Exercises: Work exercises 4, 5, 7, 11 and 15 from the back of the kinetic theory notes.

Problems to be handed in:

1) A container of gas is at thermal equilibrium at temperature $T$.
   (a) Show that the most probable speed of the molecules, $v_m$, is $\sqrt{2kT/m}$.
   (b) Find the most probable kinetic energy. HINT: The correct answer is not $\frac{1}{2}mv_m^2$.

2) (a) Find the rms speed for helium atoms at $T = 300$ K.
    (b) Find the average speed of the atoms.
    (c) Find the most probable speed of the atoms.

3) Exercise 14 from the kinetic theory notes.

4) Exercise 21 from the kinetic theory notes.

5) As shown in the notes, the energy distribution of the molecules in a gas can be written in the form
   \[ F(E) = CE^{1/2}e^{-E/kT}. \]

   Starting from this distribution function, show that the average value of $E$ is $\frac{3}{2}kT$. HINT: This problem can be done without ever actually evaluating $C$. The trick is to write down the equation for the average energy and integrate by parts. What remains is proportional to the normalization integral.

6) The speed distribution of the molecules in a container is given by the usual Maxwell formula, $f(v) \propto v^2e^{-mv^2/2kT}$. If there is a very small hole in the container some of the molecules can escape, and since the number with speed $v$ that reach the hole in any given time interval is proportional to $v$, the speed distribution of the molecules that escape is $F'(v) \propto v^3e^{-mv^2/2kT}$. Given this equation, find the average kinetic energy of the escaping molecules.

7) In class we discussed a problem in which 6 “atoms” share energy $8E$, assuming that each individual atom can have only have energies equal to an integer times $E$. From an analysis of the possible microstates of the system we were able to find values of $N_n$, the expected number of atoms with energy $nE$. The results for $N_0$ through $N_8$ are as follows:

   2.29, 1.54, 1.00, 0.587, 0.326, 0.163, 0.070, 0.0233, 0.0047.

   Try to estimate the temperature of the system if $E = 0.01$ eV.