HW #8

1. The average, rms and most-probable speed of the molecules in a gas are given by:

$$v_{ave} = \bar{v} = \frac{\int v dN}{N} = \frac{\int v n_v dv}{N} = \frac{4}{\sqrt{2\pi}}\sqrt{\frac{kT}{m}} \qquad (1)$$

$$v_{rms} = \sqrt{\overline{v^2}} = \sqrt{\frac{\int v^2 dN}{N}} = \sqrt{\frac{\int v^2 n_v dv}{N}} = \sqrt{\frac{3kT}{m}} \qquad (2)$$

$$v^* = \sqrt{\frac{2kT}{m}} \qquad (3)$$

Show how equation (3) is obtained (i.e. do the derivative by hand).

2. Compute the average, most probable and rms speed of the light gas hydrogen (H_2) and the heavy gas Radon (Rn, assume this is the longest lived isotope which has a mass of 3.69 x 10^{-25} kg), both at room temperature (293 K). Compare the results.

3. Vacancies are normally occupied atomic sites in a crystal from which an atom is missing. Vacancy formation is a thermally activated process. The number of vacancies N_v in a crystal depends on and increases with temperature according to $N_v = Ne^{-Q/kT}$, where N is the total number of atomic sites, and Q is the energy required for the formation of a vacancy. The energy for vacancy formation in copper is 0.9 eV/atom.

a) Calculate the fraction of atomic sites, $\frac{N_v}{N}$, that are vacant for copper at room temperature (27 °C). Note: be careful with units!
b) Calculate the fraction of atomic sites that are vacant for copper at its melting temperature of 1084 °C.
c) Calculate the fraction of atomic sites that are vacant for copper at -100 °C.
d) Is it possible to make a vacancy-free copper crystal? Why or why not?