Homework One, Physics 242, Spring 2009
Due Monday, April 6

[1.] Consider the following superconductors/families of superconductors:

- Hg
- Heavy fermions (e.g. $CeCu_2Si_2$)
- Cuprates (e.g. $La_{2-x}Sr_xCuO_4$)
- MgB_2
- Iron Pnictide (e.g. $LaO_{1-x}F_xFeP$)

In each case, answer the following questions: In what year was superconductivity discovered? What is the critical temperature? What is the critical magnetic field? What is the energy gap, and what is the ratio $2\Delta(0)/k_BT_c$? (How is the gap measured for the value you quote?) What is the coherence length ξ? Is there an isotope effect observed?

[2.] Consider systems with the following different energy levels:

- $E = 0, \Delta$ (A "two-level" system.)
- $E = 0, \Delta, 2\Delta, 3\Delta, \cdots$ (Discrete spectrum with no upper bound.)
- $E \in [0, \Delta]$ with density of states $N(E)$ constant
  (continuous spectrum with upper bound)
- $E \in [0, \infty)$ with density of states $N(E)$ constant
  (continuous spectrum with no upper bound)

What happens to the specific heat $C(T)$ as $T \to 0$ and as $T \to \infty$ in each case? Why? What general rules do you think might be true relating the spectrum of energy levels and the low/high T behavior of $C(T)$? Can you write down analytic expressions for $C(T)$ for all T?