1. In class, we examined the band structure of a square lattice of $s$ orbitals. Sketch out the band structure of a rectangular lattice of $s$ orbitals with $a$ and $b$ as the lattice parameters and $a < b$. Remember that $X(0, \frac{\pi}{a})$ and $Y(\frac{\pi}{b}, 0)$ will not be degenerate. Sketch the DOS alongside.

2. Sketch the band structure of square lattice of $p_x$ and $p_y$ orbitals, with the DOS alongside.

3. Sketch the most bonding and the most antibonding crystal orbitals formed from $sp^2$ orbitals on carbon in graphite. Do the same for $p_z$ orbitals.

4. Sketch the most antibonding $sp^3$ crystal orbital for (a few) Si atoms within the unit cell of diamond Si. Why is molten Si metallic, while crystalline Si is insulating.

5. FeS$_2$ (fool’s gold) has the pyrite structure (octahedral Fe) and because of a bond between the two S atoms (characterized by a short S-S distance), it can be formulated Fe$^{2+}$[S$_2$]$^{2-}$. Magnetic measurements suggest that the compound is non-magnetic.
   (a) Sketch out the crystal field (showing $t_{2g}$ and $e_{g}$ levels) and fill them with the correct number of electrons.
   (b) Sketch out schematic densities of states showing Fe $d$ states and S $p$ states. Do you expect a metal or an insulator ?
   (c) What do you expect the situation in CoS$_2$ to be ? It has the same crystal structure.

6. TiS$_2$ has the layered CdI$_2$ structure, and there are no short S-S distances.
   (a) What is the oxidation state of Ti ?
   (b) Sketch out schematic DOS showing Ti $d$ states and S $p$ states. Do you expect an metal or an insulator ?
   (c) TiS$_2$ shows metallic conductivity. Suggest a possible origin ?