\ \text{cm}^2$

$\sigma\rho =$

$\lambda \frac{1}{\sigma\rho}$

$\lambda\rho = \frac{1}{\sigma}$

$$\sigma = 10^{-11}\left(\frac{1}{10kT}\right)^2$$



Noble Gas lighter than Cs

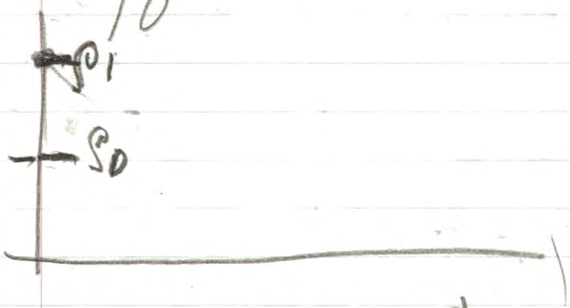
Noble Gas heavier than Cs
stops convection

$$-\frac{d\rho}{dx}\frac{\lambda v}{3} + a\rho v = J$$

$$0;\quad S_1 - v\rho(0) = J \qquad J = \varepsilon S$$

$$0 \Big| -\frac{d\rho}{dx}\frac{\lambda v}{3} + a(S+J) = J$$

$$\left(\frac{d\rho}{dx}\right)_0 = \big(J - a(S+J)\big)\frac{3}{\lambda v} \approx J\frac{3}{\lambda v}$$



$$\frac{J}{v} < \rho(0)$$

$$\left(\frac{d\rho}{dx}\right)_0 \frac{\lambda v}{3} >> a(S+J)$$

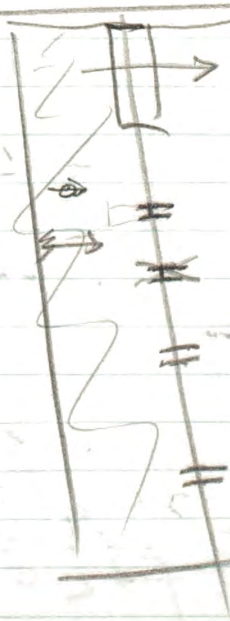
$$J >> a(S'+J)$$

$$\frac{d\rho}{dx}\frac{\lambda v}{3} = \frac{S}{2}$$

$$\rho_0 = \frac{1}{2}\rho_1$$

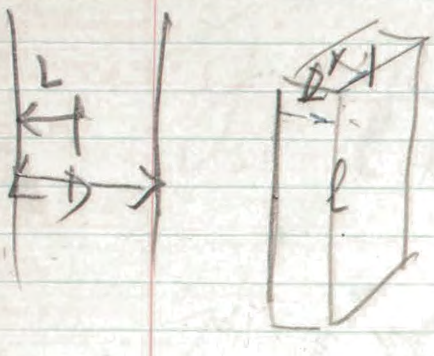
$$\frac{1}{2}\rho_1 v = \frac{1}{2}S$$

$$\frac{1}{\rho}\frac{\rho}{dx}\frac{\lambda}{3} = 1$$



$$\frac{\rho'}{\lambda}$$

$$\bar{v} = \frac{1}{3}\left(\frac{L^*}{2}\right)^2 \frac{\Delta P}{l}\,\frac{1}{\eta} = \frac{1}{12} L^{*2} \frac{\Delta P}{l}\,\frac{1}{\eta}$$



$$L^* \rho g = \frac{\Delta P}{l}$$

$$\frac{1}{10}\,\frac{L^* M}{22000}\,10^3\, p^{\text{atm}} = \frac{\Delta P}{l}$$

$$T = 10\,T_0$$

$$w = \frac{1}{12}\,\frac{L^{*3}}{\eta} M\, p^{\text{atm}}\, \frac{1}{220}$$

transport for $\rho^* = 1$ $= \dfrac{10^{-3}}{2.6}\,\dfrac{L^4}{\eta} M\, p^{\text{atm}}$ density of vapour at cathode

$$\eta = \frac{\frac{1}{3} n \lambda M \bar{v}}{6\cdot 10^{23}} = \frac{1}{3}\,\frac{1}{\sigma}\,\frac{M\bar{v}}{6\cdot 10^{23}}$$

Argon $\mu = 220\ 10^{-6} = 2\cdot 10^{-4}$

$\sigma = 6\ 10^{-16}$ $\quad M = 20$ $\quad v = 6\ 10^4$

$$\frac{10^{16}}{3\times 6}\,\frac{20\ 6\ 10^4}{6\times 10^{23}} = \frac{1.2\ 10^{22}}{10^{25}}$$

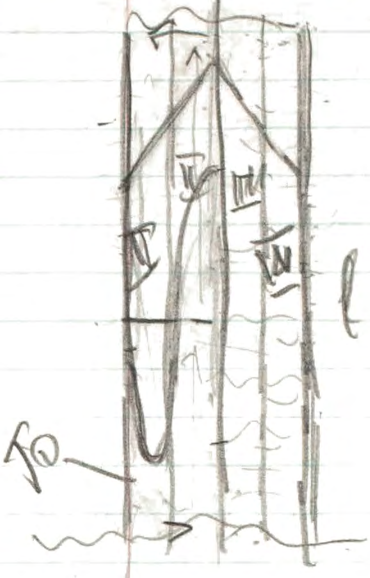
V = 2000 transp. ($\rho^* = 1$) $= \dfrac{10^{-3}}{2.6} L^4 p^{\text{atm}}\, \dfrac{3\sigma}{v}\ 6\ 10^{23}$

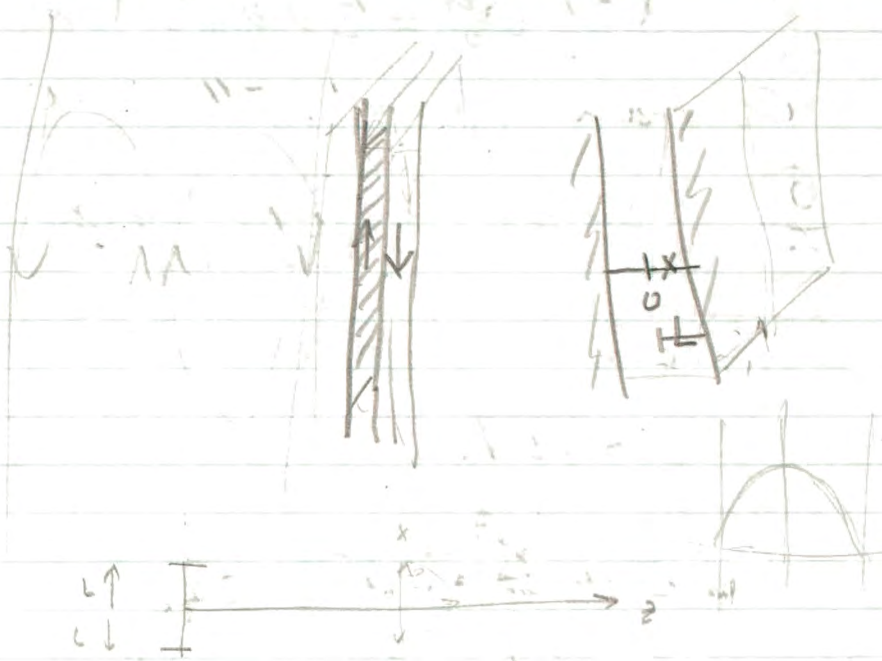
$$n = \frac{6\times 10^{23}\ p^{\text{atm}}}{22000\times 10}$$

diff trans. $\dfrac{l}{L}\,\dfrac{\lambda v}{3} = \dfrac{1}{3}\,\dfrac{l}{L}\,\dfrac{v}{\sigma}\,\dfrac{1}{n} = \dfrac{1}{3}\,\dfrac{l}{L}\,\dfrac{v}{\sigma}\,\dfrac{2.2\ 10^5}{p^{\text{atm}}\ 6\,10^{23}}$

Convection

M





$$w = B(L^2 - x^2) \qquad w(x)$$

$$\rho (v \cdot \mathrm{grad})\, v = -\mathrm{grad}\, p + \eta \Delta v \qquad \mathrm{div}\, v$$

$$+\frac{-\Delta P}{l} = \eta \frac{d^2 w}{dz^2} = -2B\eta$$

$$B = \frac{\Delta P}{2 l \eta}$$

$$w = \frac{\Delta P}{2 l \eta}(x - L)^2$$

$$2\int_0^L (-x^2 + L^2)\, dx =$$

$$= -2\,\frac{1}{3} L^3 + 2L^2 L = \quad +2L^3$$

$$= \frac{4}{3} L^3$$

$$\frac{\Delta P}{\eta l} = -\frac{d^2 w}{dz^2}$$

$$w = -\frac{\Delta P}{\eta l}\frac{1}{2} z^2 + \cancel{Bz} + C$$

$$0 = \frac{\Delta P}{2\eta l} L^2 + C$$

C

$2L^3 -$

$$\frac{\Delta P}{2 l \eta} \cdot \frac{4}{3}\frac{L^3}{2L} = \frac{1}{3}\frac{\Delta P}{l \eta} L^2 = \overline{w}$$

assume Cs atom for electrons

$$\sigma_0^{el} = 300 \, 10^{-16} \text{ cm}^2 = 3 \, 10^{-14}$$

Cs ion $\sigma_i = 10^{-11}$

$\frac{\sigma_i}{\sigma_0} \approx 300$ or if $f = 3\%$

ten percent of resistance resides in Cs atoms

neon could be added to increase resistance by another 10% — 300 fold.

Affect of Cs $2\frac{1}{2}$ times less than Xenon for equal σ ; σ is $\frac{1}{2}$ of Xe

[illegible] ~~[illegible]~~ 60 fold [illegible]

Another consideration might be limiting pressure of Cs and Ne because of diffusion hindrance of positive ions to cathode ~~[illegible]~~ region where recombination might lower f^0

Xe assume $\sigma_{el} \times 10 \times 10^{-16}$

Xe pressure could be chosen 30 fold

$$\pi a^2 = 0.53 \, 10^{-16} \text{ cm}^2$$

a = Bohr radius

$$\frac{\text{conv transport}}{\text{diff transport}} =$$

$$= \frac{10^{-3}}{2.6} \frac{2\,10^{24}}{2\times10^5} \frac{L^5}{\ell} M (p\,\text{atm})^2 \frac{\sigma}{v\eta}$$

$$= \frac{L^5}{\ell}$$

$M = 100$

$\sigma = 10^{-15}$

~~Frank~~ $v = 6\,10^4$

$\eta = 3\,10^{-4}$

$$\frac{10^{-3}\ 2\,10^{24}\ 10^{2}\ 10^{-15}}{2.6\,\cancel{\times}2\,10^5} \frac{1}{6} 10^{-4} \frac{1}{3} 10^{4}$$

$$\frac{L}{} \; 2\,\frac{10^{-5}}{10^5}\,10^{30}\,10^{-19}\,\frac{L^5}{\ell}(p\,\text{atm})^2 =$$

$$\doteq 20\,\frac{L^5}{\ell}(p\,\text{atm})^2$$

Cross section He Ne Ar. etc

Neon below 1 Volt $\sigma_{d} = 1\times\pi a^2 \approx 10^{-16}\ \text{cm}^2$

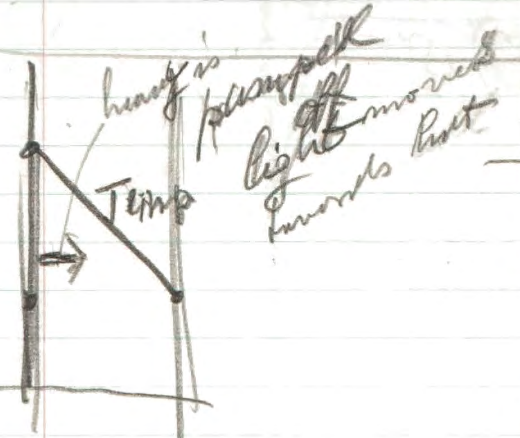
$a = 0.53\ 10^{-8}$

$\pi a^2 = 0.85\ 10^{-16}$

~~A~~. $\sigma_{\text{gas}} \cong 6\,10^{-16}\ \text{cm}^2$

Xe $\sigma_{\text{gas}} = 12\,10^{-16}\ \text{cm}^2$

$\boxed{\text{Cs — Cs cross section } 2{,}400\ 10^{-16}\ \text{cm}^2}$ H



$$\boxed{\frac{1}{3\,10^{-14}} = 10^{4}\ \text{cm}} \quad \text{Grammlamp}$$

$$\rho = \tfrac{1}{3}\,10^{18} = 3\,10^{17}$$

for 1 ~~sapphire~~ gives factor 1000 less information
at room Temp. — pressure

$3\,10^{17}\ 22\,400 = 6.2\ 10^{21}$

or $\frac{1}{100}$ atm | 7.6 mm Hg

Temp 2700 gives factor 10 less i.e. factor 100
and if layer $\frac{1}{10}$ mm we gain only factor 10

If cathode heavier than gas" it is pumped
off by thermal ~~diffusion~~ " current
otherwise it is conserved. —

---

for black bodies at 2500 K Radiation $\approx \frac{1}{2}$ of Rad at 3000 K

for " " at 2000 K rad = $\frac{1}{2.5}$ of rad at 2500 K

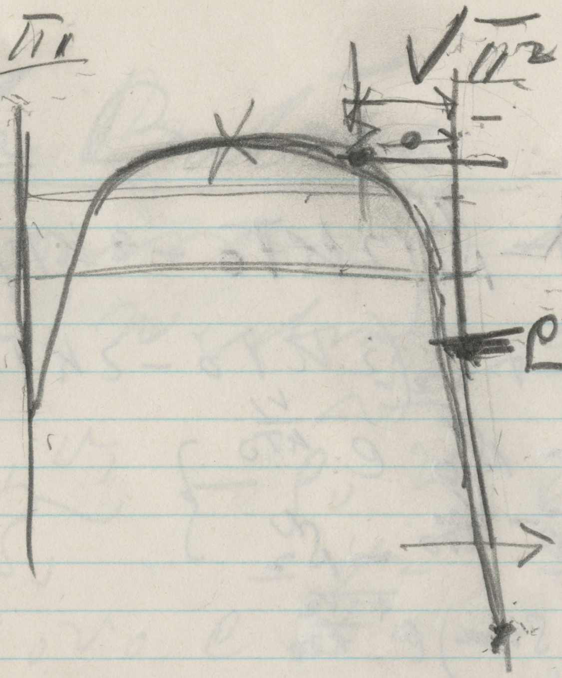
Black		
At 3000 K	460 Watt	$\frac{30}{230+120+30} = 16\%$
At 2500 K	230 Watt	$30 \times 4 = 120$ / 0.4
At 2000 K	95 Watt comp. to ~~Bedell output~~ ~~12 %~~	$\frac{30}{245}$

120

not black $\frac{1}{3}$ | $95 + 30 \times 4 + 30$

32
120
~~30~~
$\overline{182}$ $= \frac{30}{152} = \cancel{16.7\%}\ 20\%$

$$M = \frac{V}{W_1 + \dfrac{64\left(\dfrac{T}{2000}\right)^4}{(W_1 - W_2 - V)\,S^2}}$$



$$RT \ln \frac{\varsigma}{\varsigma_2}$$

EMF — A

$$AT^2 e^{-\frac{W}{kT}}$$

$$\frac{4\varsigma}{S} = W_1 - W_2 - V \qquad \varsigma V = \tfrac{1}{4}(W_1 - W_2 - V) S V$$

$W_2 = 1.5$

$$S = 100\, T_1^2 e^{-\frac{W_1}{kT_1}}$$

optimal W for given T_1

~~or including radiation loss optimal T~~

$\alpha^* = \frac{1}{5}$ incorp. to $\alpha = \frac{1}{3}$

$$\text{Rad} = \alpha^* 5.66 \left(\frac{T}{2000}\right)^4 \times 16 \text{ watts/cm}^2 \cong 91 \text{ watts} \left(\frac{T}{2000}\right)^4 \times \text{ watts/cm}^2$$

~~use $\alpha^* = \frac{1}{5.66}$~~

maximize
$$\frac{\frac{1}{4}(W_1 - W_2 - V) S V}{16\left(\frac{T}{2000}\right)^4 + \varsigma W_1}$$

$$= \frac{\frac{1}{4}(W_1 - W_2 - V) S V}{16\left(\frac{T}{2000}\right)^4 + \frac{1}{4}(W_1 - W_2 - V) S W_1}$$

$T_1 \neq T_2$

4. $$y(V_1 - V_2) = s_1'(2kT_0 - 2kT_1) + s_2(2kT_0 - 2kT_2)$$

1.) $$y = s_1 - s_0' e^{-\frac{V_1}{kT_0}}$$

2.) $$y = s_0 e^{-\frac{V_2}{kT_0}} - s_2$$

$$s_0' = (y + s_2) e^{+\frac{V_2}{kT_0}}$$

$$y = s_1' - (y - s_2) e^{-\frac{V_1 - V_2}{kT_0}}$$

$$A = 1 - \left(A - \frac{s_2}{s_1}\right) e^{-\frac{V_1 - V_2}{kT_0}}$$

$$\frac{s_2}{s_1} \ll A$$

$$\left\{ \begin{array}{l} 1 - A \cong A e^{-\frac{V_1 - V_2}{kT_0}} \\ A(V_1 - V_2) \cong 2kT_0 - 2kT_1 \end{array} \right\}$$

$$\frac{1-A}{A} = e^{-\frac{V_1 - V_2}{kT_0}}$$

$$A = \frac{2kT_0 - 2kT_1}{V_1 - V_2}$$

$$\frac{1 - \frac{2k(T_0 - T_1)}{V_1 - V_2}}{\frac{2k(T_0 - T_1)}{V_1 - V_2}} = e^{-\frac{V_1 - V_2}{kT_0}}$$

$$\frac{1}{A} = \frac{V_1 - V_2}{2k(T_0 - T_1)}$$

$$\frac{A(V_1 - V_2)}{2} + kT_1 = kT_0$$

$$\frac{(V_1 - V_2) - 2k(T_0 - T_1)}{2k(T_0 - T_1)} = \frac{V_1 - V_2}{2k(T_0 - T_1)} - 1$$

$$\frac{V_1 - V_2}{2k(T_0 - T_1)} = e^{-\frac{V_1 - V_2}{kT_0}}$$

$$\frac{1}{A} = e^{-\frac{V_1 - V_2}{\frac{A}{2}(V_1 - V_2) + kT_1}} = e^{-\frac{1}{\frac{A}{2} + \frac{kT_1}{V_1 - V_2}}}$$

with Balars

high pressure approximation

$n_1 = n_2$ no drawn current

1.) $y = \underbrace{\rho_1 v_1}_{S_1} - \overbrace{\rho_0 v_0}^{S_0} e^{-\frac{V_1}{E_0}}$

2.) $y = \rho_0 v_0 e^{-\frac{V_2}{E_0}} - \underbrace{\rho_2 v_2}_{S_2}$

3.) $V_1 - V_2 = \underline{\text{given}}$

$\underline{S_1 = S_2}$ $\underline{T_1 = T_2}$

4) $y(V_1 - V_2) = (S_1 - y)\, 2kT_0 - S_1 2kT_1 \boxed{+ y V_1 +}$

$+ (S_2 + y)\, 2kT_0 - S_2' 2kT_2$

$y(V_1 - V_2) = 2S\, 2kT_0 - 2S\, 2kT_1$

$\frac{A}{2}(V_1 - V_2) = 2(kT_0 - kT_1)$

$\frac{A}{4}(V_1 - V_2) + kT_1 = kT_0$

5

$$A = \frac{1 - e^{-\frac{V_1 - V_2}{kT_0}}}{1 + e^{-\frac{V_1 - V_2}{kT_0}}}$$

$\left.\begin{array}{l} y = S_1 - S_0 e^{-\frac{V_1}{kT_0}} \\ y = S_0 e^{-\frac{V_2}{kT_0}} - S_{2} \end{array}\right\}$ $S_0 = (y + S_2)\, e^{+\frac{V_2}{kT_0}}$

H.

Deby length $\quad h\nu = \frac{1}{6}$

$$\lambda = \sqrt{\frac{kT}{4\pi \rho e^2}} =$$

$$v_1 \rho_1 = \frac{30 \; 3 \, 10^9}{5} \, 10^{10} = 2 \, 10^{20} \qquad \rho \approx 10^{13}$$

$v = 2 \, 10^7$

$$h\nu = \frac{1}{6} eV = \frac{1.6}{6} 10^{-12} \text{ erg}$$

$$e^2 = 25 \, 10^{-20}$$

$$\lambda = \sqrt{\frac{3 \, 10^{-13} \, 10^{20}}{4\pi \, 10^{13} \, 25}} = \sqrt{10^{-20} \, 10^{-20}}$$

10^{-4} cm

λ mean free path $= 10^{14} = \frac{1}{\rho \sigma} = 10^{-2}$ cm

$\rho = 10^{14}$ $\quad \cancel{10^{14} \, 10} \quad \sigma = 10^{-11}$

$T_1 = T_2$

$$\ln \frac{1+A}{1-A} = \frac{V_1 - V_2}{\frac{A(V_1 - V_2)}{4} + kT_1} = \frac{1}{\frac{A}{4} + \frac{kT_1}{V_1 - V_2}}$$

$$\frac{1}{\ln \frac{1+A}{1-A}} = \frac{A}{4} + \frac{1}{C} \qquad C = \frac{V_1 - V_2}{kT_1}$$

$$\ln(1 + 2A_1) \approx \frac{1}{\frac{A}{4} + \frac{kT_1}{V_1 - V_2}}$$

$$2A \approx \frac{1}{\frac{A}{4} + \frac{kT_1}{V_1 - V_2}}$$

$$\frac{A}{4} + \frac{kT_1}{V_1 - V_2} = \frac{1}{2A}$$

$$\frac{kT_1}{V_1 - V_2} = \frac{1}{2A} - \frac{A}{4}$$

$$\frac{A}{1-A} = e^{\frac{V_1 - V_2}{\frac{A}{2}(V_1 - V_2) + kT_1}} = e^{\frac{1}{\frac{A}{2} + \frac{kT_1}{V_1 - V_2}}}$$

$$\ln \frac{A}{1-A} = \frac{1}{\frac{A}{2} + \frac{kT_1}{V_1 - V_2}}$$

$$\frac{1}{\ln A} = \frac{A}{2} + \frac{kT_1}{V_1 - V_2}$$

$A = e^{-3}$

$$-\frac{1}{3} = \frac{1}{40} + \frac{kT_1}{V_1 - V_2}$$

De Novo

H

1.) $y = S_1 - S_0 e^{-\frac{V_1}{kT_0}}$ | $S_0 = (S_1 - y) e^{\frac{V_1}{kT_0}}$

2.) $y = S_0 e^{\frac{-V_2}{kT_0}} - S_2$ $\quad S_0 = (S_2 + y) e^{\frac{V_2}{kT_0}}$

3.) $y(V_1 - V_2) = (S_1 - y) 2kT_0 - S_1 2kT_1$

$(S_2 + y) 2kT_0 - S_2 2kT_2$

(1,2) $\quad (S_1 - y) e^{\frac{V_1}{kT_0}} = (S_2 + y) e^{\frac{V_2}{kT_0}}$

$$\frac{S_2 + y}{S_1 - y} = e^{\frac{V_1 - V_2}{kT_0}}$$

$A = \frac{y}{S_1}$

(1-2) $\quad \dfrac{\frac{S_2}{S_1} + A}{1 - A} = e^{\frac{V_1 - V_2}{kT_0}}$

3.) $\quad \dfrac{A(V_1 - V_2)}{2} = \left(1 + \frac{S_2}{S_1}\right) kT_0 - kT_1 - \frac{S_2}{S_1} kT_2$

$T_1 = T_2 = T_1$

$$\frac{1 + A}{1 - A} = e^{\frac{V_1 - V_2}{kT_0}}$$

$$\frac{A(V_1 - V_2)}{4} = kT_0 - kT_1$$

$T_2 \ll T_1$

$$\frac{A}{1 - A} = e^{+\frac{V_1 - V_2}{kT_0}}$$

$$\frac{A(V_1 - V_2)}{2} = kT_0 - kT_1$$

A1

[illegible]

$$\rho_1 2kT_1 + \rho_1 V_1 - (\rho_1 - \rho)(V_1 + 2kT_0) - (\rho - \rho_2)(V_2 + 2kT_0) + \rho_2 V_2 = 0$$

$$V_1 + \frac{S_2}{S_1} V_2 + 2kT_1 + 2kT_2 \frac{S_2}{S_1} =$$

$$= (1-A)(V_1 + 2kT_0) + \left(A + \frac{S_2}{S_1}\right)(V_2 + 2kT_0)$$

$\frac{S_2}{S_1} \ll 1 \quad T_2 \ll T_1$

$$V_1 + 2kT_1 \approx (1-A)V_1 + (1-A)2kT_0 + AV_2 + A2kT_0$$

$$(V_1 - V_2)A + 2 [illegible] \approx 2kT_0 - 2kT_1$$

O.K.!

$$gV_1 = S 2kT_1^*$$

$$V_1 = kT_1^* \ln \frac{\rho_0}{\rho_1^*}$$

$$V_2 = kT_2^* \ln \frac{\rho_0}{\rho_2^*}$$

$$\frac{AV_1 + 2kT_1 - \frac{C}{S_1}}{2(1-A)} = kT_1^*$$

$$V_1 = \frac{AV_1 + 2kT_1 - \frac{C}{S_1}}{2(1-A)} \times \Bigg(\overbrace{\ln\frac{v_1^*}{v_1} + \ln\frac{1}{1-A} + \frac{W_1}{RT_1} - \ln\frac{\rho_m}{\rho_0}}^{\varphi} \Bigg)$$

$$2(1-A)V_1 - \varphi A V_1 = \left(2kT_1 - \frac{c}{S_1}\right)\varphi$$

$$V_1 = \frac{\left(2kT_1 - \frac{c}{S_1}\right)\varphi}{2(1-A) - \varphi A} = \frac{2kT_1 - \frac{c}{S}}{\frac{2(1-A)}{\varphi}}$$

$$\ln\frac{S_1^*}{S_1} = \ln\frac{\rho^* v_1^*}{\rho_1 v_1} = \ln\frac{v_1^*}{v_1} + \ln\frac{\rho^*}{\rho_1} =$$

$$\ln\frac{\rho^*}{\rho_1} = \frac{W_1}{RT_1} - \ln\frac{\rho_m}{\rho_0}$$

$$\cancel{18 - 24 - 11.5}$$

$2.5 < W_1 < 4$

$15 < \frac{W_1}{RT} < 25$

$3.5 < \ln\frac{\rho^*}{\rho_1} < 13.5$

$$\varphi \simeq 22 - 11.5 \simeq 10$$

Taken from Balass

$$V_1 = \frac{c/S_1 - 2kT_1}{A - \dfrac{2(1-A)}{\ln\frac{v^*}{v_1} + \ln\frac{\rho^*}{\rho_1} - \ln(1-A)}}$$

17

New theory ~ <u>no heat cond.</u>

$$y = S_1 - \rho_0 v_1^* e^{-\frac{V_1}{kT_1^*}} = \qquad S_1 = \rho_1 v_1 \qquad \Big| \quad \frac{y}{S_1} = A$$

$$V_1 = kT_1^* \ln \frac{\rho_0 v_1^*}{S - y} =$$

$$V_1 = kT_1^* \ln \frac{\rho_0 / S \times v_1^*}{1-A} = kT_1^* \ln \frac{\rho_0}{\rho_1} \frac{v^*}{v_1} \frac{1}{1-A}$$

$$\boxed{\ln \frac{\rho_0}{\rho_1} = \ln \frac{\rho_0}{\rho_m} \frac{\rho_m}{\rho_1}}$$

$$S = \rho_1 v_1$$

$$\rho_1 = \rho_m e^{-\frac{W}{kT_1}} \qquad \alpha_1 = \ln \frac{\rho_0}{\rho_1} = \ln \frac{\rho_0}{\rho_m} + \frac{W}{kT_1}$$

$$V_1 = kT_1^* \Big(\underbrace{\ln \frac{v_1^*}{v_1} + \ln \frac{1}{1-A}}_{\varphi} + \frac{W_1}{kT_1} - \ln \frac{\rho_m}{\rho_0} \Big)$$

$$(1.)\ V_1 = kT_1^* \ln \frac{S_1^*}{S_1 - y} \qquad S_1^* = \rho_0 v_1^*$$

$$(2.)\ V_2 = kT_2^* \ln \frac{S_2^*}{y - S_2} \qquad S_2^* = \rho_0 v_2^* \qquad \Big| \quad y = S_2^* e^{-\frac{V_2}{kT_2^*}} - S_2$$

$$V_2 = kT_2^* \Big(\ln \frac{v_2^*}{v_2} + \ln \frac{1}{B-1} + \frac{W_2}{kT_2} - \ln \frac{\rho_m}{\rho_0} \Big)$$

$$3.)\ y V_1 + 2 S_1 kT_1 = S_1^* e^{-\frac{V_1}{kT_1^*}} 2kT_1^* + C (T_1 - T_2)$$

$$C = Km (T_1 - T_2) \rho_0$$

<u>m</u> number of mean free paths

from (1) and (3)

$$y V_1 + 2 S_1 kT_1 = \cancel{S_1^*} \frac{S_1 - y}{\cancel{S_1^*}} 2kT_1^* + C$$

$$A V_1 + 2kT_1 = (1-A) 2kT_1^* + \frac{C}{S_1}$$

$$\mathcal{J} V_1 = (S_1 - \mathcal{J})\, 2kT_1^* - S_1 2kT_1 + \mathcal{J} \lambda kT_1^*$$

$$V_1 = \left\{2\frac{1-A}{A} + \lambda\right\} kT_1^* - \frac{1}{A} 2kT_1$$

$$V_1 = kT_1^* \varphi$$

$$kT_1^* = \frac{V_1}{\varphi}$$

$$V_1 = \left\{2\frac{1-A}{A} + \lambda\right\} \frac{V_1}{\varphi} - \frac{1}{A} 2kT_1$$

$$V = \frac{1-A}{A}\, 2\frac{V}{\varphi} + \lambda \frac{V}{\varphi} - \frac{1}{A} 2kT_1$$

$$V\left(1 - \frac{1-A}{A}\, 2\frac{1}{\varphi} - \frac{\lambda}{\varphi}\right) = -\frac{1}{A} 2kT_1$$

$$V = \frac{\qquad}{\frac{1-A}{A}\frac{2}{\varphi} - \frac{\lambda}{\varphi} - 1}$$

$$2kT_1 = \left(\frac{2(1-A) + \lambda A}{\varphi} - A\right) V$$

$$AV_1 = \{2(1-A) + \lambda A\}\frac{V_1}{\varphi} - 2kT_1$$

$$\varphi\, 2kT_1 = \left\{2\left\{(1-A) + \frac{\lambda A}{2}\right\} - \varphi A\right\} V_1$$

A_{max} $\quad 2(1-A_{max}) + \lambda A_{max} = \varphi A_{max}$

$$2 + (\lambda - 2)A = \varphi A$$

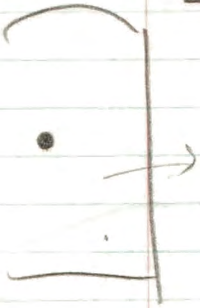
$$2 = (\varphi - (\lambda - 2))A$$

$$A = \frac{2}{\varphi - (\lambda - 2)}$$

$$S_1 2kT_1 + S_1 V_1 = S_1^* e^{-\frac{V_1}{kT_1^*}} \frac{1}{2}kT_1^* + S_1^* e^{-\frac{V_1}{kT_1}} V_1$$

$$\frac{(S_1 - J)\left(\frac{1}{2}kT_1^* + V_1\right)}{\Delta H + \frac{1}{2}kT}$$

$\underline{\Delta H}$



$\frac{3}{2}kT$ $\quad$ $\underline{2kT}$

$$S_1(V_1 + 2kT_1) = (S_1 - J)\left(V_1 + \frac{1}{2}kT_1^*\right)$$

$$JV_1 + S_1 2kT_1 = (S_1 - J)\frac{1}{2}kT_1^*$$

$$\boxed{AV_1 + 2kT_1 = (1 - A)\frac{1}{2}kT_1^*}$$

$V_2 = 0$

$\underline{JV_1} = \cancel{S_1 kT_1 A\, S_1 2kT_1}$

$JV_1 = (S - J)2kT_1^*$ $\quad$ $-S_1 2kT_1$

$JV_2 = 0$

$$\frac{J(V_1 - V_2) + JV_2}{}$$

$\underline{S_1 V_1} + S_1 2kT_1 = S_1^* e^{-\frac{V_1}{kT_1^*}} V_1$

$(S_1 - J)V_1 + J\frac{5}{2}kT_1^*$

$JV_1 + S_1 2kT_1 = J\frac{5}{2}kT_1^*$

$\underline{JV_1} = (S_1 - J)2kT_1^* - S_1 2kT_1$

$-J \Lambda kT_1^*$

$\pi_1 = W_1 - Q_1$

$$V_1 = kT_1^*\left(F + \ln \rho_0 + \ln \frac{T_2}{T_1^*} - \ln T_1^*\right)$$

$$\cancel{\text{Stat}} \quad y = S_0 e^{-\frac{V_1}{kT_2^*}}$$

De Novo for V_2

$$V_2 = kT_2^* \ln \frac{S_2^*}{J + S_{02}}$$

$$V_2 \simeq kT_2^* \ln \frac{S_2/S_1}{A}$$

$$V_2 \cong kT_2^* \ln \frac{1}{A} + kT_2^* \ln \frac{S_2^*}{S_1}$$

$$\ln \frac{S_2^*}{S_1} = \ln \frac{\rho^* v^*}{\rho_1 v_1} = \ln \frac{v^*}{v_1} + \ln \frac{\rho^*}{\rho_1}$$

$$V_1 = kT_1^* \ln \frac{S_1^*}{S_1 - J} = kT_1^* \ln \frac{S_1^*/S_1}{1-A}$$

$$S_1^* = S_2^* \qquad T_1^* = T_2^*$$

$$V_1 - V_2 = kT^*\left(\ln \frac{1}{1-A} - \ln \frac{1}{A}\right) = kT^* \ln \frac{A}{1-A} + \frac{\rho^*}{\rho_1} - \frac{\rho^*}{\rho_2}$$

$$J \gg S_2$$

$$S_1 = S_2 \quad \cancel{\text{W}} \quad 1.5\, S_{\cancel{*}} = S^* e^{-\frac{V_2}{kT^*}}$$

$$A = 1/2 \qquad V_2 = kT^* \ln \frac{S^*}{1.5 S_1}$$

(H)

De Novo

$$\partial V_1 = (S_1 - J)\, 2kT_1^* - S_1\, 2kT_1 + J\, \lambda\, kT_1^* + \beta(T_1^* - T_1)$$

$$V_1 = kT_1^* \varphi \qquad \lambda T_1^* = \frac{V_1}{\varphi}$$

$$V_1 = \left(\frac{1}{A} - 1\right) 2kT_1^* - \frac{1}{A} 2kT_1 + \lambda kT_1^* + \frac{\beta/k}{J}(kT_1^* - kT_1)$$

$$V_1 = \left[2\frac{1-A}{A} + \lambda + \frac{\beta/k}{J}\right]\frac{V_1}{\varphi} - \frac{1}{A} 2kT_1 - \frac{\beta/k}{J} kT_1$$

$$V_1\left(\frac{1}{\varphi}\left\{2\frac{1-A}{A} + \lambda + \frac{\beta/k}{J}\right\} - 1\right) = \left\{\frac{2}{A} + \frac{\beta/k}{J}\right\} kT_1$$

$$V_1\left(\frac{1}{\varphi}\left\{\lambda - 2 + \frac{2}{A} + \frac{\beta/k}{J}\right\} - 1\right) = \left\{\frac{2}{A} + \frac{\beta/k}{J}\right\} kT_1 .$$

$$V_1 = \frac{\left\{\frac{2}{2A} + \frac{\beta/k}{J}\right\} kT_1\, \varphi}{\lambda - 2 + \frac{2}{A} \qquad - \varphi\left(1 - \frac{\beta/k}{\varphi J}\right)}$$

$$V_1 \approx \frac{\frac{2}{A} kT_1}{\frac{2}{20A} - 1} = \frac{2kT_1}{\frac{1}{10} - A}$$

$$\cancel{\frac{1}{10} - A \approx \frac{2kT_1}{V_1}}$$

$$\cancel{A \approx \frac{1}{10} - \frac{2kT_1}{V_1}} \qquad 2kT_1 = \frac{4}{10}$$

$$A \approx \frac{1}{4} - \frac{2kT}{V_1} \qquad \frac{4}{15} - \frac{4}{15} \qquad \frac{2}{25} \qquad A = \frac{1}{10}$$

Summary:

$$\begin{cases} V_1 = kT_1^* \left\{ \ln \frac{S_1^*}{S_1} + \ln \frac{1}{1-A} \right\} \\ V_2 = kT_2^* \left\{ \ln \frac{S_1^*}{S_1} + \ln \left[\frac{T_1^*}{T_2^*} \right] + \ln \frac{1}{\frac{S_2}{S_1} - A} \right\} \end{cases}$$

$$\boxed{V_1 - V_2} = kT^* \ln \frac{1+A}{1-A}$$

$W_1 = W_2$
$T_1 = T_2$

T_2^*

$$\boxed{V_2 = 2k(T_1^* - T_2^*)}$$

$V_1 - V_2$

$$V_2 \cong kT_2^* \ln \frac{S_2^*/S_1}{A} = kT_2^* \ln \frac{\sqrt{\frac{T_1}{T_2^*}}\, S_1^*/S_1}{A}$$

$$V_1 = kT_1^* \ln \frac{S_1^*/S_1}{1-A} = kT_1^*$$

$V_1 - V_2 \approx$

De Novo:

$$S_1 - y = S_1^* e^{-\frac{V_1}{kT_1^*}}$$

$$S_2 + y = S_2^* e^{-\frac{V_2}{kT_2^*}}$$

$$\frac{S_1 - y}{S_2 + y} = \frac{S_1^*}{S_2^*} e^{-\frac{V_1}{kT_1^*}} e^{+\frac{V_2}{kT_2^*}}$$

$$\frac{1-A}{\frac{S_2}{S_1} + A}$$

$\frac{S_2}{S_1} + A$

$$1 - A = \frac{S_1^*}{S_1} e^{-\frac{V_1}{kT_1^*}}$$

$$\frac{1}{1-A} = \frac{S_1}{S_1^*} e^{\frac{V_1}{kT_1^*}}$$

$$\frac{S_1^*}{S_2^*} = \sqrt{\frac{T_2^*}{T_1^*}}$$

$$\frac{S_2^*}{S_1^*} = \sqrt{\frac{T_1}{T_2}}$$

$$\boxed{kT_1^* \left\{ \ln \frac{S_1^*}{S_1} + \ln \frac{1}{1-A} \right\} = V_1}$$

$$kT_2^* \left\{ \ln \sqrt{\frac{T_1}{T_2}} \frac{S_1^*}{S_1} + \ln \frac{1}{\frac{S_2}{S_1} + A} \right\} = V_2$$

Heat transfer

$\rho = 10^{16}$ heat transfer per electron

$\rho = 3\,10^{12}$ ~~[illegible]~~

is 30 Amps for $v = 2\,10^{7}$

Heat from Ions

ρ higher by mass factor 300

v lower by factor $\sqrt{200{,}000}$ | 500

Not enough!

Irradiation: $\frac{1}{10}\,10^{15} \times 2\,10^{7}\, e^{-\frac{1.5}{x}}\, 10^{-16}$ eVolt/sec

$\frac{1}{10}\,\rho_{ion}^{2}\, 2\,10^{7}\, 10^{-16}\, e^{-\frac{1.5}{x}}$ eV/cm²

(10) $\frac{30 \times 3\,10^{9}}{5\,10^{-10}}\, x$

Deutsch

H

σ in reciprocal ohm meter

$= n e^2 \cancel{\ } L$

number of electrons in m^3

e in coulombs

L meters

m mass of electrons in kg

v in meters per sec

K heat cond in · watt / degree / meter

$$\frac{K}{\sigma_{meter} T} = (3)\left(\frac{k}{e}\right)^2$$

86 ~~microvolt / degree~~ $\times 10^{-6}$ volt / degree

Wilson

Assume
2500 K

$$\rho_{A+} = p\, 4\, 10^{15}$$

$$f = \frac{2.5}{\sqrt{p}}\, 10^{-1.8}$$

$$f \rho_A = \sqrt{p} \times 10^{14}$$

When $\rho_1 = f \rho_A$

$$W = 3.2 - \frac{\ln p}{9.4}$$

In general

$$\rho_1 = 2.7\, 10^{20}\, e^{-\frac{W}{kT}}$$

$$\rho_{1_{el}} = \frac{1}{\alpha} \sqrt{p}\, 10^{14}$$

$$\rho_{ion}\,(\text{wall}) = \alpha \sqrt{p}\, 10^{14}$$

~~[illegible]~~ [illegible] of ~~[illegible]~~ vapor as ion p_i and as atom p_A

$$\rho_{A+}\, p_i = \rho_{ion}(\text{wall})\, p_A$$

$$\frac{p_i}{p_A} = \sqrt{}$$

$$\frac{p_i}{p_A} = 10^{-8}\, e^{\frac{W}{kT}} \qquad T = 2500\,K$$

"Resonance Ionization"

Saha

$f = 2.4 \times 10^{-4}\, T^{5/2}\, p^{-1}\, e^{-\frac{V_i}{kT}}$ $\boxed{\text{for } f \ll 1}$

$f = \frac{1}{\sqrt{p}}\, e^{-\frac{1}{2}\frac{V_i}{kT}} - 10^{-5}\, T\, \cancel{T^{1/4}}\, 1.5\, \frac{1}{100}$

$f\rho_0$ || $1.3\, p_{mm} = 10^{-3}$ atm | 10^{-3} atm $= 0.76$ mm |

$\rho_0 = \frac{1.3\, p \cdot 6 \times 10^{23}}{2.2\; 10^{4}}\, 10^{-3}\, \frac{273}{T} = \cancel{1.3 \times 6 \times 273}$

$[f\rho_0] = \quad = \frac{1.3 \times 6}{2.2}\, 273\; 10^{+16}\, \frac{p}{T} = \frac{p}{T}\, 10^{+19}$

$[f\rho_0] \quad = \sqrt{p}\, e^{-\frac{1}{2}\frac{V_i}{kT}}\, (T)^{1/4}\; 1.5 \times 10^{17} = \text{Saha}$

$T \approx 2500 \qquad T^{1/4} = 7$

$[f\rho_0] = \quad 10^{18} \sqrt{p}\, e^{-\frac{1}{2}\frac{V_i}{kT}}$

~~$\frac{V_i}{kT} = 3.8$~~

for $\left.\begin{array}{l} V_i = 3.8 \\ kT = \frac{1}{6} \end{array}\right\}$ $f\rho_0 \cong 10^{+18} \sqrt{p}\; 10^{-5}$

$= 10^{13} \sqrt{p}$

$$\rho_{At} = 3\frac{S_1}{400}\frac{\cancel{500}}{2\,10^7} = \frac{3\,S_1}{2\,10^7}$$

$$\rho_{At} = p \times 4 \times 10^{15}$$

$$p = \frac{3\,S_1}{2\,10^7 \; 4\,10^{15}} = \frac{3}{8}\frac{S_1}{10^{22}}$$

$S_1 =$ ~~[illegible]~~ 100 Amps/cm²

$$\frac{100 \;\; 3\,10^9}{5\,10^{-10}} = \frac{1}{2}\,10^{21}$$

$$p = \frac{3}{16}\,10^{-1} \text{ [illegible]}$$

or perhaps 3 times less because

$\frac{S_1}{400}$ is wrong $\quad p < 10^{-2}$ [illegible] nothing $\frac{\cancel{p}_i}{\cancel{p}_{At}} = R$

H

$\frac{p_i}{1-p_i} = R$ $p_i = R - R\,p_i$

$p_i(1+R) = R$

$p_i = \frac{R}{1+R}$

Conditions for no ion loss at cathode

$\rho_{At} \frac{v_1}{3} \frac{R}{R+1} + \frac{S_1}{400} \frac{R}{R+1} = \frac{S_1}{400}$

$\frac{R}{R+1} = \frac{S_1/400}{S_1/400 + \rho_{At} \frac{v_1}{3}}$

Relationship: $R = 10^{-8} e^{\frac{W}{kT}}$ gives

for small R

$\frac{6}{\rho} 10^{-3} = R$

$\boxed{W = 3.8 - \frac{1}{4.7} \ln \frac{1}{R}}$

for $R = 1$

$\frac{1}{2} = \frac{S_1/400}{S_1/400 + \rho_{At} \frac{v_1}{3}}$

and $\rho_{At} = p \times 4 \times 10^{15}$ $\frac{1}{2} \frac{S_1}{400} + \rho_0 \frac{v_1}{6} = S_1/400$

$\rho_{At} = \frac{6}{2} \frac{S_1}{400} \frac{1}{v_{At}} = 3 \frac{S_1}{400} \frac{500}{2\,10^5}$ $\rho_{At} \frac{v}{6} = \frac{1}{2} \frac{S_1}{400}$

The electrons produced $= 2N$

$$2 \times e^{-\frac{3.8}{kT^*}} \cancel{\rho_{el}^* v_{el}} \rho_0 l \sigma = \cancel{\rho_{el}^* v_{el}^*} e^{-\frac{V_1}{kT^*}}$$

$$\ln 2 \rho_0 l \sigma + \frac{V_1}{kT^*} = \frac{3.8}{kT^*}$$

$$V_1 = \left\{ 3.8 - \ln 2 \rho_0 l \sigma \right\} kT^*$$

no good

Ion method w of no neg space charge at cathode

$$\rho_{ion}^* = e^{\frac{-V_1^*}{kT_1}} = \rho_1$$

further

$$V_1^* = kT^* \ln \frac{\rho_d^* v_{el}^*}{\rho_1 - J}$$

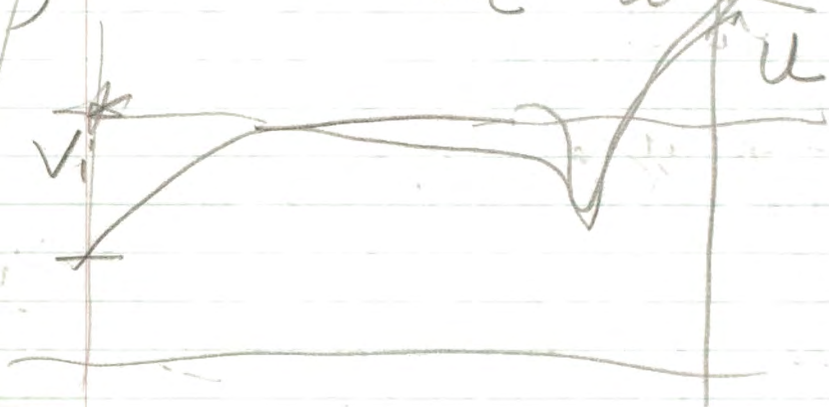
ρ^*

Results

2.) $N = \rho_{ion}^{*} v_{ion}^{*} e^{-\frac{U}{kT_i}}$

$\cancel{N = C(T)\frac{\rho^{*2}}{\rho}}$

3.) $J_1 - J_2 = \rho_{el}^{*} v_{el}^{*} e^{-\frac{V_i}{kT_{el}^{*}}}$



$\cancel{N = C(T)\,\rho^{*}\rho_0}$

1.) $\cancel{N = f\rho_0 v^{*}}$ $N = e^{-\frac{V_i}{kT^{*}}}\rho_{el}^{*}\rho_a v_{el}^{*} l\sigma$

from 1.) and (2.)

$$\frac{\rho_{el}^{*}\rho_0 v_{el}^{*} l\sigma}{\rho_{ion}^{*} v_{ion}^{*}} e^{\frac{U}{kT_{ion}}} = e^{\frac{3.8}{kT_{el}^{*}}}$$

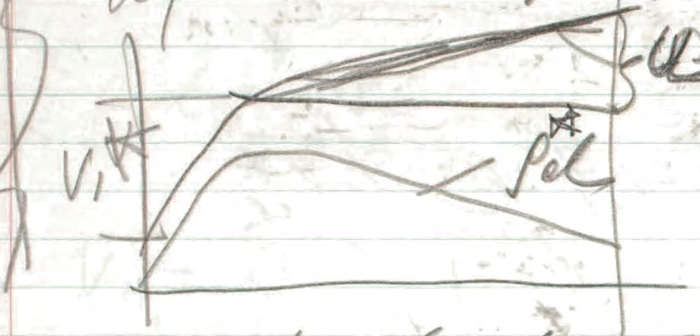
$$U = kT_{ion}\left\{\frac{3.8}{kT_{el}^{*}} + \ln\frac{\rho_{ion}^{*}}{\rho_{el}^{*}} + \ln\frac{v_{ion}}{v_{el}^{*}} + - \ln \rho_0 \sigma l\right\}$$

$$U = 3.8\frac{kT_{ion}}{kT_{el}^{*}} + kT_{ion}\{-7 + 4.6\}$$

New departure

MIO Apr. 13 /09

Key factor ~~#~~ is loss of ions to anode!



U is ions produced

~~If U ... anode~~

1) is upper no loss of ions to cathode

2) Assume U jumping near anode!

$$U = kT_i \ln \frac{v_i^* \rho_i^*}{4.4 N}$$

where N is ion production

$$N = l \sigma v_{el}^* \rho_0 e^{-\frac{3.8}{4\pi^* \rho_{el}^*}}$$

$$\rho_{el}^* = \alpha \rho_i \qquad A = \frac{4}{\rho_i}$$

α is 3 to 10 drift velocity divided by $v_{el}^*/4.4$

Boltzmann

$$j = \frac{1}{4} \rho c \quad \text{where} \quad c = \sqrt{\frac{8kT}{\pi m}}$$

Boltzmann

$$\frac{1}{2} m v^2 = \frac{3}{2} kT \qquad v = \sqrt{\frac{3kT}{m}}$$

Boltzmann

$$j = \frac{1}{4.4} \rho v$$

New Approaches [illegible]

$$\text{[illegible]} = \frac{\rho^*_{el} \, S_1 L}{(V_1)^2} = a S_1$$

$$\boxed{\begin{array}{l} [\,\,] = \rho^*_{el} \, v_{el} \, e^{-\frac{V_1}{kT^*}} \\ \text{En. loss in gas} \\ \quad a S_1 V_1 = S_1 \, 2 k T^* \end{array}}$$

$$\left\{ \begin{array}{l} J = (1-\kappa) S_1 + \dfrac{v^* \lambda^*}{3} \dfrac{\rho_e^*}{e} \\ \lambda = \dfrac{\left[\frac{3}{2} k T^*\right]^2}{\rho_e^* C} \end{array} \right.$$

Try again other approach.

$a S_1$ becomes thermalized

$$\left\{ \begin{array}{l} N = e^{-\frac{3.8}{kT^*}} \rho_0 \rho^*_{el} v^*_{el} \sigma l \\ \cancel{\rho^*_{el} v^*_{el} = 4.4\,\alpha J} \\ \cancel{N = e^{-\frac{3.8}{kT^*}} \rho_0 \sigma l\, 4.4\,\alpha J} \end{array} \right.$$

$$U = kT_1 \ln \frac{v_i \rho_i}{4.4 N}$$

$$U = kT_1 \ln \frac{v_{ion}}{v^*_{el}} + 3.8 \frac{kT_1}{kT^*} + kT_1 \ln \frac{\rho_i}{\rho^*_{el}} + kT_1 \ln \frac{1}{l \rho_0 \sigma}$$

$\ln \frac{1}{1000}$

$\ln 1 = 0$

$\ln \sigma = 10^{-16}$

equal $\ln 300$

$$- \ln 4.4$$

$$U \approx 3.8 \frac{kT_1}{kT^*} - \underbrace{kT_1 \ln 3.3 - kT_1 \ln 4.4}$$

$$\approx 0.63 \quad - 2.5\, kT_1 \approx 0.2 \text{ Volts}$$

$kT_1 = \frac{1}{6}$

Important assumption above!

$$\left\{ \begin{array}{l} \cancel{\text{above}} \quad \rho_{ion} = \rho^*_{el} \\ kT^* = 1 \text{ Volt} \end{array} \right.$$

A

$$\alpha = \frac{\frac{v^*_{el}}{4.4}\rho^*_{el}}{Y}$$

$$\alpha = \frac{\cancel{\rho_1 v_1/4.4}}{A}\,\frac{v^*_{el}}{v_1}\,\frac{\rho^*_{el}}{\rho_1}$$

$$\alpha = \frac{1}{A}\,\frac{v^*_{el}}{v_1}\,\frac{\rho^*_{el}}{\rho_1}$$

Classical

$$V_1 = kT_1^* \ln\left(\frac{\rho^*_{el}\, v^*_{el}/4.4}{\rho_1 - Y}\right)$$

$$\rightarrow V_1 = kT_1^* \ln \frac{\alpha Y}{\rho - Y} = kT_1^* \ln\frac{\alpha A}{1-A}$$

Now for U ;

$\frac{V_3+V_1}{kT^*}$ is ~~maximal~~ minimal

for $\alpha = \frac{3}{4.4}\frac{l}{\lambda}$

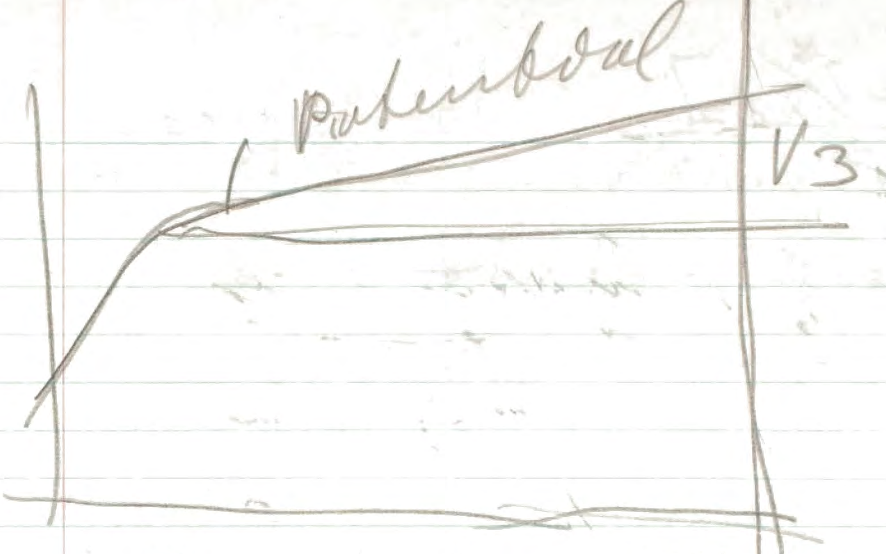
Value of ~~maximum~~ minimum $=$ ~~$1+\ln$~~

$$\left\{\frac{V_3+V_1}{kT^*}\right\}_{min} = 1 + \ln \underbrace{\frac{\frac{3}{4.4}\frac{l}{\lambda}A}{1-A}}_{\text{must be positive}}$$

$V_3\ min = kT^*$

$V_1\ min = kT^* \ln \frac{3}{4.4}\frac{l}{\lambda}\frac{A}{1-A}$

~~Minimize the width V_3~~



Premises $V_1^* > 0$
so that we may assume
$\rho^*_{el} = \rho^*_{ion}$ and
yet have ~~sp~~ negative space
charge neutralised even
near cathode. — This will
mean that A has to stay above
a certain minimal value. —

$$J = -\frac{\lambda v^*_{el}}{3}\left(\frac{d\rho^*_{el}}{dx} - \frac{\rho^*_{el}}{kT^*}\frac{dV}{dx}\right)$$

assumption $\boxed{\rho^*_{el} \approx \text{constant}}$

$$\frac{dV}{dx} = \frac{V_3}{l}$$

introduce $\alpha = \dfrac{v^*_{el}\,\rho^*_{el}}{4.4\,J}$

2.) $V_1 = kT^* \ln \frac{\alpha A}{1-A}$ 1.) $V_3/kT^* = \frac{3}{4.4}\frac{l}{\lambda}\frac{1}{\alpha}$

$$\frac{V_3 + V_1}{kT^*} = \frac{3}{4.4}\frac{l}{\lambda}\frac{1}{\alpha} + \ln\alpha + \ln\frac{A}{1-A}$$

$$6^2 = \frac{D_i\left[1 + T^*/T_i\right]}{\delta}$$

(5) $\rho^* = \rho_0^* \cos\frac{x}{6} + \text{Const.} \sin\frac{x}{6}$

assume Const. = 0

substitute ρ^* in to (3) gives

$$J_{el} = D_{el}\frac{\rho_0^*}{6}\sin\frac{x}{6} + \frac{D_{el}}{KT^*}\rho_0^*\cos\frac{x}{6}\frac{dV_3}{dx}$$

~~for~~ $\boxed{\frac{x}{6} << 1}$ ~~gives~~

$$\cancel{\frac{V_3}{KT^*} = \frac{J_{el}}{D_{el}}\frac{x}{\rho_0^*} - \frac{1}{2}\left(\frac{x}{6}\right)^2}$$

$$\cancel{V_3 \simeq KT^*\frac{3J_{el}}{v_e^* \lambda_{el}}\frac{x}{\rho_0^*}}$$

take into account that $\lambda_{el}^* = \frac{\text{Const}}{\rho_{el}^*}$

$$V_3 \cong KT^*\left[\frac{3J_{el}\sigma_{el}^*}{v_{el}^*}x\right]$$

merge U with V_3 H

neglect dependance of λ on g^*!

assume electron current J

is constant $\frac{dJ}{dx} = 0$

$$\begin{cases} 1.) \ \frac{dJ_i}{dx} = \delta \rho^* & (\rho^*_{el} = \rho^*_i + \Delta \quad \Delta << \rho^*_i) \\ 2.) \ J_i = -D_i \frac{d\rho^*}{dx} - \frac{D_i}{kT_i} \rho^* \frac{dV_3}{dx} & \end{cases}$$

$\rho^* \frac{dV_3}{dx} \,//\, Q$

$$\frac{dJ_i}{dx} = -D_i \frac{d^2\rho^*}{dx^2} - \frac{D_i}{kT_i} \frac{dQ}{dx}$$

or

$$\delta \rho^* = -D_i \frac{d^2\rho^*}{dx^2} - \frac{D_i}{kT_i} \frac{dQ}{dx}$$

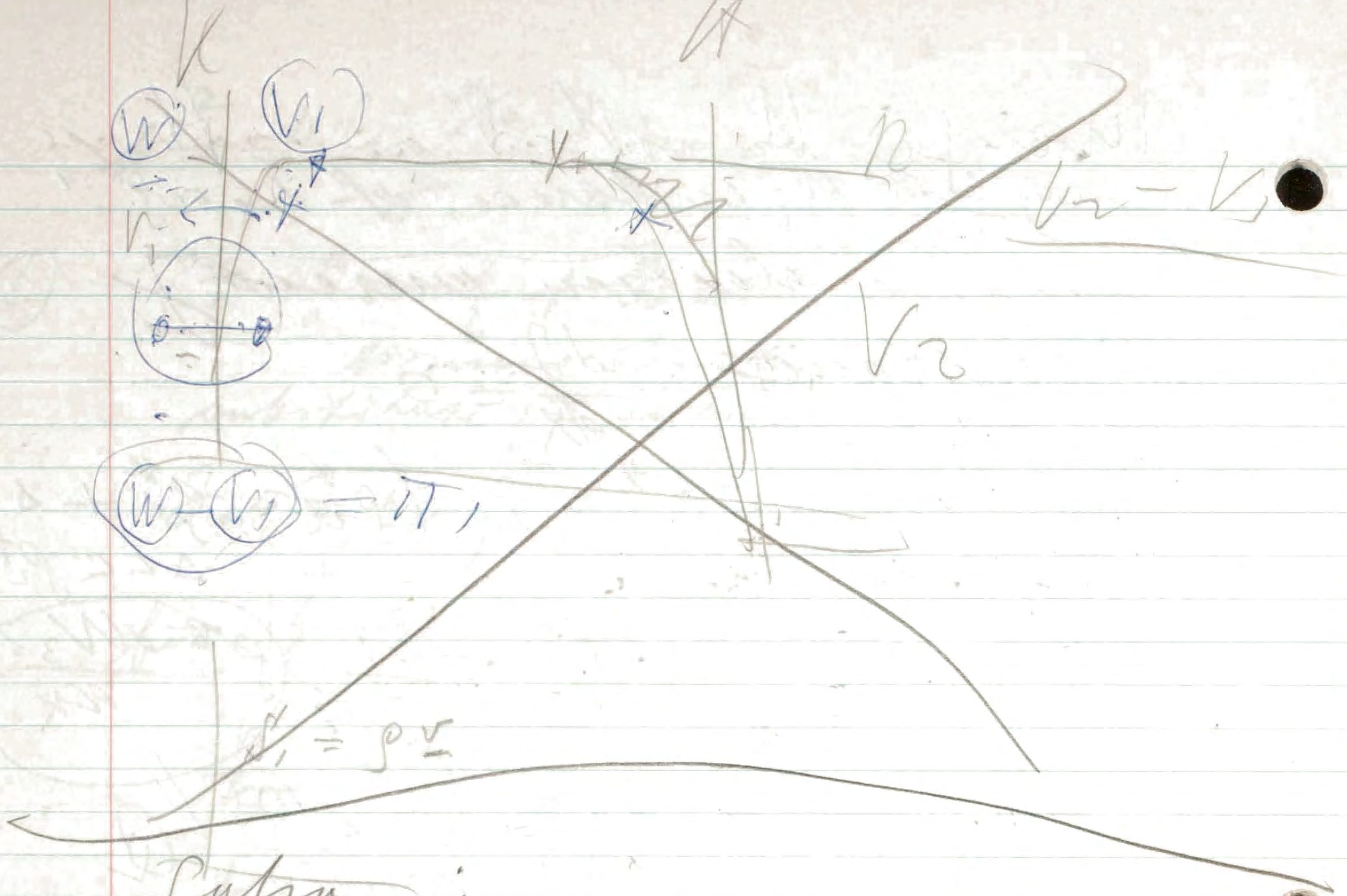
$$\begin{cases} 3.) \ J_{el} = -D_{el} \frac{d\rho^*}{dx} + \frac{D_{el}}{kT^*} \rho^* \frac{dV_3}{dx} \\ 4.) \ \frac{dJ_{el}}{dx} = 0 \end{cases}$$

$$0 = -D_{el} \frac{d^2\rho^*}{dx} + \frac{D_{el}}{kT^*} \frac{dV_3}{dx}$$

or

$$\frac{d^2\rho^*}{dx^2} = \frac{1}{kT^*} \frac{dQ}{dx}$$

$$\rightarrow \frac{d^2\rho^*}{dx^2} = \frac{-\delta}{D_i\left[1 + \frac{T^*}{T_i}\right]} \rho^*$$



Saha ;

$$21)\quad \frac{p_i\, p_{el}}{p_A} = 2\left(\frac{2\pi m kT}{h^3}\right)^{3/2} kT\, e^{-\frac{V_i}{kT}}$$

Combine 2 with 1 gives

$$\frac{p_i}{p_A} = e^{\frac{(W-V_i)}{kT}}$$

or from (0)

$$\frac{P_i}{P_A} = e^{\frac{W-V_i}{kT}}$$

H

~~Review of conditions~~
~~for no den loss at cathode~~

Compute from equilibrium

$$\frac{P_i}{P_a} \; ; \; P_i + P_w = 0$$

In equilibrium

$$\rho_A P_i = \rho_i P_A$$

this follows from

$$\frac{v}{4.4}\rho_A = P_A(\rho_A + \rho_i)\frac{v}{4.4}$$

$$\frac{v}{4.4}\rho_i = P_i(\rho_A + \rho_i)\frac{v}{4.4}$$

or introducing partial pressures p_i and p_A

(0) $$\frac{P_i}{P_A} = \frac{\rho_i}{\rho_A} = \frac{p_i}{p_A}$$

~~$\frac{p_A}{p_{el}\,p_i} = K(T)$~~ ~~$\frac{p_i\,p_{el}}{p_A}$~~

pel at surface of cathode:

$$1) \quad p_{el} = \underbrace{2\frac{(2\pi m T)^{3/2}}{h^3} e^{-\frac{W}{kT}}}_{\rho_1} \times kT$$

no net ~~charge~~ space charge at cathode.

$$\rho_A = \frac{500}{600} \frac{4.4\, S_1}{v_1}\left[\frac{R+1}{R} - 2\right]$$

$v_1 = 2\,10^7$

$$\rho\ \text{mhm} = \frac{500}{600} \frac{4.4}{3.5} \frac{S_1}{v_1}\, 10^{-15} \left[\frac{R+1}{R} - 2\right]$$

$$\cong \frac{1}{2} S_1\, 10^{-22} \left[\frac{R+1}{R} - 2\right]$$

$S_1 = 30$ amps $= \dfrac{30\ 3\,10^9}{5\,10^{-10}} = 2\ 10^{20}$

$$\rho\ \text{mhm} = 10^{-2}\left[\frac{R+1}{R} - 2\right]$$

If $[\ ] = 1$; $R = \frac{1}{2}$; W lower than V_i by less than kT and $\rho\ \text{mhm} = 10^{-2}$ mhm

If $[\ ] = 10$; $R = \frac{1}{11}$; W lower than V_i by $2.4\,KT$

$V_i = 3.87$

H

We write

$$\frac{P_i}{P_A} \equiv R \qquad P_i = \frac{R}{R+1}$$

If we demand no net space charge at cathode; if we assume positive ions hit cathode with 1 Volt, if mass ratio of atoms to electrons ~ 200000 we may write for ion current to cathode: $\frac{S_1}{600}$ *

No ion loss ~~...~~ at cathode means:

$$\rho_A \frac{v_A}{4.4} \frac{R}{R+1} + \frac{S_1}{600} \frac{R}{R+1} = \frac{S_1}{600} \underbrace{\left(1 - \frac{R}{R+1}\right)}_{P_e}$$

or

$$\rho_A \frac{v_A}{4.4} \frac{R}{R+1} = \frac{S_1}{600}\left(1 - 2\frac{R}{R+1}\right)$$

introducing R from

$$R = \frac{P_i}{P_A} = e^{\frac{W-V_i}{kT_1}}$$

$$\boxed{\rho_A \approx p \frac{}{}\,\text{mm} \times \frac{1.3 \cdot 6\ 10^{23}\ 10^{-3}}{2.24 \times 10^4} \frac{1}{10} = p \times 3.5\ 10^{15}}$$

273°K

$$\rightarrow \rho_A = \frac{4.4}{600} \frac{S_1}{v_A} \frac{R+1}{R}\left[1 - \frac{2R}{R+1}\right]$$

$$\boxed{\rho_A = \frac{4.4}{600} \frac{S_1}{v_A} \left[\frac{R+1}{R} - 2\right] = \frac{500 \times 4.4 S_1}{600\ v_1}[\ ] = \frac{500}{600} \rho_1 \left[\frac{R+1}{R} - 2\right]}$$

* $\frac{1}{60}$ was obtained by saying that ion current to cathode and from cathode are equal and

Recompute U: W

$$N = e^{-\frac{3.8}{kT^*}} \rho_0 \rho^*_{el} v^*_{el} \sigma l$$

$$\text{loss to Anode} = \frac{v_i \rho_i}{4.4} e^{-\frac{U}{kT_1}}$$

$$N = \frac{v_i \rho_i}{4.4} e^{-\frac{U}{kT_1}}$$

$$-\frac{3.8}{kT^*} + \ln \rho_0 \sigma l + \ln \rho^*_{el} v^*_{el} = \ln v_i \rho_i - \ln 4.4 - \frac{U}{kT_1}$$

$$\frac{U}{kT_1} = \frac{3.8}{kT^*} - \ln 4.4 - \ln \rho_A \sigma l - \ln \frac{\rho^*_{el} v^*_{el}}{v_i \rho_i}$$

$$\rho_A = p \cdots 3.5\,10^{15}$$

$$\frac{U}{kT_1} = \frac{3.8}{kT^*} + \ln \frac{1}{p \cdots} + \left\{ \ln \frac{1}{\sigma l} \underbrace{- \ln 3.5\,10^{15} - \ln 2 \times \overset{1000}{500} - \ln 4.4}_{} \right\}$$

$$\left\{ \ln \frac{1}{\sigma l} - \ln 1.5\,10^{19} \right\}$$

$$\underbrace{\sigma = 10^{-16};\ l = \tfrac{1}{10}}$$

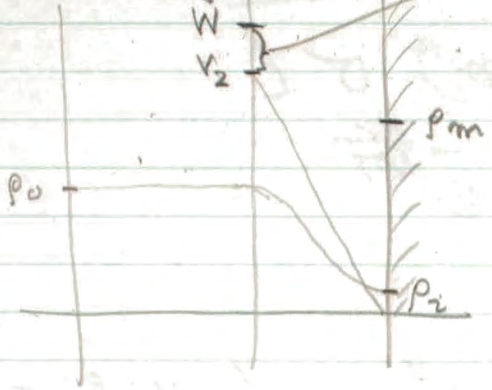
$$-\ln 1.5\,10^{2} = -5$$

but $\sigma = 10^{-17};\ l = \frac{1}{10}$

$$-\ln 1.5 \times 10 = -2.7$$

$J = 0$

Anode region:



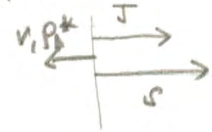
$V_2 = W - kT_2 \ln \rho_m/\rho_0$ $\qquad$ $V_2 < 0$ at anode.

$J \neq 0.$

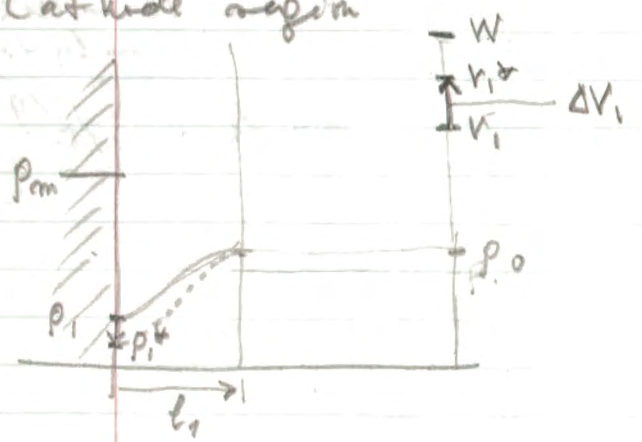
$$J = -\frac{\lambda v_1}{3}\left(\frac{d\rho_1^*}{dx} - \frac{V_1^*\rho_1^*}{kT_1 l_1}\right)$$

Boundary condition

$$J = S - v_1 \rho_1^*(0)$$



Cathode region



$$\frac{\Delta V_1}{kT_1} \simeq -\ln\left[1 - \frac{J}{S_1}\left(1 + \frac{3kT_1}{V_1^*}\frac{l_1}{\lambda}\right)\right]$$

if $J \ll S_1$

$$\frac{\Delta V_1}{kT_1} \simeq \frac{J}{S_1}\left(1 + \frac{3kT_1}{V_1}\frac{l_1}{\lambda}\right)$$

l_1 = characteristic length in which V_1 rises from 0 to V_1

λ mean free path of el in region l_1

Review!

H

Notation: cathode region index 1
anode " index 2.

ρ_0 : charge density of completely ionized gas in central regions

ρ_m: charge density in metal, due to non deg. electrons.

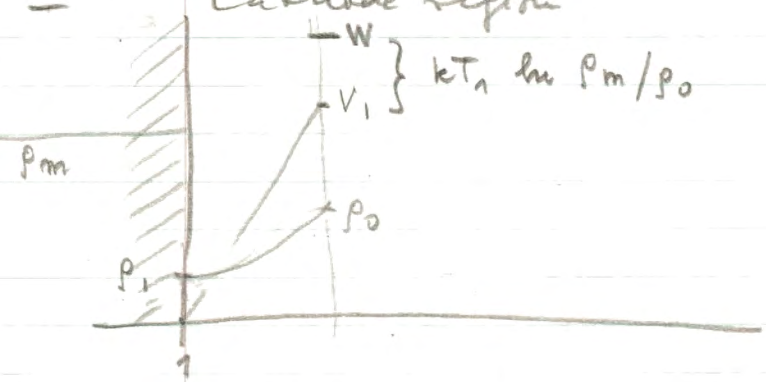
W : work function.

If current J is not zero all quantities which change due to J acquire a star.

We assume $T_2 < T_1$.

J = 0

— Cathode region



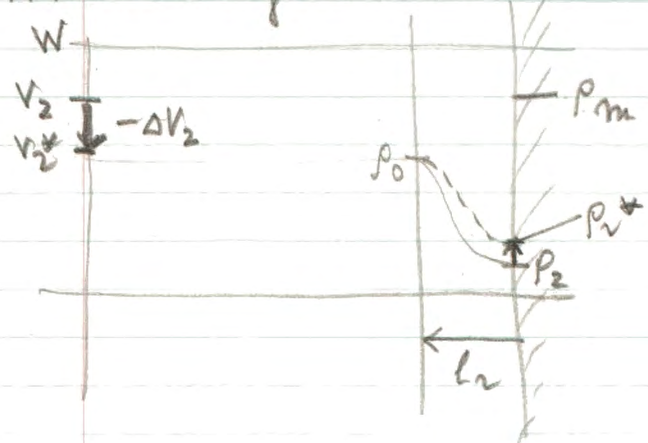
$V_1 = kT_1 \ln \rho_0/\rho_1 = W - kT_1 \ln \rho_m/\rho_0$; $V_1 = 0$ at cathode.

since $\rho_1 = \rho_m e^{-W/kT_1}$

$J \neq 0$

H

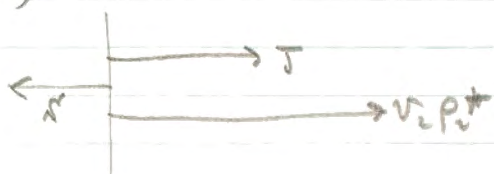
Anode region:



$$-\frac{\Delta V_2}{kT_2} \simeq \ln\left[\frac{J}{S_2}\left(1 + 3\frac{kT_2}{V_2^*}\frac{l_2}{\lambda}\right)\right]$$

$$J = -\frac{\lambda v_2}{3}\left(\frac{d\rho_2^*}{dx} + \frac{V_2^*\rho_2^*}{kT_2 l_2}\right)$$

B.c. $\quad J = v_2\rho_2^* - S$



Thermionic Emission
Wayne B. Nottingham
Technical Rept. 321
Res. Lab of Electronics
MIT