Problem Set #6
Physics 436

Friday, 25 February 2022

The following problems come from Schroeder's *An Introduction to Thermal Physics*:

- Problem 3.23 on page 107 (*20 points*) $\Rightarrow$ You complete the analytic work for the two-state paramagnet by finding the entropy. Discuss how you could have determined the low- and high-temperature limits of S *without* knowing the analytic result. After completing the problem, make a nice computer plot of S/Nk versus $kT/\mu B$ for $0 \leq kT/\mu B \leq 10$. Include the analytic result for the $kT/\mu B \to \infty$ limit of S/Nk.

- Problem 3.25 on page 108 (*50 points*) $\Rightarrow$ You work through the analytic details for an Einstein solid in this problem. This is a very important problem through which to work! The Einstein solid's prediction for the heat capacity has a flaw at low temperatures. Peter Debye fixed the problem in 1912 by considering how *phonons* affect the heat capacity of a solid. (For other work, Debye received the Nobel Prize in Chemistry in 1936.)
  - For part (e) of this problem, make a nice computer graph of C/Nk versus kT/ϵ for $0 \leq kT/\epsilon \leq 2$. When you compare with Figure 1.14, note especially the low temperature features of your graph and what you see in Figure 1.14.
  - When you estimate ϵ for each of the three solids shown in Figure 1.14, give your result in meV. Schroeder asks for eV as the energy unit, but that is too big.
  - Discuss why one solid's value of ϵ is larger than another solid's ϵ.
  - You will need to use an expansion of e^x and the binomial expansion for part (f). When you have completed part (f), add your part (f) result to the computer graph you made for part (e). You only need to hand in *one* graph; it should contain two curves. Because your part (f) result is valid only for high temperatures, just use a plot range of $0.5 \leq kT/\epsilon \leq 2$ for your part (f) result.

Due date: **Friday, 04 March 2022**