Crystallography

A crystal is a solid substance whose molecular structure locally exhibits three independent translational symmetries. The possible crystal lattices (taking the nucleii of the constituent atoms as points in the lattice) have been completely classified according to their symmetry and many of them are actually realized in nature.

1. Here we will consider lattices involving a single element.

a. Which, if any, of the Platonic solids can be put together to fill space in such a way that their centers form a three dimensional lattice?

b. Can any of these be realized with a single atom of a common element at each point? Why? What would Plato think of this?

c. What is the closest one can come, with a single atom, to filling space with a Platonic solid? What substance, if any, do you think your lattice corresponds to?

2. Although not quite a lattice, layers of a one dimensional hexagonal lattice can be "stacked" though of course the layers will not be bonded with the same strength as the individual sheets.

a. How would you expect these layers to stack?

b. Would you expect neighboring atoms within a layer to be closer to one another than to neighboring atoms in differenet layers? Why?

c. What type of force would you expect to hold the layers together?

The force holding different layers together here is called the van der Waal force. With carbon atoms at each vertex, this structure is very stable and it is graphite.

3. Much greater variety is possible for forming a three dimensional lattice if different elements are used. For example sodium chloride forms a very stable lattice with one atom, roughly, at each integer valued point (a, b, c) in space. If the sum of a, b, c is even, you put a sodium atom and if the sum is odd you put a chlorine atom. What type of bonding is present in this system? Why is it stable?

4. Crystals, when broken, tend to maintain certain symmetries.

a. Suppose you have a very simple crystal system such as that formed by salt. If you break such a crystal, where to do you expect it to break?

b. What angles would you expect to find between adjacent faces?

c. Suppose you are given two crystals and you do not know their chemical make–up. Could you decide that they are based on mathematically different lattices by analyzing angles?

5. Ths basic unit in quartz, like in diamond, is a tetrahedron with a silicon atom at the center and four oxygen atoms surrounding the silicon atom.

a. Each oxygen atom is bonded to only two silicon atoms. Why?

b Each silicon atom is bonded to four oxygen atoms which form a tetrahedron around the silicon atom. The bonds in question "violate" the general rule of stability coming from having complete electron shells. Why?

c. How does the structure of quartz differ from that of diamond? Would you expect quartz to be as hard as diamond? Why?