Crystal Model Kits for Use in the General Chemistry Laboratory

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Efforts to teach crystal structure concepts have been linked to the development of models that illustrate the three-dimensional structure of crystals (*1–14*). As early as 1813, a commercial set of crystal models was developed by Frederick Accum to accompany his text (*15*).

Most of the models described previously are *static* models, built by the instructor, rather than *dynamic* models which the student builds for himself or herself (*16*). This paper describes dynamic crystal model kits which were developed independently at the Worcester Polytechnic Institute (WPI) and Purdue University. Laboratory experiments in which students use these kits to build models have been extremely successful in providing students with an understanding of the three-dimensional structures of the common cubic unit cells as well as hexagonal and cubic closest packing of spheres.

The WPI Kit

The crystal model kit developed at WPI consists of a Plexiglas cubical cabinet with five equally-spaced Plexiglas shelves, a close-packing shelf cut with grooves, and a collection of colored plastic spheres which are used to represent atoms. The particular kit shown in Figure 1 is about 25 cm on an edge, but we have built a model more than 3 times larger than this for use in lecture demonstrations.

The most valuable feature of the WPI design is the closest-packing shelf which can be placed on the top shelf of the cabinet. This shelf allows the student to build a model of a hexagonal or cubic closest packed arrangement of spheres and a face-centered cubic unit cell at the same time. By viewing both the cubic closest-packed and face-centered cubic structures simultaneously, the student may see the equivalence of these alternate descriptions of the same structure. In addition, the middle three shelves are movable (and removable) to allow for quick and easy illustration of edge defects and to make it easy to insert balls at any desired location in the model.

The Purdue Kit

The Purdue model (*17*) in Figure 2 uses four long pieces of threaded rod to maintain the proper spacing between shelves. A nut is placed above and below each shelf, and tightened to hold the shelf in place. One hundred eighty large models 21.5 cm on a side were originally built for use in the laboratory (12 models for each of 15 labs), as well as larger kits for lecture demonstrations. The Purdue kit is inexpensive and easy to build because there are no side walls. The student can reach into the model from any direction, making it easier to add and remove balls[2] from the shelves. There is no provision for closest-packing of spheres.

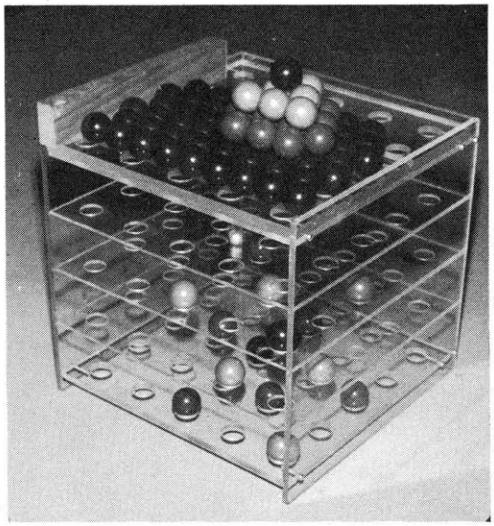

Figure 1. A photograph of the WPI kit.

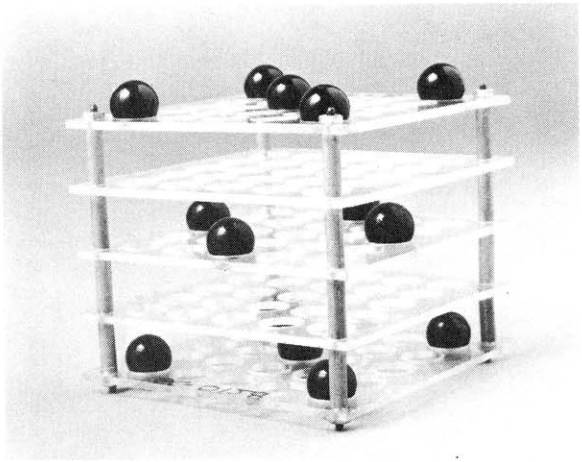

Figure 2. A photograph of the small Purdue model.

Structures Illustrated by the Kits

The following crystal structures or structural features are readily illustrated with the WPI kits. Those that are not marked with an asterisk can be demonstrated with the Purdue kits.

*1) Hexagonal closest-packing
*2) Cubic closest-packing
3) Octahedral holes
4) Tetrahedral holes
5) Simple cubic unit cells and ionic structures based on this unit cell, such as cesium chloride.

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6) Body-centered cubic unit cells
7) Face-centered cubic unit cells, and the following ionic or covalent structures based on this unit cell
   a) Rock salt
   b) Zinc blende
   c) Fluorite
   d) Antifluorite
   e) Diamond
8) Other structures with cubic unit cells (*18*)
   a) ReO_3 } Tungsten bronzes
   b) Perovskite }
   c) Mn_2O_3
   d) Spinel and inverse spinels
9) Point defects
*10) Edge Dislocation

The authors will be happy to provide copies of the experiments that use these models and details for construction of the kits upon request.

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Literature Cited

(1) Stillwell, C. W., J. CHEM. EDUC., **13,** 415, 469, 521, and 566 (1936), and J. CHEM. EDUC., **14,** 34 and 131 (1937).
(2) Scattergood, A., J. CHEM. EDUC., **14,** 140 (1937).
(3) Seymour, K. M., J. CHEM. EDUC., **15,** 192 (1938).
(4) Hauser, E. A., J. CHEM. EDUC., **18,** 164 (1941).
(5) Westbrook, J. H., and DeVries, R. C., J. CHEM. EDUC., **34,** 220 (1957).
(6) Kenney, M. W., J. CHEM. EDUC., **35,** 513 (1958).
(7) Komuro, Y., and Sone, K., J. CHEM. EDUC., **38,** 580 (1961).
(8) Gehman, W. G., J. CHEM. EDUC., **40,** 54 (1963).
(9) Sims, R. J., J. CHEM. EDUC., **40,** 61 (1963).
(10) Livingston, R. L., J. CHEM. EDUC., **44,** 376 (1967).
(11) Olsen, R. C., J. CHEM. EDUC., **44,** 728 (1967).
(12) Mann, A. W., J. CHEM. EDUC., **50,** 653 (1973).
(13) Suchow, L., J. CHEM. EDUC., **53,** 227 (1976).
(14) Bodner, G. M., Greenbowe, T. J., and Robinson, W. R., J. CHEM. EDUC., **57,** 555 (1980).
(15) Browne, C. A., J. CHEM. EDUC., **2,** 829, 1008 (1925).
(16) Herron, J. D., State-of-the-Art Symposium: Chemical Education for the 80's, J. CHEM. EDUC., **61,** (1984).
(17) Bodner, G. M., Livingston, R. L., and Robinson, W. R., Abstracts of the 184th ACS National Meeting, Kansas City, MO, September **1982.**
(18) Mackay, K. M., and Mackay, R. A., "Introduction to Modern Inorganic Chemistry," 3rd Edition, International Textbook Co., London, **1981,** pp. 84—85, p. 235.

[2] Champion Agate Co., Inc. P.O. Box 516, Department 10, Pennsboro, WV sells solid black and solid white 3/4 in. diameter marbles for roughly 2.5¢ each.