Physics 3P41/5P11 Assignment 1

Due: Monday October 7, 2019 in drop box across from MC B210a by 12:00 noon.

1. (a) Calculate the total thermal energy in a liter of Helium gas at room temperature and atmospheric pressure.

   (b) Repeat the calculation for a liter of air. Assume air is made up of Nitrogen and Oxygen only. That is ignore the 1% Argon.

2. If the energy E of a system is not quadratic, but behaves like $E = \alpha|x|$ where $\alpha > 0$ find the average energy.

3. Consider a 2-state paramagnet with 10^{23} elementary dipoles, with the total energy fixed at zero so that exactly half of the dipoles point up and half point down.

   (a) How many microstates are available to the system? (Hint: Use Stirling's approximation)

   (b) Suppose that the microstate of this system changes a billion times per second. How many microstates will it explore in 10 billion years (the approximate age of the universe)?

   (c) Is it correct to say that, if you wait long enough, a system will eventually be found in every 'accessible' microstate? Explain your answer.

4. (a) Calculate the *rms* speed of a Sodium atom in the solar atmosphere at 6000 K.

   (b) The Sodium D lines ($\lambda = 5900\mathring{A}$) are observed in a solar spectrum. Estimate the Doppler broadening in GHz.

5. (a) Given that the number of molecules hitting a unit area of a surface per second with speeds between v and $v + dv$ and angles between θ and $\theta + d\theta$ to the normal is: $\frac{1}{2}vnf(v)dv\sin(\theta)\cos(\theta)d\theta$ find the average value of $\cos(\theta)$ for these molecules.

   (b) Show that for a gas obeying the Maxwell-Boltzmann distribution that the average energy for all of the molecules is $\frac{3}{2}k_BT$, but the average energy of those hitting the surface is $2k_BT$.