DEMONSTRATION 1
Notes for the Instructor

PURPOSE

To demonstrate electron flow within an energy band.

METHOD

The introductory material that accompanies this unit discusses the band theory of metals and electrical conduction at some length. This demonstration will reinforce the concept that only those electrons in partially filled energy bands are capable of contributing to electrical conductivity. Furthermore, only those electrons that are near the top of the filled energy levels in the unfilled band can actually contribute in a net sense. Three clear bottles with caps; one filled completely with sand, one half-filled with sand, and one empty are needed. Tip each bottle at a 45° angle from vertical, a mechanical analog of applying a voltage, and look for the flow of sand, a mechanical analogy to the electrical current flow.

EXPECTED RESULTS

Obviously, the net movement of sand can only occur in the partially filled bottle, which makes this a good analogy for electrical conduction. A class discussion involving the following questions should clarify and extend the analogy.

FOLLOW-UP QUESTIONS

1. What does the sand represent in this demonstration? **Valence Electrons.**

2. What does the empty bottle represent? **An energy band that has no electrons in it.**

3. What does the completely full bottle represent? **A band that is completely filled with electrons.**

4. What does the half-full bottle represent? **A partially filled band.**

5. What does tilting the bottles represent? **Supplying energy to the electrons (applied voltage).**

6. What is significant about the fact that only the sand at the top of the partially filled bottle moves? **It is the movement of electrons occupying energy levels near the top of the partially filled band into the unfilled energy levels of the band that provide a net flow of carriers, representing electrical conductivity. The electrons below this level simply move into levels that were previously occupied and do not lead to a net flow of electrons.**

INVESTIGATION 1
Notes for the Instructor

PURPOSE

To have the students become familiar with the structure of graphite prior to the demonstration of the oxidative intercalation of this structure to illustrate the enhancement of electrical conductivity by removing electrons from a filled energy band.

METHOD

The students are provided with a model or preferably they are asked to construct a model of graphite using the Solid State Model Kit available from ICE. It is suggested that the students only construct that portion of the model identified by dotted lines that define the unit cell.

ANSWERS TO FOLLOW-UP QUESTIONS

1. Each carbon atom has three nearest neighbors.

2. The nearest neighbors are arranged in a trigonal planar arrangement.

3. For the graphite unit cell:

    8 corner atoms x 1/8 = 1

    2 face atoms x 1/2 = 1

    4 edge atoms x 1/4 = 1

    1 interior atoms x 1 = 1

    = 4 atoms total

4. See diagrams on page 67 of the manual that accompanies the Solid State Model Kit.

5. The fact that carbon forms only three bonds and not four means that there is a single delocalized valence electron that acts as a charge carrier when excited. The extra electron can move energetically to a nearby empty band above it. This question will probably require some class discussion and should be used nevertheless in conjunction with the intercalation demonstration that follows.

INVESTIGATION 1

PURPOSE

To become familiar with the structure of graphite. To understand on the basis of this structure why graphite is an electrical conductor.

PROCEDURE

If a model of the graphite structure has been made available to you, look at it carefully as you answer the following questions. If you are to build the model yourself, follow the instructions on page 67 of the manual that accompanies the Solid State Model Kit.

FOLLOW-UP QUESTIONS

1. How many nearest neighbors does each carbon atom have in this structure?

2. How are the nearest neighbors arranged about a given central atom? What is the name of the shape these neighbors assume?

3. How many atoms are in the unit cell ? (**HINT: Recall from your earlier investigations that a unit cell is defined as a three dimensional, six sided figure having parallel faces. When a face is reproduced and moved along its edges a distance equal to the length of the edge, generates the entire structure.)**

4. Draw the *z* layer sequence showing the position of the atoms at *z* = 0, _, and 1.

5. Consider your answer to (2) above and the following information. Carbon typically forms four bonds by sharing the four electrons in its outermost enery level (valence level). This bond formation "localizes" these valence electrons about the atom and restricts their movement throughout the remainder of the structure. In addition the formation of four bonds with other carbon atoms(such as the diamond structure) results in a completely filled band. Why then is graphite a conductor?