ASTR 311 STELLAR ASTROPHYSICS
Problem Set #5
(due 10 Oct 09)

For full credit, show all of your work and clearly state any assumptions. Include graphs and tables if helpful.

1) Atomic Energy Units; The elctron-volt
Show that at room temperature, the thermal energy kT is about 1/40 eV. At what temperature is KT equal to 1 eV? to 13.6 eV?

2) The Maxell-Boltzman Distribution
Show that the most probable speed of the Maxwell-Boltzmann distribution of molecular speeds

$$n_v\, dv = n\,(m/2\pi kT)^{3/2}\, e^{-(mv^2)/(2kT)}\, 4\pi v^2\, dv$$

is given by v_{mp}= square_root(2kT/m)

3) The Boltzman Distribution; Excitation Levels LeBlanc, Chapter 1 (p 32): 1.7
Calculate the temperature at which the number density of hydrogen atoms in the excited state is ten times less than the number density of those in the fundamental level.

4) The Saha Distribution; Ionization levels LeBlanc, Chapter 1 (p 32): 1.9
What is the ionization fraction of HI at a depth where T=9000 K and P=140 dyn/cm^2 in a star composed of pure hydrogen (assume U_1=2)?

5) Lyman, Balmer, Paschen Series
Find the shortest wavelength photon emitted by a downward electron transition in the Lyman, Balmer, and Paschen series (see notes). These wavelengths are known as the *series limits*. In which regions of the electromagnetic spectrum are each of these wavelengths found?

6) Quantum Numbers
Each quantum state of the hydrogen atom is labeled by a set of four quantum numbers: [n, l, m_l, m_s]. (a) List the sets of quantum numbers for the hydrogen atom having n=1, n=2, and n=3. (b) Show that the degeneracy of energy level n is $2n^2$.