611-2170 (30-065) BB Board

Introduction: Metals are interesting materials. When non-metals bond, a few electrons in the outer electron shell of each atom are shared, called a *covalent* bond. Another type of bond is when one atom looses an electron to a second atom, which is called an *ionic* bond. This is not the way metals behave.

In metals, especially elemental ones, the electrons in the orbital shells of all the atoms become disassociated from their respective nuclei. This is not to say that the atoms come apart, but the electrons are shard amongst multiple atoms. This creates a *sea of electrons*. This sea is one of the reasons metals generally are good conductors. It also allows the atoms in a metal to move around a little and line up in interesting ways.

Since the BB's in the BB board are made of steel, the BB board is meant to represent the behavior of iron atoms. Think of each individual BB as a single atom of iron. This experiment will show the behavior of iron under certain conditions. For the best demonstration, you will need the following items:

--- 4 pieces of steel wire. Paper clips, bobby pins, or similar will also work
---1 Bunsen burner
---1 beaker of cold water
---1 set of tongs

Description: Your BB board is essentially two pieces of acrylic with BB's sandwiched between. The unit is sealed to prevent the BB's from escaping. In addition, the space between the plates is large enough to allow the BB's to move, but small enough to confine them to one layer. Thus the BB's are forced to move in two dimensions. This allows you to see how they line up under certain circumstances, and also allows the entire unit to be placed on an overhead projector.

Steel is mostly iron, and works nicely for these experiments. Steel is purified iron with a small percentage of carbon in it. Other materials may be added to produce different properties.

EXPERIMENT NUMBER ONE:

For this experiment, take one piece of steel wire with the tongs, and heat it until it glows red-hot. Allow it to cool slowly. This process is called annealing and it allows otherwise rigid iron to become more flexible, allowing it to be worked easier. It comes with a price: lower strength and hardness.

To demonstrate the effect using the BB board, hold the board horizontally and shake the board vigorously to represent heating. As the iron wire was heated, the individual atoms gained more energy, causing them to move faster. After you have thoroughly shaken the board, gently shake it until the BB's fall into an orderly pattern. You can see by the evenness of the spacing that the individual BB's are better able to slide around each other. This is what allows a piece of annealed iron to bend so easily: the atoms can move past each other in uniform ways.
Defect holes, places where the pattern is not perfect, may be present. This is normal and in fact almost impossible to eliminate. Think of the iron as a single crystal composed of many smaller crystals. As it cools, smaller crystals join to form larger ones. However, the iron does not cool at an exactly uniform rate, and some areas may cool faster than others. Instead of a single giant crystal, the piece of iron may be composed of several large ones. Where they join together are breaks in the pattern.

EXPERIMENT NUMBER TWO:

For this experiment, take a piece of steel wire with the tongs again, heat it until it is red hot, and immediately immerse it in cold water. Wait a few moments. Do not be alarmed if steam escapes the beaker. When you have fully cooled the wire, remove it from the water. You will notice that it easily breaks into smaller pieces. This process is called *hardening.*

To recreate the effect, shake the BB board vigorously, and then stop abruptly. You will notice that the BB's become very disordered, with defect holes and fault lines reaching throughout the structure. This causes the iron to become extremely brittle, because it has so many fault lines along which to fracture. In effect, it makes many tiny grains of iron instead of a few big ones. However, this process also increases the hardness of the iron. The hardness is dependent on many factors: what temperature the iron is heated to, how fast it is cooled, what impurities are present, and so forth.

EXPERIMENT NUMBER THREE:

For this experiment, you want to slowly heat the steel wire. Do this by holding it above the flame of a Bunsen burner with the tongs until a bluish oxide form on the surface. Remove it from the heat and allow it to cool slowly. When it is fully cooled, gently bend the wire and release it. You will notice it springs back to its original position. This is known as *tempering.*

To demonstrate the same effect, shake the board vigorously to indicate heating. Stop sharply. Then, gently tap the board a few times to induce a more uniform pattern. The process of tempering is somewhat between annealing and hardening.

The purpose of the fourth wire is as a control. You can compare this untreated wire against the three you have experimented on.

Warranty and Parts:
We replace all defective or missing parts free of charge. Additional replacement parts may be ordered toll-free. We accept MasterCard, Visa, checks and School P.O.s. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse or normal wear and tear. Intended for children 13 years of age and up. This item is not a toy. It may contain small parts that can be choking hazards. Adult supervision is required.