Physics 114 – Statistical Physics
Seminar 6
Monday, February 25, 2008

Reading — Schroeder Chapter 6, Blundell^2 Chapters 21,22

Written Problems – Everyone is to hand in solutions to the following problems:

Schroeder 6.18, 6.19, 6.31

B&B 17.3

Reif 7.5 - A rubber band at absolute temperature T is fastened at one end to a peg, and supports from its other end a weight W. Assume as a simple microscopic model of the rubber band that it consists of a linked polymer chain of N segments joined end to end; each segment has a length a and can be orineted either parallel or antiparallel to the vertical direction. Find an expression for the resultant mean length $\bar{\ell}$ of the rubber band as a function of W. (Neglect the kinetic energies or weights of the segments themselves, or any interaction between the segments.)

Seminar Problems – Everyone is to prepare these problems for discussion in seminar.

Problem	Comments
Schroeder 6.48	Verify the Sackur-Tetrode entropy for a diatomic gas.
B&B 21.3	Do it two ways, with $g(k)$ and a phase space integral over $\frac{d^3\mathbf{r}d^3\mathbf{p}}{h^3}$
Reif 7.11	Treat $\omega_\perp$ classically and $\omega_\parallel$ with quantized a oscillator (Einstien Solid).
Reif 7.14	It's nice to know that the classical model works.
Honors Problem	This problem was taken from the University of Chicago Graduate Problems in Physics. Start with Blundell^2 Chapter 7, but there's a subtlety with the question. The density depends on position on the screen and the units are 1/area, so you have to find the relation between solid angle and surface area at some angle θ.

Reif 7.11

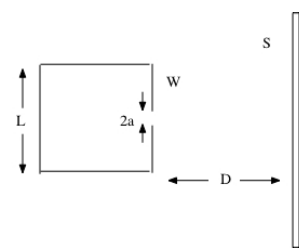
Assume the following highly simplified model for calculating the specific heat of graphite, which has a highly anisotropic crystalline layer structure. Each carbon atom in this structure can be regarded as performing simple harmonic oscillations in three dimensions. The restoring forces in directions parallel to a layer are very large; hence the natural frequencies of oscillations in the x and y directions lying within the plane of a layer are both equal to a value $\omega_\parallel$ which is so large that $\hbar\omega_\parallel \gg 300k$. On the other hand, the restoring force perpendicular to a layer is quite small; hence the frequency of oscillation $\omega_\perp$ of an atom in the z direction perpendicular to a layer is so small that $\hbar\omega_\perp \ll 300k$. On the basis of this model, what is the molar specific heat (at constant volume) of graphite at $300K$?

Reif 7.14

Consider an assembly of N_0 weakly interacting magnetic aroms per unit volume at a temperature T and describe the situation *classically*. The each magnetic moment μ can make any arbitrary angle θ with respect to a given direction (call it the z direction). In the absence of a magnetic field, the probability that this angle lies between θ and $\theta + d\theta$ is simply proportional to the solid angle $2\pi \sin\theta d\theta$ enclosed in this range. In the In the presence of a magnetic field H in the z direction, this probability must further be proportional to the Boltzmann factor $e^{-\beta E}$, where E is the magnetic energy of the moment μ making this angle θ with the axis. Use this result to calculate the classical expression for the mean magnetic moment $\bar{M}_z$ of these N_0 atoms.

Honors Problem 1 - 1990

A3 - A circular hole or radius of a is punched on one wall , W, of a cubical box of side $L \gg a$. The box contains a dilute monatomic gas with atoms of mass m at temperature T. Atoms escaping from the hole in the wall are incident upon, and adhere to, a screen parallel to W and a distance, D away. Ignoring the effects of any external fields, calculate the surface density of gas atoms adsorbed on the screen.



Presentations

1 - General theory of paramagnetism is covered in Reif 7.8. Also, present Schroeder problem 6.22. If there is any excuse to play with liquid nitrogen, it would be to make liquid oxygen and suspend it between magnets.

2 - Magnetic cooling. This is a technique that can cool to very, very low temperatures, but is limited to small volumes and to the last stage of a cooling process. Basically, the volume must already be very cold.