REVIEW: OBTAINING THE ELECTRON TEMPERATURE

1. **ELECTRON TEMPERATURE** is obtained from a power balance

$$\frac{d}{dt}\left(\frac{3}{2}\,k_{BOLTZ}T_e n_e\right) = \frac{n_e\,q^2E^2}{m\,k_m N} - n_e\left(\frac{2m_e}{M}\right)k_m\,N\,\frac{3}{2}\,k_B\,(T_e - T_g)$$

$$\begin{bmatrix}\text{Total energy}\\ \text{density of electrons}\end{bmatrix} \begin{bmatrix}\bullet\ E\\ \text{power deposition}\end{bmatrix} \begin{bmatrix}\text{power loss due}\\ \text{to elastic collisions}\end{bmatrix}$$

$$- n_e N \sum_i k_i \Delta\varepsilon_i$$

$$\begin{bmatrix}\text{power loss due to}\\ \text{inelastic collisions}\end{bmatrix}$$

In principle, you can solve for T_e if you know the value of E/N.

$$T_e = T_g + \frac{2}{3k_{BOLTZ}}\,\frac{1}{\left(\frac{2m_e}{M}\right)}\left[\frac{q^2}{m_e k_m^2}\left(\frac{E}{N}\right)^2 - \frac{\sum_i k_i\Delta\varepsilon_i}{k_m}\right]$$

The electron temperature is elevated above the gas temperature due to heating by the electric field. Inelastic collisions reduce temperature.

2. **DOMINANT LOSSES** of electrons and ions in many low pressure glow discharges is by diffusion

$$\frac{\partial n_e}{\partial t} = n_e\,k_{ION}\,N - n_e\,k_{att}\,N + \bullet D\ n_e$$

Ionization Attachment Diffusion

If the diffusion coefficient is independent of position then

$$\frac{\partial n_e}{\partial t} = \ldots + \bullet D\ n_e = D\ {}^2 n_e \approx \frac{-D}{\Lambda^2}\,n_e$$

where Λ = diffusion length of container

$= \frac{L}{\pi}$ (L = spacing between parallel plates)

$= \frac{R}{2.405}$ (R = radius of discharge tube)

3. **IF DIFFUSION DOMINATES** then the continuity equation is homogenous; and you cannot solve for n_e in the steady state. The electron density must be obtained from another relationship, such as that for the current density.

$$\frac{\partial n_e}{\partial t} = n_e k_{ION}(T_e)N - n_e \frac{D(T_e)}{\Lambda^2} = 0$$

$$k_{ION}(T_e)N - \frac{D(T_e)}{\Lambda^2} = 0$$

Since, however, k_{ION} and D are functions of T_e, then you can solve for T_e from the continuity equation by requiring that the source of electrons by ionization be balanced by the loss of electrons by diffusion.

$$k_{ION}(T_e)N = \frac{D(T_e)}{\Lambda^2}$$

Once you solve for T_e from this equation, you can solve for E/N from the energy balance equation.