Cost-Effective Teacher

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Cubic Unit Cell Construction Kit

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Crystal lattice models are useful in both classroom and laboratory settings. This *Journal* periodically publishes articles on this topic and advertisements for commercially available models are frequently found here as well. Most familiar is the Solid State Model Kit distributed by the Institute for Chemical Education.[1] I have designed a simple interactive unit-cell construction kit that allows for the construction of the three cubic lattice types (simple, body-centered, and face-centered). The kit is built from inexpensive and readily available materials and can be built in any number of sizes.

Figure 1 shows the unit-cell construction kit configured for a fully assembled face-centered lattice. The balls slide onto the steel rods so that the user can readily assemble and disassemble the lattice for teaching and learning activities. The steel rods are set in holes drilled in the base and can be repositioned on the same base to demonstrate the other cubic lattice types.

Working with the unit cell construction kit enables one to *experience* the differences between the three simple lattices. The relative sizes of the cells and the spatial location of the intermolecular contacts are clearly noted by firsthand observation. We have found that students are naturally inclined to use the device to answer questions about unit cells.

We use this device in two settings. In General Chemistry, it is used by the lecturer when discussing unit cells. In Descriptive Inorganic Chemistry, students use the device in laboratory. Even on their first experience with the kit, students can assemble each lattice type in a matter of minutes. To fully appreciate this lesson in applied geometry, students may be asked to calculate the values in Table 1.

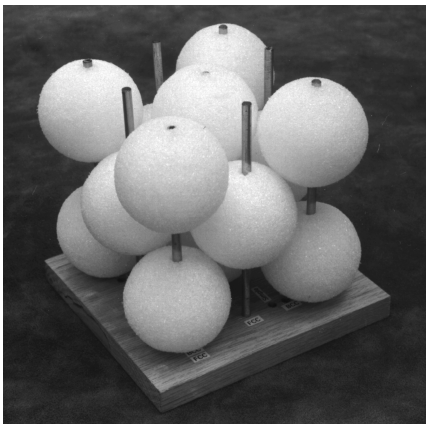

Figure 1. Unit cell construction kit configured in a face-centered cubic lattice.

Table 1. Coordinates of Holes for the Unit Cell Construction Kit

Drilled Hole	Geometric Coordinates *x,y*	Decimal Coordinates *x,y*	Coordinates for 3-in. spheres *x,y*
origin[a]	0, 0	0, 0	0, 0
simple(2)	d, 0	d, 0	3.000, 0
simple(3)	0, d	0, d	0, 3.000
simple(4)	d, d	d, d	3.000, 3.000
bcc(2)	$2d/\sqrt{3}$, 0	1.155d, 0	3.464, 0
bcc(3)	$d/\sqrt{3}$, $d/\sqrt{3}$	0.577d, 0.577d	1.732, 1.732
bcc(4)	0, $2d/\sqrt{3}$	0, 1.155d	0, 3.464
bcc(5)	$2d/\sqrt{3}$, $2d/\sqrt{3}$	1.155d, 1.155d	3.464, 3.464
fcc(2)	$d/\sqrt{2}$, 0	0.707d, 0	2.121, 0
fcc(3)	$\sqrt{2}d$, 0	1.414d, 0	4.243, 0
fcc(4)	0, $d/\sqrt{2}$	0, 0.707d	0, 2.121
fcc(5)	$d/\sqrt{2}$, $d/\sqrt{2}$	0.707d, 0.707d	2.121, 2.121
fcc(6)	$\sqrt{2}d$, $d/\sqrt{2}$	1.414d, 0.707d	4.243, 2.121
fcc(7)	0, $\sqrt{2}d$	0, 1.414d	0, 4.243
fcc(8)	$d/\sqrt{2}$, $\sqrt{2}d$	0.707d, 1.414d	2.121, 4.243
fcc(9)	$\sqrt{2}d$, $\sqrt{2}d$	1.414d, 1.414d	4.243, 4.243

[a]Origin for all three structures: simple(1); fcc(1); bcc(1). The location of the holes is shown in Fig. 2.

Instructions for Building the Unit Cell Construction Kit

Supplies (sizes suggested in the Construction section)

Materials	Tools
14 solid spheres	drill press
9 steel rods	drill bit
wood or plastic	flat file
spray paint (optional)	

Construction

Proper construction of this device requires the use of a drill press. Start by purchasing the 14 solid balls that will be used. We use 3-inch (7.62-cm) diameter expanded polystyrene spheres available at most hobby and craft shops. It is possible to spray-paint the spheres if desired. The paint propellant will dissolve the expanded polystyrene unless the spheres are held at least 2 feet (60 cm) away and the paint is applied in very short bursts. An even coat of paint can be

obtained by placing the spheres on the end of a spatula or a glass pipet, which serves as a spindle that can be rapidly hand-rotated while painting. Drill a hole with the same diameter as that of the rods through the center of each sphere. The holes must be accurately centered through the spheres in order to function properly. Hold the spheres gently but firmly in the drill press table's hole and drill through the center.

The device requires nine steel or aluminum rods with a suggested diameter of $\frac{1}{4}$ inch (6.4 mm) and a length 2.1 times the diameter of the spheres. Thus, 3-inch (7.62-cm) diameter spheres would require $6\frac{1}{4}$-inch (15.9-cm) steel rods. The ends of the rods must be filed to remove the burrs.

The base may be constructed from wood or plastic. Its shape is that of a square with a minimum side dimension 2.4 times the diameter of the spheres and a minimum thickness of $\frac{3}{4}$ inch (2.0 cm). A total of 16 holes must be drilled into the base according to the plan given in Figure 2. The precise *x,y* coordinates of the holes are given in Table 1, where "*d*" is the diameter of the spheres. The holes must have the same diameter as the rods and must be drilled to a depth of $\frac{1}{2}$ inch (1.3 cm) with the aid of a drill press.

The project is completed by adding labels to the 16 holes in the base as shown in Figure 2.

Note

1. Solid State Model Kits from the Institute of Chemical Education (ICE, Department of Chemistry, University of Wisconsin–Madison, 1101 University Ave., Madison, WI 53706-1396) are available in a deluxe version (order number 92-004) and a student version (order number 94-006).

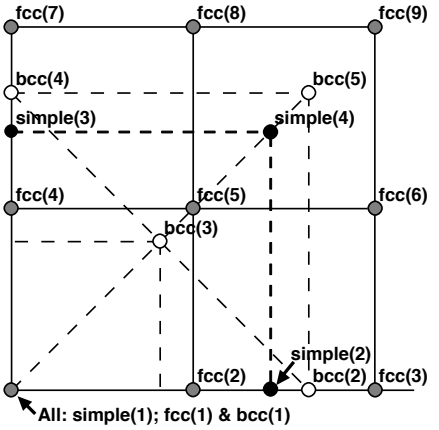

Figure 2. Location of holes in unit cell construction kit. Coordinates are shown in Table 1.

Literature Cited

1. Ellis, A. B.; Geselbracht, M. J.; Johnson, B. J.; Lisensky, G. C.; Robinson, W. R. *Teaching General Chemistry: A Materials Science Companion*; American Chemical Society Publication; Oxford University Press: New York, 1993.
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3. Ellis, A. B. *J. Chem. Educ.* **1997**, *74*, 1033.