The Structure and Properties of Solids

Chapter 4.8
Types of Solids

• There are 4 types of solids:
  1. Ionic Crystals
  2. Metallic Crystals
  3. Molecular Crystals
  4. Covalent Network Crystals
Ionic Crystals

- **Ionic Crystals** are solids in which positive and negative ions arrange in a crystal lattice structure, with alternating packing of the positive and negative ions.
Properties of Ionic Crystals

Ionic Crystals are BRITTLE

The crystal lattice structure of an ionic crystal is held together by the attraction of oppositely charged ions.

If the crystal is struck with a hammer, the ions become distorted.

And they repel one another, causing the crystal to break or shatter.
Properties of Ionic Crystals

Ionic Crystals are SOLUBLE in water

They also CONDUCT ELECTRICITY but only in solution or in the liquid state
Other Properties of Ionic Crystals

- Hard
- High melting points
Metallic Crystals

- **Metallic Crystals** are solids with closely packed atoms held together by electrostatic interactions and free moving electrons.
- **Electron Sea Theory** is a theory that states that the electrons in a metallic crystal move freely around the positively charged nuclei.
- **Metallic Bonding** is the bonding that holds the nuclei and electrons of metals together.

Metals have a low ionization energy and easily give up electrons.

The metallic ions pack together as closely as possible and are held in place because of strong electrostatic forces between the ions and the delocalized electrons.
Properties of Metallic Crystals

- Melting points vary widely

Table 1 Properties of Metallic Solids

<table>
<thead>
<tr>
<th>Property</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>sheen</td>
<td>Mobile valence electrons absorb and emit light energy of many wavelengths of light.</td>
</tr>
<tr>
<td>malleability</td>
<td>The “electron sea” allows atoms to slide over each other.</td>
</tr>
<tr>
<td>electrical conductivity</td>
<td>Mobile valence electrons produce an electric current when a metal is connected to a battery.</td>
</tr>
<tr>
<td>hardness</td>
<td>The “electron sea” surrounding the positive nuclei produces strong electrostatic attractions that hold the nuclei together.</td>
</tr>
</tbody>
</table>
Molecular Crystals

- Molecular crystals are solids composed of individual molecules held together by intermolecular forces of attraction
# Properties of Molecular Crystals

<table>
<thead>
<tr>
<th>Property</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>low melting point</td>
<td>intermolecular interactions</td>
</tr>
<tr>
<td>little hardness</td>
<td>intermolecular interactions</td>
</tr>
<tr>
<td>electrical non-conductor</td>
<td>composed of neutral molecules</td>
</tr>
</tbody>
</table>
Covalent Network Crystals

• A **Covalent Network Crystal** is a solid in which the atoms form covalent bonds in an interwoven network

Ex: Quartz Crystal
Properties of Covalent Network Crystals

- Very high melting points
- Extreme hardness
- Not good conductors of electricity
Diamond vs. Graphite

<table>
<thead>
<tr>
<th>Diamond</th>
<th>Graphite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardest natural substance</td>
<td>Soft and slippery</td>
</tr>
<tr>
<td>Density 3.5 g/cm³</td>
<td>Density 2.4 g/cm³</td>
</tr>
<tr>
<td>Non-conductor of electricity</td>
<td>Good conductor of electricity</td>
</tr>
<tr>
<td>Colourless and transparent</td>
<td>Black and opaque</td>
</tr>
<tr>
<td>High refractive index of 2.4</td>
<td>Opaque to light</td>
</tr>
<tr>
<td>Does not mark paper</td>
<td>Leaves mark on paper</td>
</tr>
<tr>
<td>Burns at 900 degree c to form carbon dioxide</td>
<td>Burns at 700 degree c to form carbon dioxide</td>
</tr>
</tbody>
</table>

tetrahedral carbon in diamond

trigonal planar carbon in graphite with p orbital
HOMEWORK

Required Reading:
   p. 248-254
(remember to supplement your notes!)

Questions:
   p. 254 #1-9