MS 131, Problem Set #1

assigned 9/28/05
due 10/05/05

1. Consider a free electron gas.

   (a) Show that the kinetic energy at 0K, E_K^0, is given by

   $$E_K^0 = \frac{3}{5} N\varepsilon_F^0$$

   (b) Show that the pressure at 0K, P, is given by

   P = 2/3 E_K^0/V

   (c) Bulk modulus, B, is defined as B = -V(∂P/∂V). Show that at 0K

   B = 10/9 E_K^0/V

2. Assume conventional valencies and treat sodium, potassium and aluminium using the free electron gas model.

   (a) For each metal, estimate the Fermi energy (at 0K)

   (b) For each metal, estimate the bulk modulus (at 0K)

   You will need to look up some information about these materials to complete the problem. Compare your answers with the experimental values.

3. Solve the time-independent Schrodinger wave equation for a particle in a square box, with edge dimension L. Let the box extend from (-L/2, -L/2) to (L/2, L/2). Show that there are two quantum numbers that define each eigenfunction ψ(x,y).

4. Consider a free two-dimensional free electron gas. Calculate

   (a) the heat capacity

   (b) the density of states

   (c) the Fermi energy

5. The Bohr correspondence principle states that quantum mechanics results must approach the classical results at the appropriate limit. Examine the probability function for a particle in a 1-dimensional box and show that as n → ∞, this function approaches the classical result.