Crystalline Solids

1. Crystal Lattice

A crystal lattice is a regular, repeating, 3-dimensional pattern in which the particles of a crystalline solid are arranged.

Depending on the type of substance, the lattice sites can be occupied by atoms, molecules, or ions.

unit cell -- simplest geometrical unit that defines the crystal lattice

Common types of crystal lattices:

simple cubic
-- particle at 8 corners of a cube
-- total of one particle per unit cell

face-centered cubic (e.g., NaCl)
-- simple cubic plus particle at center of each face of the cube
-- total of 4 particles per unit cell

body-centered cubic
-- simple cubic plus particle at center of cube
-- total of 2 particles per unit cell

2. X-Ray Diffraction

X-Ray Diffraction technique for determining crystal lattice and molecular structures provides very accurate bond distances and angles

Bragg equation -- basic mathematical tool of x-ray diffraction (Figure 12.1)
3. **Types of Crystals** (Figure 12.10)

<table>
<thead>
<tr>
<th>Crystal Type</th>
<th>Lattice Sites</th>
<th>Forces</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ionic</td>
<td>anions and cations</td>
<td>electrostatic</td>
<td>hard, brittle, high mp / bp, conduct electricity when molten but not solid</td>
</tr>
<tr>
<td>Molecular</td>
<td>atoms or molecules</td>
<td>dipole-dipole, London forces, or H-bonding</td>
<td>soft, low mp / bp, non-conductors of electricity</td>
</tr>
<tr>
<td>Covalent (network)</td>
<td>atoms</td>
<td>covalent bonds</td>
<td>very hard, very high mp's, non-conductors</td>
</tr>
<tr>
<td>Metallic</td>
<td>positive ions</td>
<td>metallic bonds (cations in a &quot;sea of electrons&quot;)</td>
<td>soft to hard, low to high mp, lustrous, good conductors</td>
</tr>
<tr>
<td>Non-bonding</td>
<td>atoms</td>
<td>London dispersion</td>
<td>very low mp's (e.g. solid Ar)</td>
</tr>
</tbody>
</table>

4. **Amorphous Solids** -- non-crystalline, glassy substances

**Bonding in Solids -- Band Theory**

An energy "band" is composed of a very large number of closely spaced energy levels that are formed by combining similar atomic orbitals of atoms throughout the substance.

Metals and metalloids have a

"*conduction band*" $\rightarrow$ set of highly delocalized, partially filled, MO's that extend over the entire solid lattice structure

"*band gap*" $\rightarrow$ energy difference between filled "*valence band*" and the *conduction band*

**Polymers and Plastics (Section 12.9)** -- Save until end of next semester!