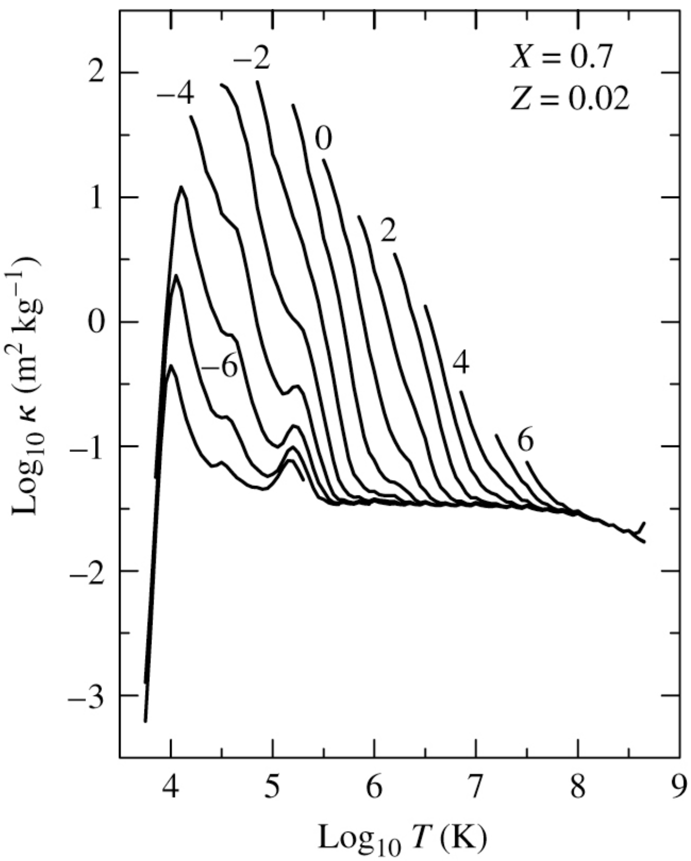
Hmwk 2, Astr 420 Name: _________________________

1. Textbook, Problem 9.6: Using the root-mean-square speed, $v_{RMS}$, estimate the mean free path of the nitrogen molecules in your classroom at room temperature (300K). What is the average time between collisions? Take the radius of a nitrogen molecule to be 0.1 nm and the density of air to be 1.2 kg $m^{-3}$. A nitrogen molecule contains 28 nucleons (protons and neutrons).

2. Texbook, Problem 9.10: By measuring the slope of the curves in Fig 9.10 (below), verify that the decline of the curves after the peak in the opacity follows a Kramers law, with the absorption coefficient, κ, proportional to $T^{-3.5}$.




3. Texbook, Problem 9.11: According to one model of the Sun, the central density is 1.53 x $10^5$ kg $m^{-3}$ and the Rosseland mean opacity at the center is 0.217 $m^2$ $kg^{-1}$.
   (a) Calculate the mean free path of a photon at the center of the Sun
   (b) Calculate the average time it would take from the photon to escape from the Sun if this mean free path remained constant for the photon's journey to the surface. (Ignore the fact that identifiable photons are constantly destroyed and created through absorption, scattering and emission.)

4. (Computer programming). Download an IDL-readable table with values for physical depth, temperature, density and opacity from http://www.physics.sfsu.edu/~fischer/data/tbl9_5.dat
To restore this table:
idl> restore,'tbl9_5.dat'
idl> help ; shows the variable names: r, temp, rho and kap
(a) Find the optical depth at each point by numerically integrating Eq (9..15, below). Use a simple trapezoidal rule such that:

$$d\tau = -\kappa\rho\ ds$$

Becomes:

$$\tau_{i+1} - \tau_i = -\left(\frac{\kappa_i\rho_i + \kappa_{i+1}\rho_{i+1}}{2}\right)(r_{i+1} - r_i)$$

Where i and i+1 designate adjacent zones in the model. Note that because s is measured along the (radial) path traveled by the photons, ds = dr.

(b) Make a graph of the temperature (vertical axis) vs. the optical depth (horizontal axis).
(c) For each value of the optical depth, use Eq (9.53, below) to calculate the temperature for a plane-parallel gray atmosphere in LTE. Plot these values of T on the same graph.

$$T^4 = \frac{3}{4}T_e^4\left(\tau_v + \frac{2}{3}\right)$$

(d) The temperature, density and Rosseland mean opacity at the top of the atmosphere are zero for simplicity. Comment on the validity of the surface value that you found.