Solid State Physics, Physics 551
Homework Assignment 2, due February 22, 2010

Problem 1. Kittel, Problem 3.3.

Problem 2. Kittel, Problem 3.1 for H_2 crystal from problem 1 (Kittel 3.3). Assume that in the ground state the wave function λ_0 within each lattice site is taken as a half of the distance between nearest neighbors. Does this contribution improve our estimate for the binding energy of solid molecular hydrogen? Can a better estimate be obtained for a different value of λ_0?

Problem 3. Kittel, Problem 4.5.

Problem 4. Kittel, Problem 4.6.

Problem 5. Kittel, Problem 5.4.

Problem 6. Thermodynamic properties of an isotropic dielectric crystal at temperatures above the Debye temperature are dominated by phonon contribution.
a) Show that the free energy of phonons in the high-temperature limit is given by

$$F = N\epsilon_0 - 3NT \ln\left(T/\hbar\bar{\omega}\right). \tag{1}$$

Define ϵ_0 and $\bar{\omega}$.
b) Calculate energy E of the crystal, its entropy S and heat capacity C.
c) Determine the maximal work, which can be obtained from two identical solid bodies at initial temperatures T_1 and $T_2 > T_1$, in the process when their temperatures become equal. Hint: use expressions for the entropy S and internal energy E from part (b) of this problem.