Solid-State Chemistry Encyclopedia Article

Solid-State Chemistry

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Contents

Solid-State Chemistry Encyclopedia Article.....1

Contents.....2

Solid-State Chemistry.....3

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Chemists often make use of the observed shapes of crystals to help in their identification. The description of the shapes of crystals is the subject of the science of **crystallography**. Every crystal can be classified in one of the following six crystal systems:

Cubic. Three axes are at right angles and a re of equal length.

Hexagonal. Three equal lateral axes are intersecting at angles of 60° and vertical axis of variable length are at right angles (as in the hexagonal prism).

Tetragonal. All three axes are at right angles and the two lateral axes are equal.

Orthorhombic. Three unequal axes are at right angles to each other.

Monoclinic. Three unequal axes that have only one oblique intersection.

Triclinic. Three unequal axes that intersect at oblique angles.

Five-fold symmetry was ignored for a long period of time in science, especially in crystallography. This was because of a proof of the impossibility of a five-fold symmetry axis in a crystal medium. Only one-, two-, three-, four-, and six-fold symmetry axes are possible. Three-dimensional structures with five-fold symmetry cannot be packed to fill all available space and cover a surface without gaps. This was an official understanding until 1985 when Kroto/Smalley (1996 Nobel Prize in Chemistry) research team discovered the carbon-60 (C_{60}) molecule--a truncated icosahedron with 12 pentagons, 20 hexagons, 60 vertices, and 90 edges. Its discovery opened a new branch in crystallography.

The basic physical properties of C-60 are: **density** 1.67 g/cm^{3}, diameter 0.71 nm, lattice constant 1.42 nm, **ionization** potential 7.6 eV ($12.16x10^{-19}$J). In the crystal state (central-cubic), it shows only rotation. Experimental results strongly indicate that rotation in crystal is faster than in **solution** (rotational **diffusion** constant is $3x10^{10}$ vs. $1.8x10^{10}$ per second).