PHYSICS 535, Spring 2016 – ASSIGNMENT 09
Reading: Select an article from http://kestrel.nmt.edu/~rsonnenf/phys535/pubs/student_presentations/ by Wed. 4/13. You will be presenting it to the class during the week of 4/17.

Problems Due 4/15

1) Ambipolar Diffusion:

(a) Draw a figure showing the physical situation described on B&R page 30. They claim that eliminating the E_x terms from the first two equations on p. 30 leads to the result

$\Gamma_x = -D_a \frac{\partial n}{\partial x}$,which has the form of a diffusion equation, with $D_a = \frac{D_+ \mu_e + D_e \mu_+}{\mu_e + \mu_+}$

Fill in the missing algebra (it is described in the middle of page 30 as follows "Eliminate the polarization field … by dividing the first one by μ_e and the second by μ_+ and then summing them up"). You will also have to make some assumptions about quantities that are equal to eachother to make that work. Make sure to indicate those assumptions as you go.

(b) Rewrite D_a in terms of D+ and T_e and T (Using the Einstein relation, equation 2.7)

2) At the top of page 31 Bazelyan states that $R^2 \sim 4 D_a t$. This is a direct result of the general diffusion solution for a cylindrical system without walls (i.e. a leader or streamer) which is $n(r,t) = \frac{e^{-r^2/4Dt}}{4\pi D t}$

(a) Explain why the expression for R as the "effective radius" is appropriate.

(b) The full diffusion equation is $\frac{\partial n}{\partial t} = D \nabla^2 n$.

Show by direct differentiation that the formula given above is a solution of this equation.

(c) You calculated the mobility of Nitrogen ions from first principles in previous assignments. Use the Einstein relation to calculate their diffusion coefficient D_+ .

(d) You may assume that Argon gas has the same diffusion coefficient as molecular nitrogen. If Argon is introduced at a point into still air, how long will it take for the 1/e radius of the diffusing cloud to extend 1 cm from the point of introduction. 10 cm? 1 m?

3a) Explain in your own words what a Debye radius is.

3b) At the end of page 31 the Debye radius d_D (sometimes written λ_D) is calculated for provided parameters. Check the calculation.

4) Reproduce the three Paschen curves I showed in class #31.

5a) Plot the following six parameters vs. Temperature (4000<T<26000K) for a steady-state arc: Core radius (cm), Conductivity (1/(Ohm-m)), Channel Resistance (Ohms/m), Axial Electric field (V/m), Current (Amps), Power (W/m). To begin with, assume that the thermal conductivity of the channel is a constant k=0.015 W/ cm-K over entire temperature range of interest. Reproduce slide 6 from lecture 33. (Use the set of equations listed on the third slide of lecture 32, titled "Set of quantities to self-consistently calculate")

5b) Read about 10 thermal conductivity points off Fig 2.6b and use "polyfit" to approximate Fig 2.6b.

5c) Redo 6a with a thermal conductivity that varies with temperature (using your just-built function). You will get something like the 8th slide from lecture 33.