Homework 5

Due 2/~~11~~12/2010

1. [5 points] Kittel 5.1

2. [5 points] Kittel 5.4

3. [5 points] Ferromagnetic magnons are waves of atomic magnetic moments that satisfies $\omega_{\vec{k}} \propto k^2$ at low energy. What would be the temperature dependence of C_V arising from these waves as $T \to 0$? For this problem and the previous problem, the qualitative method can be used (cf. "Qualitative table" of Lecture 09).

4. [5 points] Consider the Lennard-Jones potential $U(r) = A\left[\left(\frac{\sigma}{r}\right)^{12} - 2\left(\frac{\sigma}{r}\right)^{6}\right]$, which is quite appropriate for molecular crystals such as Ar. (a) Show that the classical equilibrium position a of this potential is σ. (b) Find the Grüneisen constant γ for the phonon frequency, arising from this potential. [Hint: Look up the definition in my lecture note. γ should be just a number independent of σ and A.]

5. [5 points] (a) Show that the kinetic energy of a free electron gas at absolute zero temperature is given by $E_0 = \frac{3}{5}N\epsilon_F$. (b) Derive the expression for the pressure $P = -\partial E/\partial V$ and the bulk modulus $B = -V\partial P/\partial V$, at $T = 0$. [cf. Kittel 6.2] (c) Estimate the contribution of the conduction electrons to B for potassium and compare your answer to the experimentally measured bulk modulus $0.37 \times 10^{10}\ \mathrm{Nm}^{-2}$. You can use the data given in table 1 of page 139.