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Prelab 3 | October 22, 2024

Experimentation Laboratory II

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1. Why are there energy bands in materials? What is a valence band? A conduction band? A band gap?

   Solution: Energy bands are the energies that electrons inside a material occupy. The valence band is defined to be the highest energy level that is occupied by electrons, the conduction band is the lowest energy level that is *not* occupied. The band gap is the difference between these two energies.

   The conduction band can be thought of as "freely moving" electrons. □

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2. How do conductors, insulators, and semiconductors differ in their energy-and structures?

   Solution: Conductors have an overlapping conduction and valence band, giving rise to "free" electrons that move with an arbitrarily small voltage.

   Insulators have a large band gap that is much larger than $k_B T$, so small voltages don't cause any electrons to excite to the conduction band, hence no current.

   Semiconductors are by definition also insulators, but where the band gap is on the order of $k_B T$, so at $k_B T$ due to the redistribution of electrons there are some electrons that do become promoted to the conduction band. □

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3. How do we explain the fact that there are free electorons in a metallic conductor? What is an extrinsic semiconductor?

   Solution: The electrostatic pull between electrons and the other nuclei give rise to free electrons in a metallic ocnductor. An extrinsic semiconductor is one that is "doped" with other atoms, in order to reduce the band gap.

   what do the holes do? Can electrons occupy those holes, and thereby we reduce the band gap? □

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4. What is the Hall effect?

   Solution: The Hall effect is created as a result of an imbalance in electrostatic charges when a magnetic field is placed across a current. □

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5. Explain the Van Der Pauw Technique.

   Solution: Uses four leads and the voltages across them to determine characteristics of the semiconductor.

   The Hall voltage can be calculated using $(R_{AC,BD} + R_{BD,AC})/2$. Combining this with the measurement of B_Z gives us the hall coefficient. We can determine it via:

   $$V_H = -\frac{I_x B_z}{end}$$

   Then, we get $E_H = qV_H$, we have:

   $$R_H = \frac{qV_H}{J_x B_z} = \frac{1}{en}$$

   The quantity on the right is probably something that'll be given to us, and the one in the middle is the one we will experimentally solve for. □

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6. What measurements are needed for studying the Hall Effect?

   Solution: Given by the table, we need measurements I, V for all four corners. □
