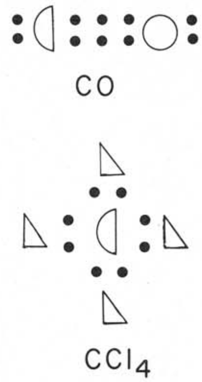
Teaching Aids for Visually Handicapped Students in Introductory Chemistry Courses

Deborah Smith[1]
University of Virginia, Charlottesville, VA 22901

The primary goal of a one-semester university Introduction to Chemistry course is to give the students an appreciation of the laws of nature that govern the behavior of matter. The topics generally studied are the periodic table, bonding, chemical equations, states of matter, solutions, acids and bases, and introduction to organic and biochemistry. At UNC-Greensboro,[2] Introduction to Chemistry is taught in large lecture sections of from 75 to 175 students meeting three class periods per week. Many visually-oriented models, examples, and demonstrations are shown. The lecture sections are broken down into groups of 30 students for weekly laboratories. In spite of the large class size and the visual orientation of the material, a blind student without any high school chemistry background has been able to complete the course very successfully. The major difficulty in teaching a blind student is that the instructor must realize what the student needs in the way of learning aids without any input from the student, who has no way of knowing what he or she is missing, and who, therefore, cannot take any initiative in requesting specific materials.



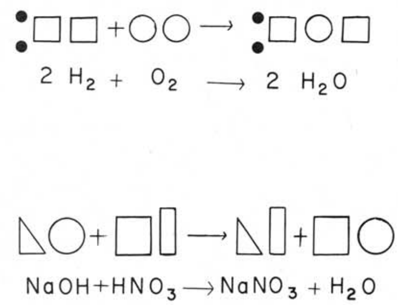


Figure 1. (left) Lewis dot structures for CO and CCl_4. Small black circles are magnets representing electrons. Shapes are cut out of balsa wood and glued to other magnets to represent atoms. Semicircles are carbon, triangles are chlorine, and large open circles are oxygen atoms. The arrangement sticks to a magnetic board and can be felt easily.

Figure 2. (right) Hydrogen and oxygen molecules reacting to form water (top) and sodium hydroxide and nitric acid reacting to produce sodium nitrate and water (bottom). Two black circles are magnets indicating the coefficient 2 in a balanced equation. The coefficient 1 is understood. Balsa wood shapes glued to magnets represent various atoms and polyatomic ions. Squares are hydrogen atoms or ions. Open circles are oxygen atoms in the top and hydroxide ions in the bottom equation. Triangles are sodium ions and rectangles are nitrate ions. The shapes and magnets are arranged on a magnetic board.

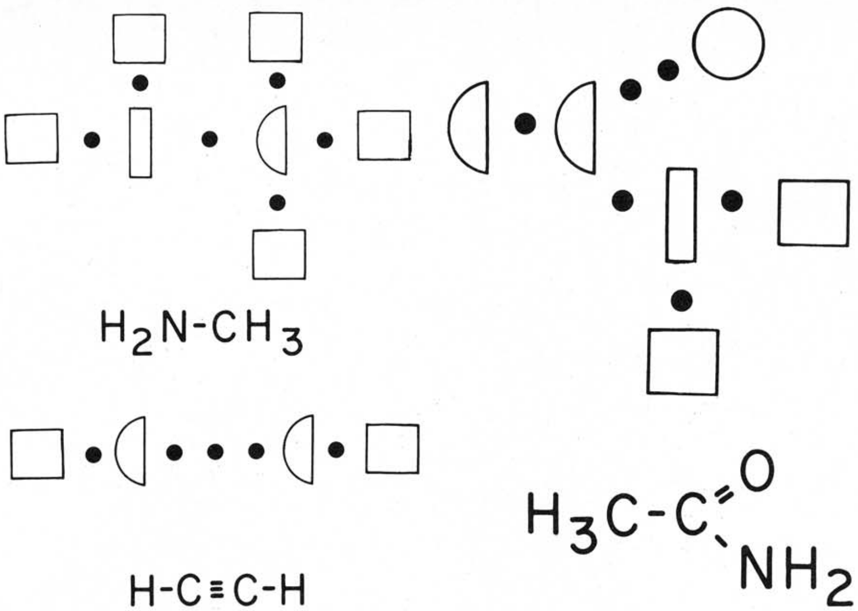
Lecture Aids

Throughout the course, emphasis is placed on the information contained in the arrangement of the elements on the periodic chart, and so it is essential that every student have access not only to a list of the elements with their atomic numbers and weights but also to the physical arrangement of the elements. For a blind student, the chart must be light and compact, so that it is easily portable, yet it must be sturdy, so that it does not fall apart with much touching and transportation. Apparently no such chart is available from the various printing houses and services for blind students, but one can be made with the student's help from two manila file folders, two 8 in. × 11 in. pieces of cardboard, strong glue, and 106 small blocks of lightweight wood, measuring about ½ in. × ¾ in. × ¼ in. The two folders are glued together with the pieces of cardboard between each leaf for strength. Then the blocks are glued to the top folder in the arrangement of the elements. Space is left over the hinge of the folders, so that the chart can be folded up. The student can braille the numbers 1 through 106 on adhesive-backed plastic tape, and these numbers are attached to the blocks. When discussing the periodic chart in class, the instructor must be sure to identify the elements by atomic number, as well as by name and not just by pointing to them. (Referring to the elements by number also helps the sighted students follow the lecture.)

In order to show Lewis structures, a magnetic board with many small magnets can be used. The board may be a magnetic hotplate found in a hardware or five and ten cent store, or a board found in children's educational toys. A good size for this board is about 12 in. × 6 in. Small magnets, about ¼ in. in diameter, with excellent hold, are available for seven cents apiece at a Radio Shack. Forty-eight magnets are needed to make a complete set. Thirty-two are used to represent

[1] The author thanks Ron Keefe for his help in preparing the figures.

[2] The work described was done while the author was employed by the University of North Carolina at Greensboro, Greensboro, NC 27412.



Figures 3a–c. Methylamine (left), acetylene (center), and acetamide (right). Black circles are magnets representing bonds. One magnet is a single bond, two magnets are a double bond, and three magnets are a triple bond. Balsa wood shapes glued to magnets represent atoms. Open circles are oxygens, squares are hydrogens, rectangles are nitrogens, and semicircles are carbons. In acetamide, the number of hydrogens bonded to each carbon is understood, as would often be the case in written structural formulas. The molecules are displayed on a magnetic board.

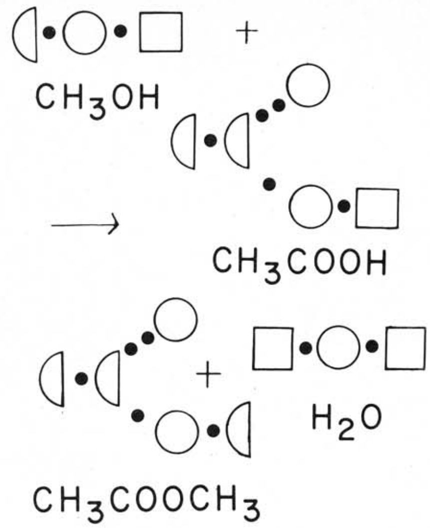


Figure 4. Methanol and acetic acid reacting to form methyl acetate and water. Each black circle is a magnet representing a bond. Balsa wood shapes glued to magnets represent atoms. Open circles are oxygen, semicircles are carbon, and squares are hydrogen. The equation is displayed on a magnetic board.

electrons, and shapes are cut out of thin balsa wood and glued to the others to represent different atoms. Circles the size of a quarter represent oxygen and other Group VI atoms. C's for carbon are made by cutting these circles in half to form semicircles. Squares 1 in. to the side represent hydrogen, and the squares cut on the diagonal to form triangles are the halogens. Nitrogens are rectangles 1 in. × 1/4 in. and are thin compared to the hydrogens. The student has to feel only two sides of these shapes to identify the element. Some diagrams of Lewis structures made with shapes and magnets are shown in Figure 1.

Although the magnets and shapes with board were developed for making Lewis structures, this equipment has many other uses. One such use is balancing chemical equations. The magnets are coefficients in the balanced equation, and the shapes represent atoms or polyatomic ions. Bonds are not represented explicitly. Diagrams of some balanced equations are shown in Figure 2. The species represented by the shapes are changed arbitrarily as many different ionic compounds come up. Partner-swapping reactions are demonstrated concretely, as well as the fact that polyatomic ions behave as a unit in ionic reactions. In fact, using shapes is helpful in explaining equation-balancing to sighted students who are having difficulty with the subject. The shapes give them something tangible with which to work.

At the end of the survey course, organic molecules are discussed briefly, and these can also be built with the shapes and magnets. One of the goals of this segment of the course is for the student to learn to recognize various functional groups. Now one magnet represents a single bond, two magnets a double bond, and three magnets a triple bond, so that groups such as carboxylic acids, esters, and amides can be built. Not as many plain magnets are needed now, so more C, O, and N shapes can be cut out and glued to magnets that have been used previously as electrons. Some examples of organic molecules represented by magnets and shapes are shown in Figure 3a–c. Although the compounds illustrated are very simple, large molecules with many functional groups can be built. Another goal is to predict the products of some common organic reactions. The instructor makes the reactants from the shapes and magnets, and the student builds the product from the reactants. The formation of methyl acetate from methanol and acetic acid is shown in Figure 4.

Laboratory Work

A major part of any chemistry course is laboratory work. In my opinion, the blind student should perform the experiments by himself or herself, if he or she wishes, with the aid of a reader. Any blind student who is in college certainly has mastered such skills as pouring, handling hot liquids, etc., and can carry out all of the procedures required in an introductory laboratory. The blind student also can make most of the observations a sighted student makes. The blind student simply has different methods of operation. For example, the various types and volumes of glassware are identified by touch. Most substances are identified by smell and by feel. The Bunsen burner is lit by touch and by sound. Crystallization is observed by mashing with a stirring rod and feeling the solid. The student needs to have someone working with him or her to do the "eyework" such as reading the graduated glassware, identifying colors, and reading the laboratory procedure. (If the instructor, as opposed to a classmate or the graduate student in charge of the laboratory, performs the function of reader, the others are freed for their own work, outside criticism is eliminated as much as possible, the blind student will more likely be allowed to do the lab work himself or herself, and the procedures and materials can be explained during the experiment.) *The instructor should be guided* by the student in the amount of help given and should avoid doing any part of the experiment the student wishes to do and can do. The first labs require more explanation, but by the end of the term, the instructor is almost obsolete. The blind student has many modes of operation and observation that the instructor knows nothing about, and the instructor can learn a lot about scientific observation from the blind student.