SOLIDS

- RIGID, DENSE, and INCOMPRESSIBLE

    - Properties of interest:

        (1) MELTING POINT

        - Temperature at which the bulk phase change from solid to liquid occurs

        (2) HARDNESS and BRITTLENESS

        - hardness: resistance of a solid to deformation (shape change) caused by the application of a force

        - brittleness: tendency of a material to fracture or break rather than to deform.

        (3) CONDUCTIVITY

        - ability of a material to conduct an electric current

... these properties will be influenced by the KINDS OF FORCES holding the solid together!

CLASSIFICATION OF SOLIDS: By attractive forces

- Solids may be classified either by the type of forces holding the solid together or by structure. We'll discuss forces first.

- Some solids are held together by the same sorts of forces found in liquids. But there are more options for solids!

- There are four kinds of solids when classified by forces.

(1) MOLECULAR SOLIDS

- held together by the same kinds of forces that hold liquids together:

(A) van der Waals forces: London dispersion forces and dipole-dipole interactions

(B) hydrogen bonds

... generally, these forces are the weakest.

Examples: candle wax, water ice

Generally, molecular solids:
- have LOW MELTING POINTS
- are SOFT
- are NONCONDUCTORS

(2) METALLIC SOLIDS

- held together by METALLIC BONDS, which involve electron sharing throughout the body of the metal..

... strength of these metallic bonds is variable.

Examples: iron, gold, copper, zinc, other metals

Generally, metallic solids:
- have a wide range of MELTING POINTS, though almost all melt above room temperature.
- range from SOFT to HARD. Many are MALLEABLE, meaning they deform before breaking.
- are good CONDUCTORS of both heat and electricity

(3) IONIC SOLIDS

- held together by IONIC BONDS:

... generally, these forces are much stronger than the ones in molecular solids.

Examples: sodium chloride, any ionic compound

Generally, ionic solids:
- have HIGH MELTING POINTS, well over room temperature
- are HARD
- are NONCONDUCTORS of electricity in the solid phase, but CONDUCT when melted or dissolved into a liquid solution.

NaCl: 801°C
1474°F

④ COVALENT NETWORK SOLIDS

- held together by COVALENT BONDS.

- are, in essence, giant molecules where the entire solid (not simply individual molecules WITHIN the solid) are held together by covalent bonds.

... these are the strongest kind of forces holding solids together.

Example: diamond

Generally, covalent network solids:
- have EXTREMELY HIGH MELTING POINTS. Many thermally decompose before melting.
- are EXTREMELY HARD. The hardest materials known are covalent network solids.
- are NONCONDUCTORS

Relative strengths of the forces holding solids together:

INTERMOLECULAR FORCES	$<$	IONIC BONDS	$<$	COVALENT BONDS
molecular solids		ionic solids		covalent network solids

... the stronger the forces, the:
- HARDER a material
- HIGHER the melting point of the material

Metallic bonds vary considerably, so they have been left out of the comparison!

CLASSIFICATION OF SOLIDS: By structure

- Solids may also be classified by structure. A more in-depth look at solids is something you would find in a materials science class, but we'll discuss two broad categories of solid materials.

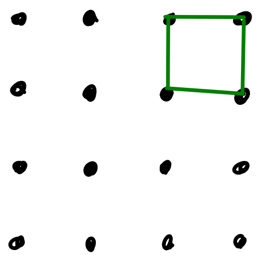
(1) AMORPHOUS SOLIDS

- have a disordered structure at the microscopic level.
- a very small amount of solids are completely amorphous, but quite a few plastics are at least partially amorphous.

(2) CRYSTALLINE SOLIDS

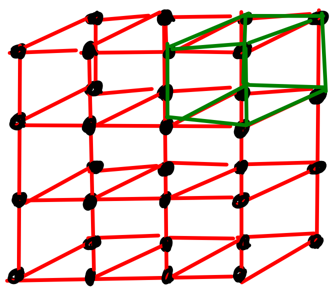
- have a well-defined three dimensional structure at the microscopic level.
- structure is made up of a regular, repeating arrangement of points in space - a CRYSTAL LATTICE

MORE ON CRYSTALS



Here's a simple CRYSTAL LATTICE in 2D. The points represent atoms occupying LATTICE POINTS

The simplest repeating pattern that describes the entire crystal is called the UNIT CELL. It's outlined in GREEN here.



Here's a crystal lattice in three dimensions. This one is called a SIMPLE CUBIC lattice. This simple structure can be found in some solid metals like polonium. A polonium atom occupies each lattice point.

The unit cell, again, is highlighted in GREEN.

See pages 449-450 (9th) for more types of crystal systems and more unit cells.

(p458 - 459 in 10th edition)

CRYSTAL DEFECTS

- Natural crystals almost always have some DEFECTS in their structure.

  - Holes in the crystal lattice, where an atom should be but isn't
  - Misaligned planes in the crystal
  - Substitutions of one atom for another in the crystal lattice

- Often defects are undesirable, but not always:

Alumina: Al_2O_3

- clear / white in color
- usually used as the "grit" in cleaners like Comet and Soft Scrub!

ruby: Al_2O_3 with some Al replaced with Cr

- red in color
- valuable gemstone!