PHYSICS 535, Spring 2016 – ASSIGNMENT 8 – Due April 8, 2016

Reading Bazelyan and Raizer Ch. 2.4 through 2.7

Your summary of Ch 2 should be page by page. What is he trying to tell us on each page? Ask two questions, one of which you can answer. You will have MANY questions.

ALSO, along with your summary of Ch. 2, prepare a sheet of definitions of all the symbols that Bazelyan is using beginning with Ch 2 (and what page he first uses them on). You will need it to survive anyway. Try to specify units for every quantity as well as the symbol and a description of its definition.

1a) Beginning with conservation of energy and momentum for hard spheres colliding in one-dimension, derive the formula that relates $v_{2-\text{final}}, v_{1-\text{final}}$ to $v_{2-\text{initial}}, v_{1-\text{initial}}$

1b) Apply the formulae just derived to the case of an electron colliding with an N_2 molecule. What fraction of its original kinetic energy did the electron lose? (Demonstrate this, you may discover that your result comes out different than Bazelyan's by a factor of 2. Don't sweat it.)

2) Make plots of the formulae that compare $\frac{\alpha}{p}$ vs. $\frac{E}{p}$

a) Reproduce figure 2.2b using the Townsend formula (2.10).

b) Now plot figure 2.2a using the appropriate formula from 2.11.

c) Finally, plot all four formulae on the same graph, but limit each to the range in which it is stated to be valid.

d) Assume the pressure is 500 torr. Plot α vs. E at that pressure.

3) Beginning with the Townsend formula (2.10)

a) Argue why an electron must acquire an energy $w=\frac{e\,E}{\alpha}$ to produce an ion pair. (The argument is simple, once you understand it … it involves the definition of Work and the definition of α .

b) Since α is approximated by the Townsend formula, $w=\frac{e\,E}{A\,p}\exp\left(\frac{B\,p}{E}\right)$.

Plot w vs. $\frac{E}{p}$ for air given $100<\frac{E}{p}<1000$. It should have a minimum at $\frac{E}{p}=365\ \text{V}\,\text{cm}^{-1}\text{Torr}^{-1}$. The minimum should be 66 eV. (Note, the formula as given is not in eV … don't forget to convert it).

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c) Use calculus to demonstrate the same result as in part "b". There is a minimum at E/p=365 and it's value is 66 eV.

4) Using equation on bottom of page 22, show that you arrive at the numbers quoted for vibrational-to-translational relaxation time for dry and moist air at room temperature.

5) Solve differential equation 2.14. (The solution is given ... just demonstrate it.).

Then plot $\frac{n_e}{n_0}$ vs $\frac{t}{\tau}$. (Both axes are dimensionless).

6) Use the Saha equation to calculate and plot the ionization fraction for $N_2+15.6\,\text{eV}\rightarrow N_2^{+}+e^{-}$ and $O_2+13.62\,\text{eV}\rightarrow O_2^{+}+e^{-}$. Use a temperature range of 0-30000 K and $n_{total}=6.25\times10^{25}$.