1. (a) What is the contact potential generated across a copper-lead junction? An indium-gold junction? Using the density of states, estimate the change in free electron density on either side of the junction. Also estimate the change in free electron density by assuming the two metals act as a capacitor. For this, we know that the thickness of the layer inside a metal where surface charges collect is on the order of 10^{-11} m.

   (b) What is the total voltage generated in a wire made of three distinct sections: copper wire, lead (Pb) junction, copper wire, indium junction, and gold wire? What is the total voltage generated in the loop of you connect the copper wire to the gold wire?

2. The packing fraction is the maximum proportion of the available volume that can be filled with hard spheres. What is the packing fraction for a fcc lattice with a conventional unit cell of volume a^3? What is it for a bcc lattice?

3. Copper forms an fcc lattice. From the density of copper and its atomic mass, calculate the length a of a side of the cubic unit cell of copper, using the conventional unit cell. Give your results in angstroms. State all sources.

4. Use a computer to draw a two-dimensional crystal structure. You can choose any lattice type that you wish, but specify what you have chosen. Create your 2-D crystal using a basis of at least two types of atom, and use size, shape or color to distinguish the different atomic species. You can use any program you wish to make your drawing. Please scale your drawing suitably and hand in a nice printout of it. Please label one atom of each type, outline one unit cell and specify your basis. Also label the lattice vectors $\vec{a}$ and $\vec{b}$.

5. Suppose you have a rectangular lattice is described by primitive basis vectors based on the Cartesian coordinate system: $\vec{a} = a\hat{x}$ and $\vec{b} = b\hat{y}$, with $b > a$.

   (a) Draw (some of) the lattice and the primitive unit cell based on these vectors.

   (b) Draw two other distinct sets of primitive lattice vectors for this lattice. Your two sets should not be trivially related to the set given above or to each other, e.g. such as a simple sign change in one or more components.

   (c) Draw the unit cells associated with your new sets of basis vectors.

   (d) Prove that the area of each of these new cells is ab, i.e. they have the same area as the rectangular primitive cell and are therefore primitive unit cells as well.

6. Prof. Sullivan's most favoritest superconductor in the world is $YBa_2Cu_3O_7$, called Y-Ba-Cu-O, yibco, Y-123, or YBCO. Wikipedia has a nice picture of the unit cell (and some extra stuff). Please write down the lattice vectors for YBCO ($\vec{a}$, $\vec{b}$, and $\vec{c}$ with the lengths and angles between them clearly defined). What kind of lattice is this? (note: Wikipedia is wrong!) Write down the basis for YBCO (there are multiple ways to do this).