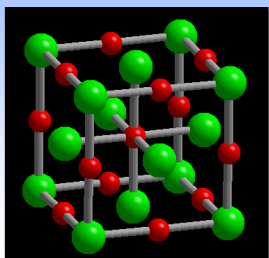


## Metallic and Ionic Solids

Section 13.4



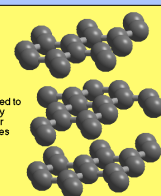
## Types of Solids

Table 13.6

TYPE	EXAMPLE	FORCE
Ionic	NaCl, CaF <sub>2</sub> , ZnS	Ion-ion
Metallic	Na, Fe	Metallic
Molecular	Ice, I <sub>2</sub>	Dipole Ind. dipole
Network	Diamond Graphite	Extended covalent

## Network Solids

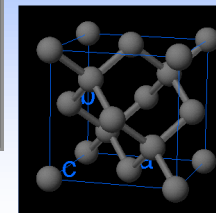
Layer of six-membered carbon rings



Layers bonded to each other by weak van der Waals forces

Graphite

Diamond



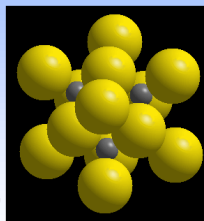
## Network Solids



A comparison of diamond (pure carbon) with silicon.

## Properties of Solids

1. Molecules, atoms or ions locked into a **CRYSTAL LATTICE**
2. Particles are **CLOSE** together
3. **STRONG IM** forces
4. Highly ordered, rigid, incompressible



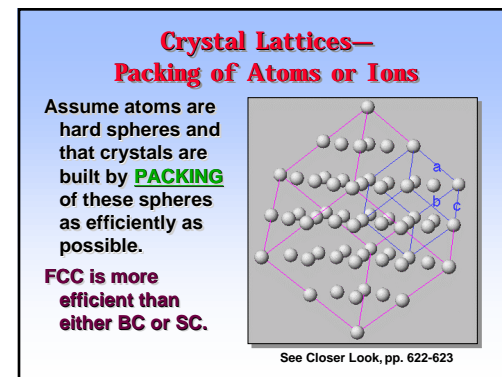
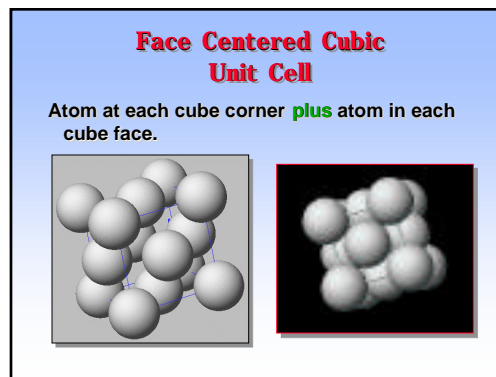
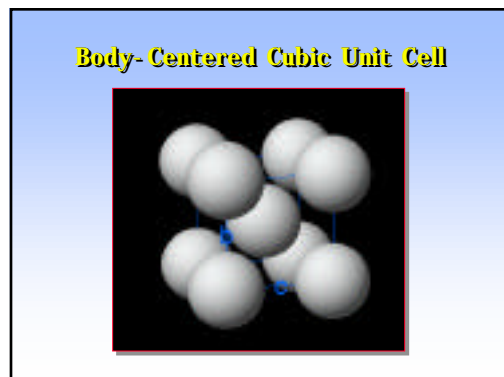
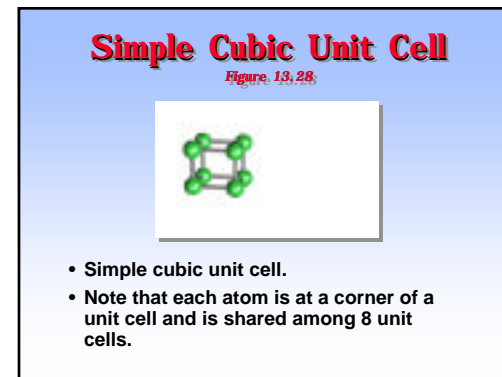
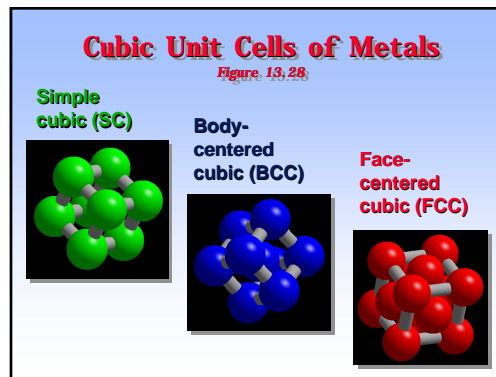
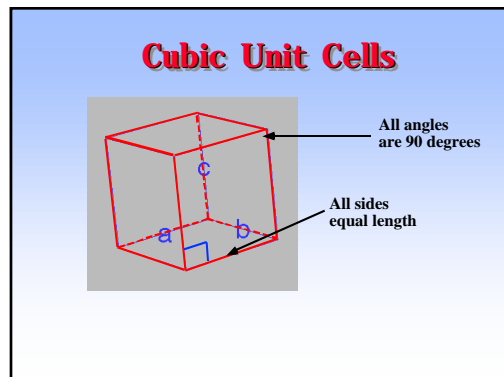
ZnS, zinc sulfide

## Crystal Lattices

Regular 3-D arrangements of equivalent **LATTICE POINTS** in space.

The lattice points define **UNIT CELLS**, the smallest repeating internal unit that has the symmetry characteristic of the solid.

**There are 7 basic crystal systems, but we are only concerned with CUBIC.**



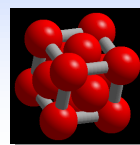
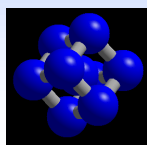
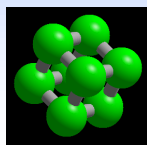
### Crystal Lattices— Packing of Atoms or Ions



Packing of  $C_{60}$  molecules. They are arranged at the lattice points of a FCC lattice.

### Number of Atoms per Unit Cell

Unit Cell Type	Net Number Atoms
SC	1
BCC	2
FCC	4



### Simple Ionic Compounds

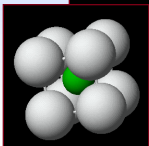
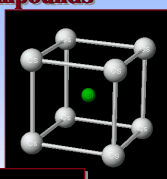
Lattices of many simple ionic solids are built by taking a SC or FCC lattice of ions of one type and placing ions of opposite charge in the holes in the lattice.

**EXAMPLE:** CsCl has a SC lattice of  $Cs^+$  ions with  $Cl^-$  in the center.

### Simple Ionic Compounds

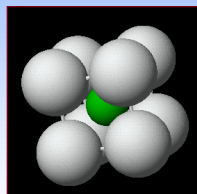
CsCl has a SC lattice of  $Cs^+$  ions with  $Cl^-$  in the center.

1 unit cell has 1  $Cl^-$  ion plus  
(8 corners)( $1/8$   $Cs^+$  per corner)  
= 1 net  $Cs^+$  ion.



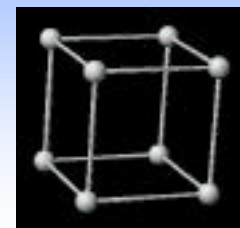
### Simple Ionic Compounds

Salts with formula MX can have SC structure — but not salts with formula  $MX_2$  or  $M_2X$



### Construction of NaCl

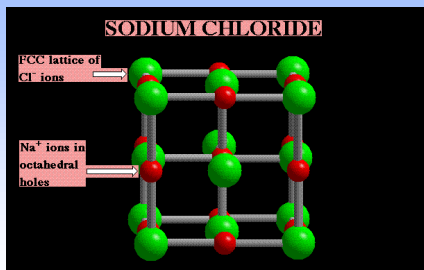
We begin with a cube of  $Cl^-$  ions. Add more  $Cl^-$  ions in the cube faces, and then add  $Na^+$  ion in the octahedral holes.



### The Sodium Chloride Lattice



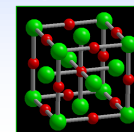
Na<sup>+</sup> ions are in **OCTAHEDRAL** holes in a face-centered cubic lattice of Cl<sup>-</sup> ions.



### The Sodium Chloride Lattice

Many common salts have FCC arrangements of anions with cations in **OCTAHEDRAL HOLES** — e.g., salts such as CA = NaCl

- FCC lattice of anions ----> 4 A<sup>-</sup>/unit cell
- C<sup>+</sup> in octahedral holes ----> 1 C<sup>+</sup> at center + [12 edges • 1/4 C<sup>+</sup> per edge] = 4 C<sup>+</sup> per unit cell

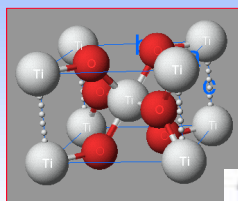


### Comparing NaCl and CsCl



- Even though their formulas have one cation and one anion, the lattices of CsCl and NaCl are different.
- The different lattices arise from the fact that a Cs<sup>+</sup> ion is much larger than a Na<sup>+</sup> ion.

### Common Ionic Solids

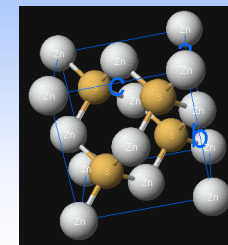


Titanium dioxide, TiO<sub>2</sub>

There are 2 net Ti<sup>4+</sup> ions and 4 net O<sup>2-</sup> ions per unit cell.

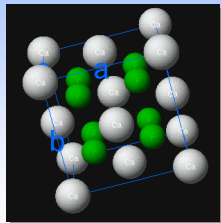


### Common Ionic Solids



- Zinc sulfide, ZnS
- The S<sup>2-</sup> ions are in **TETRAHEDRAL** holes in the Zn<sup>2+</sup> FCC lattice.
- This gives 4 net Zn<sup>2+</sup> ions and 4 net S<sup>2-</sup> ions.

## Common Ionic Solids



- Fluorite or  $\text{CaF}_2$
- FCC lattice of  $\text{Ca}^{2+}$  ions
- This gives 4 net  $\text{Ca}^{2+}$  ions.
- $\text{F}^-$  ions in all 8 tetrahedral holes.
- This gives 8 net  $\text{F}^-$  ions.