Thermodynamics & Statistical Mechanics PSet 5

1. **Book Problems:** 3.32, 3.36, 3.37, 3.39, 4.1, 4.3

2. **Charge Sharing?** We all know that electric charge is conserved, and so we could in principle study two systems (say boxes of gas) where $q_A + q_B = q_{total}$ is fixed, and think about what configuration of electric charge maximizes the total entropy, just as we maximized S with respect to energy, volume, and particle number. (We can add fixed background charge to neutralize our system.)

   Let's imagine we have a box with volume $V = 1\ m^3$ containing a mole of charged gas (treat it as a gas of individual charged particles). If there's a 1% charge imbalance between the left and right halves of the box, give a rough estimate of the potential energy of the box as a whole, and of the change in energy of a single charged particle as it moves from one half to the other. How does the latter compare to kT at room temperature... and conversely, what Kelvin temperature does this energy correspond to?

   Now consider a situation where there are only a surplus of $\sqrt{N_A}$ (where recall $N_A = 6.02 \times 10^{23}$) units of charge in the left half of the box, corresponding to our expectations for (uncharged) particle number fluctuations. What is the change in potential energy of an electron moving from one half of the box to the other, and how does this compare to kT at room temperature? Is there any point in maximizing S with respect to charge near room temperature for a box of this size... are considerations of probability and multiplicity relevant here? Could this problem be more interesting if we changed the properties of the box or the number of charges?

3. **Book Problem Extra Credit:** 3.34, 4.6, 4.12