Sections 13.1 – 13.2
Types of Solids
Metallic Solids

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Types of Solids and Metallic Solids

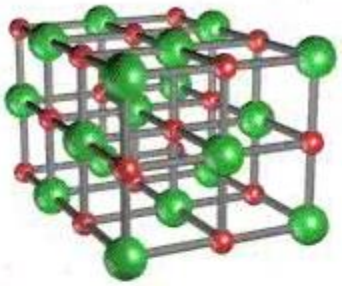
In these sections…

a. Types of Solids
b. Unit Cells
c. Cubic Unit Cells
d. X-Ray Diffraction

Types of Solids:

Ionic
Molecular
Network:
  crystalline
  amorphous
Metallic

Ionic Solid



NaCl

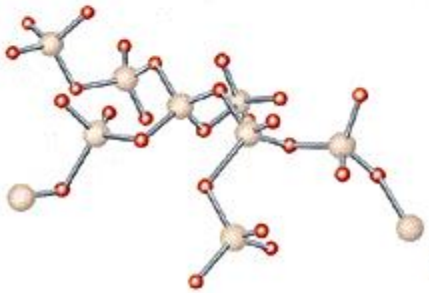
Molecular Solids: mp = 0 °C

H_2O

Extended (network) solids:
Crystalline and Amorphous

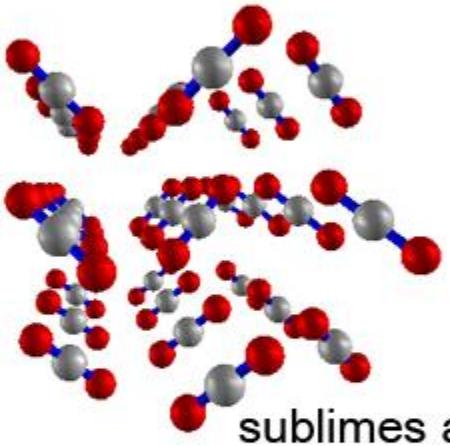
α-quartz (SiO_2), a crystalline solid

Quartz



Vitreous silica (SiO_2), an amorphous solid

Obsidian



CO_2

sublimes at -78 °C

Metallic
Close-packed

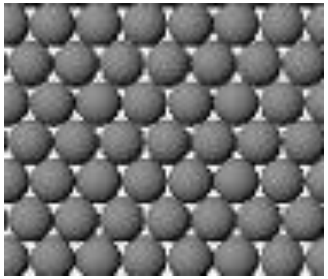
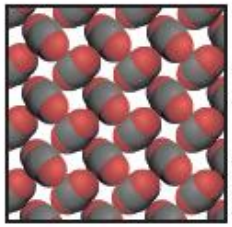
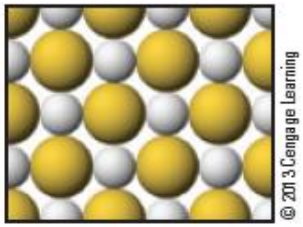
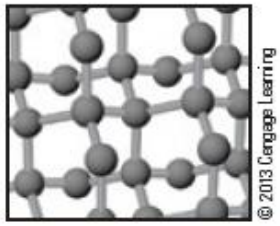
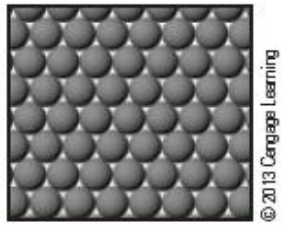
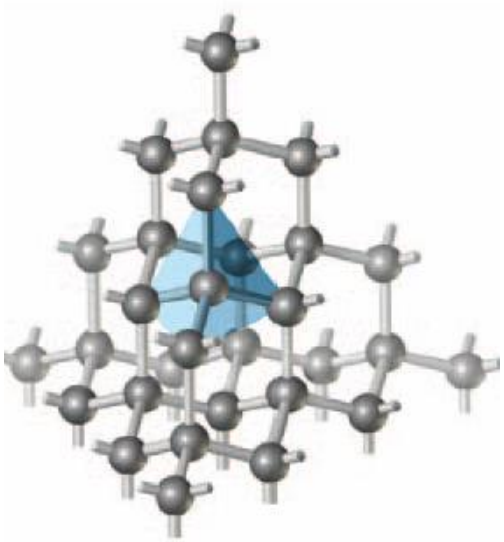


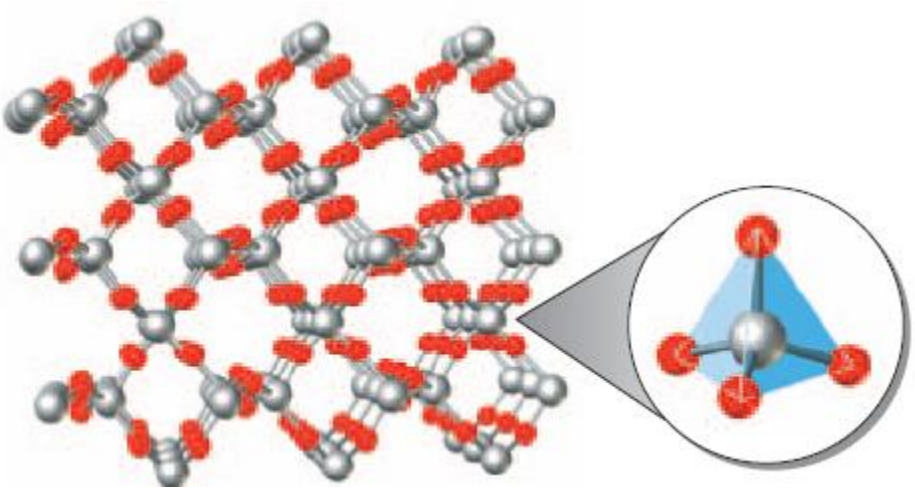
Table 12.1.1 Crystalline Solids

	Molecular	Ionic	Covalent	Metallic
Constituent particles	Molecules	Ions	Covalent network	Metal atoms
Melting point	Moderate to low	High to very high	Very high	Variable
Hardness	Soft to brittle	Hard and brittle	Very hard	Variable, malleable
Conductivity	Nonconducting	Nonconducting solid, conducting liquid	Usually nonconducting	Conducting
Attractive forces	Dipole–dipole, hydrogen bonds, London dispersion forces	Ion–ion	Covalent bonds	Metallic bonds
Schematic diagram				
Examples	Carbon dioxide (CO_2), m.p. −78 °C (sublimes) Sucrose ($C_{12}H_{22}O_{11}$), m.p. 186 °C (decomposes) Water (H_2O), m.p. 100 °C	NaCl, m.p. 801 °C K_2SO_4, m.p. 1689 °C MgO, m.p. 2852 °C	Diamond (C), m.p. 3550 °C SiO_2, m.p. 1650 °C	Na, m.p. 98 °C W, m.p. 3422 °C

More Network Solids



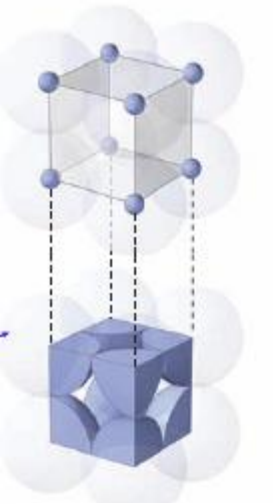
diamond



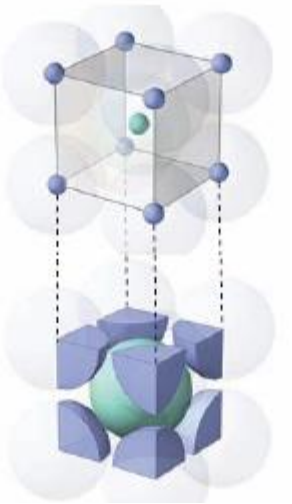
Quartz: SiO_2

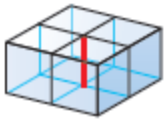
Unit Cell Types:

Primitive cubic

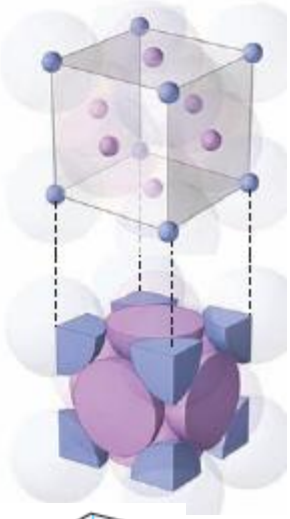


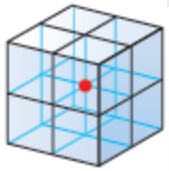
Body-centered cubic



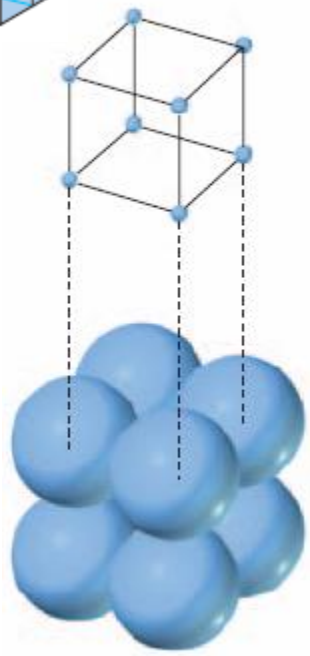


Face-centered cubic

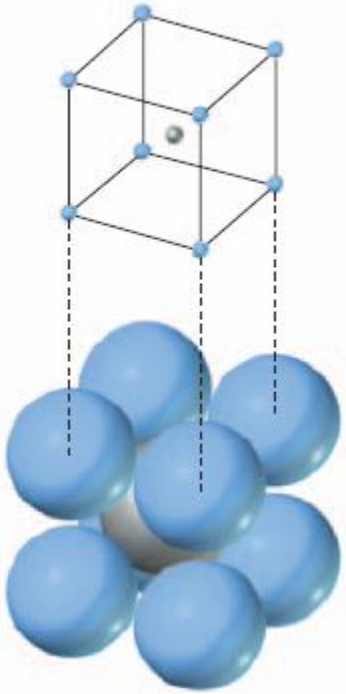




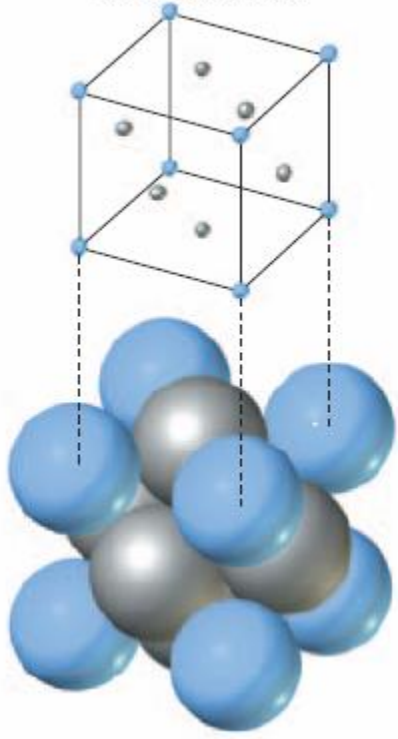
Simple cubic

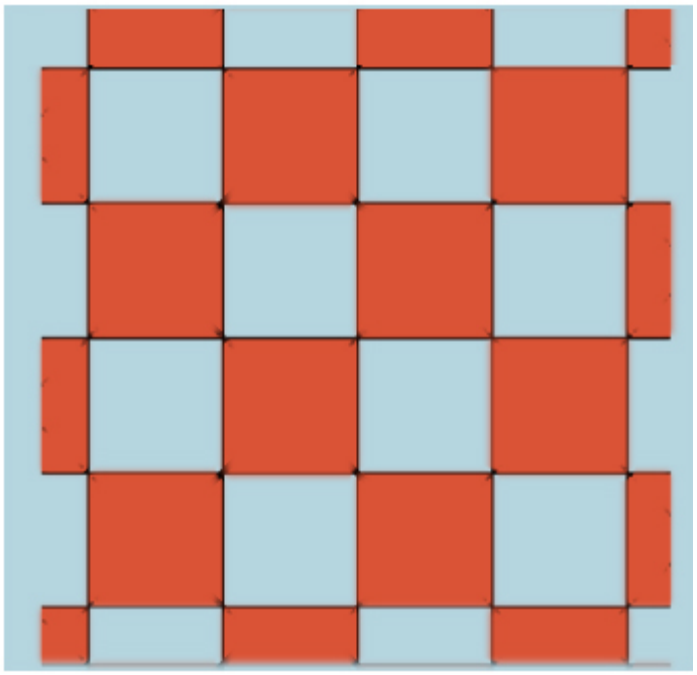


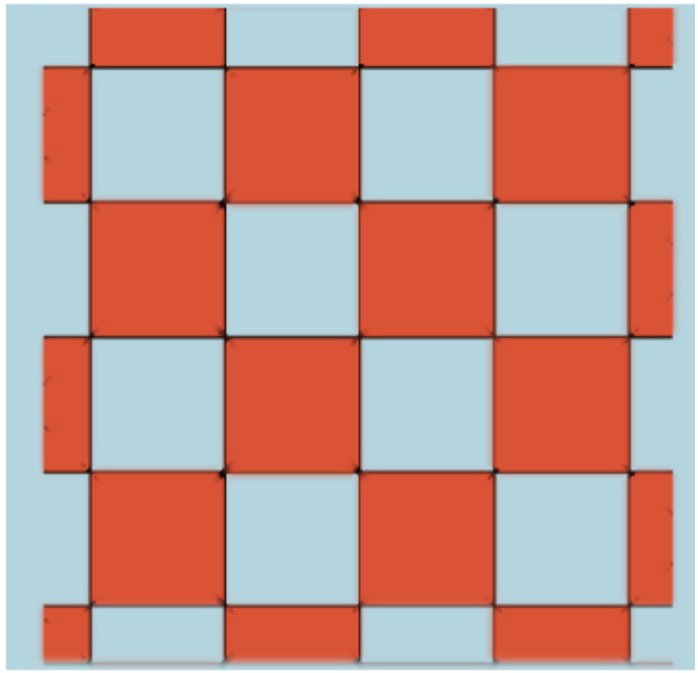
Body-centered cubic

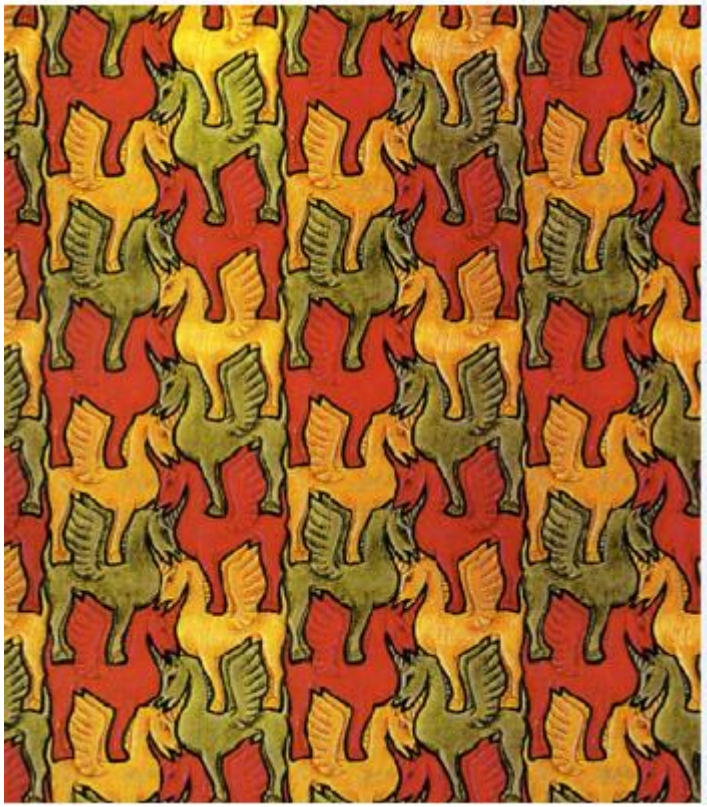


Face-centered cubic

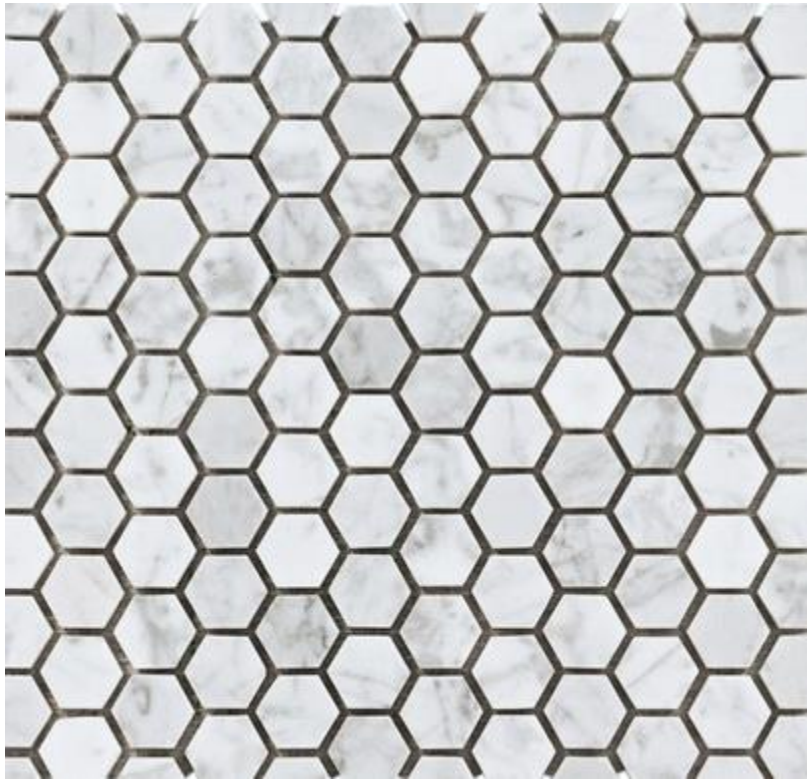




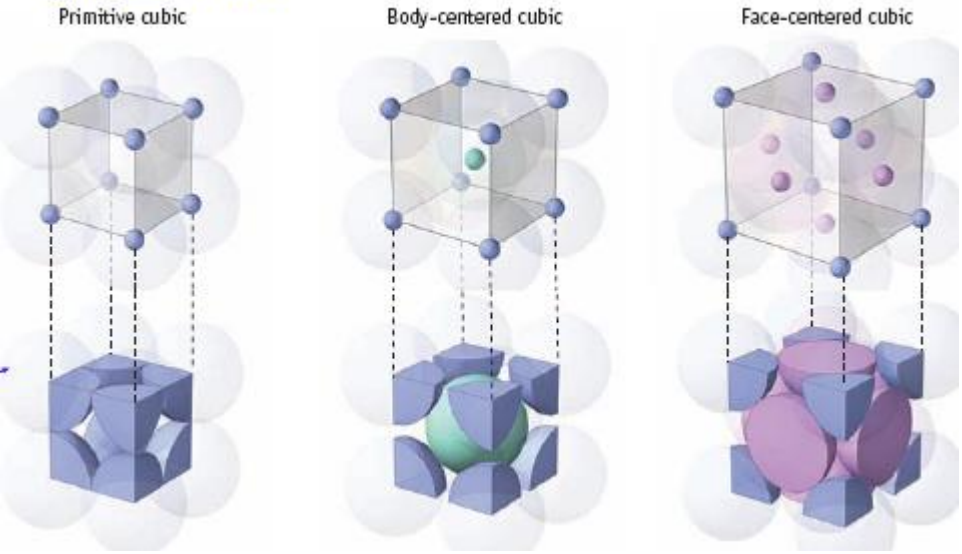




Find a unit cell:



Unit Cell Types:



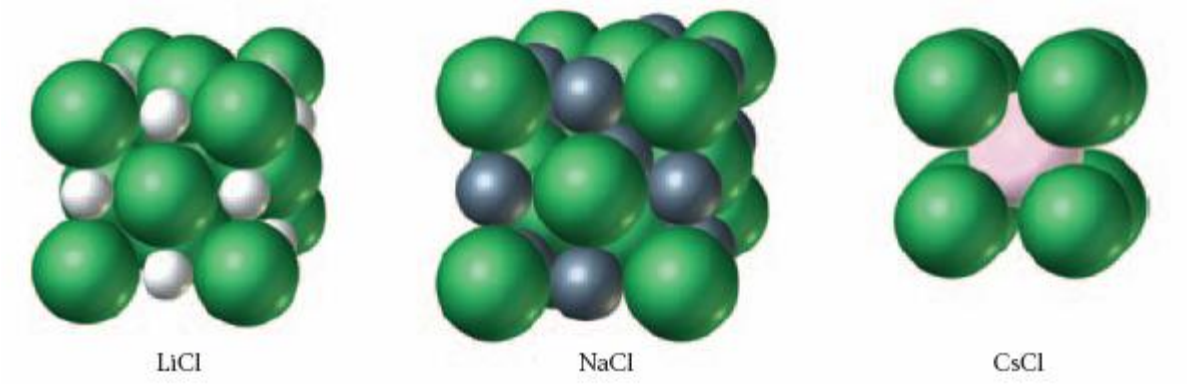
Counting Atoms in Unit Cells:

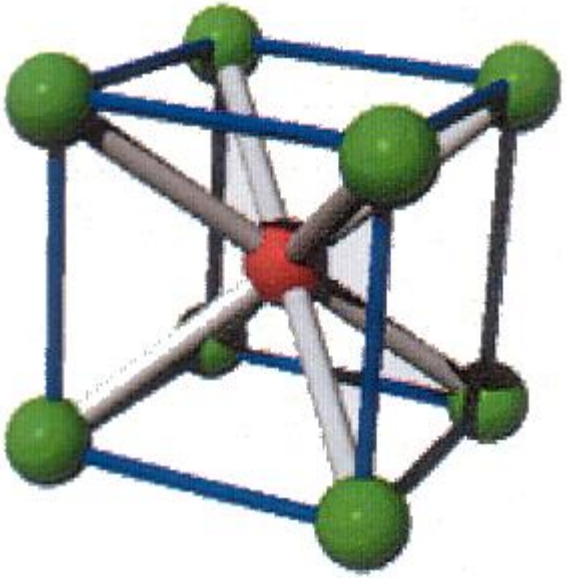
Inside: 1

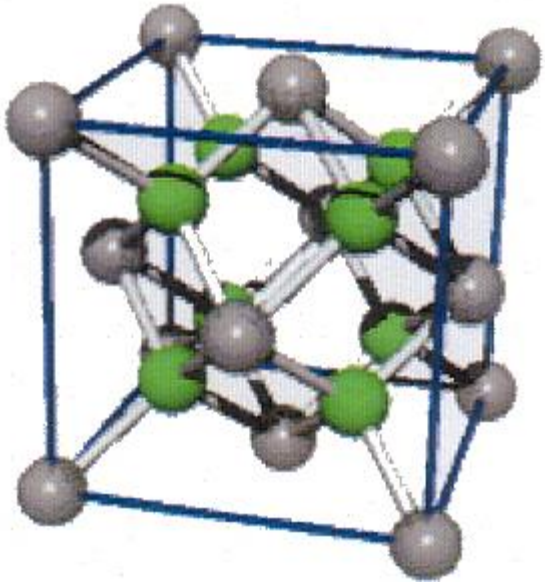
Face: ½

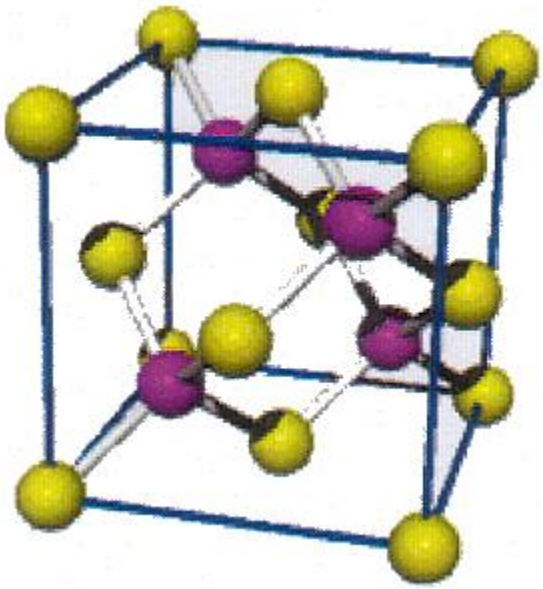
Edge: ¼

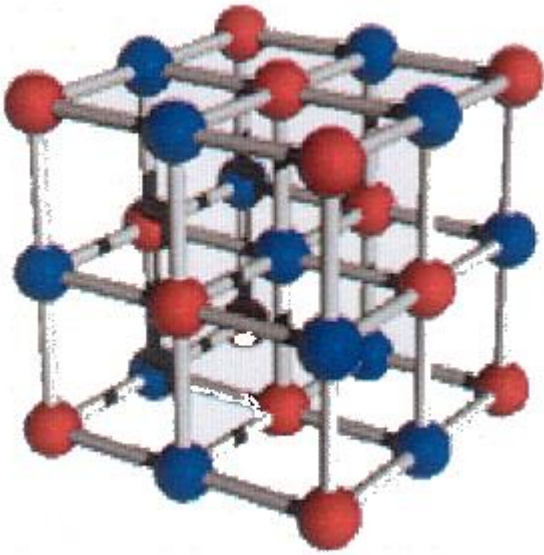
Corner: 1/8

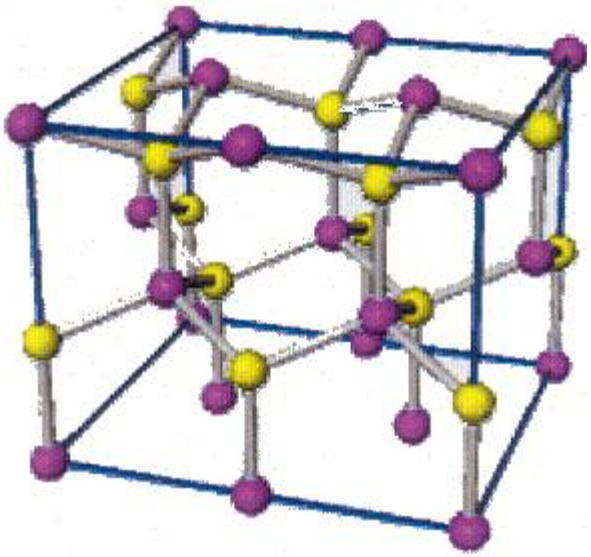






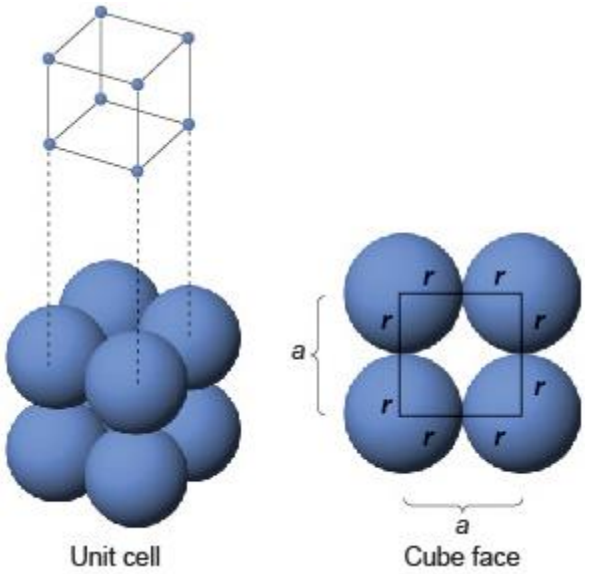






Unit Cells, Dimensions and Measurements:

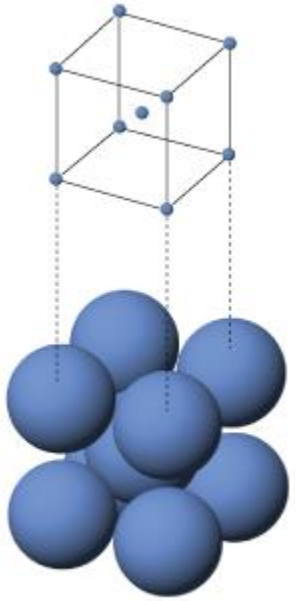
What percentage of a simple cubic unit cell is filled with atoms?

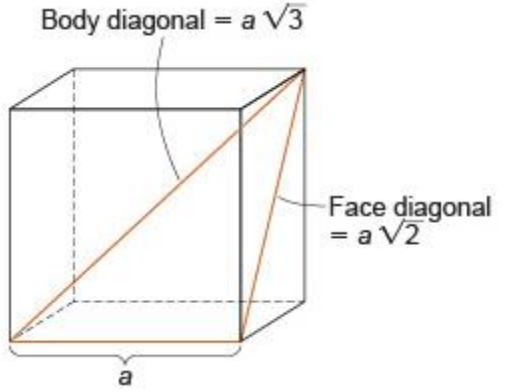


Unit Cells, Dimensions and Measurements:

U metal:
Body centered cubic unit cell
Unit cell edge = 343 pm

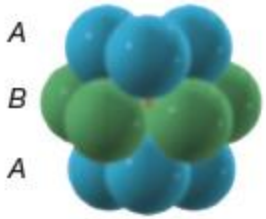
What is the radius of a U atom?





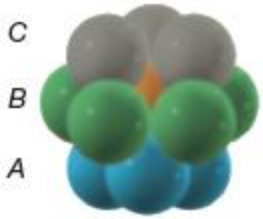
Face Centered Cubic Unit Cell =
Cubic Closest Packed Structure

(a)



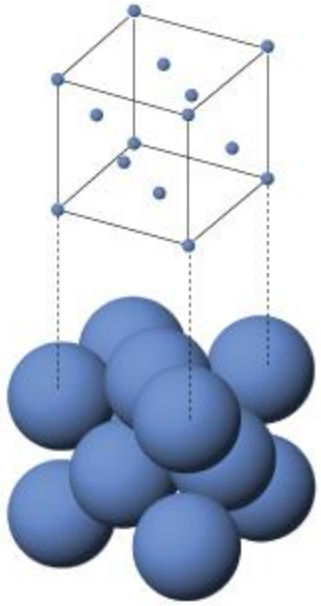
Hexagonal close-packed crystal structure

(b)

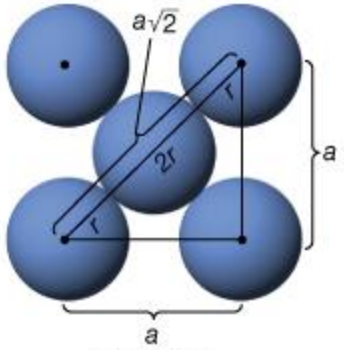


Cubic close-packed (face-centered) crystal structure

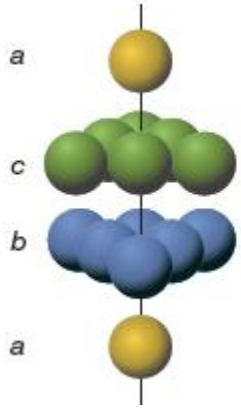
(c)

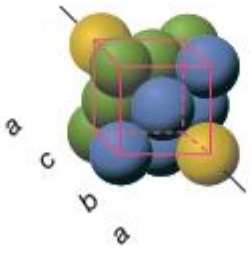


Unit cell



Cube face



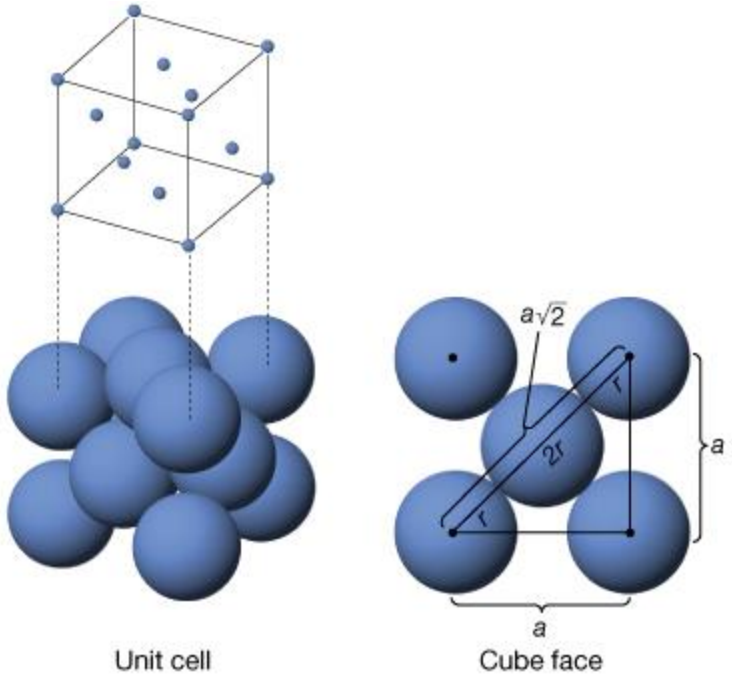


Unit cell

Unit Cells, Dimensions and Measurements:

Ca metal:
Face centered cubic unit cell
Density = 1.54 g/cm^3

What is the radius of a Ca atom?



Unit cell

Cube face

What fraction of a simple cubic unit cell is filled with atoms?

What fraction of a face-centered cubic unit cell is filled with atoms?

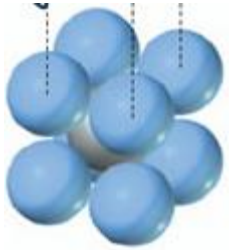


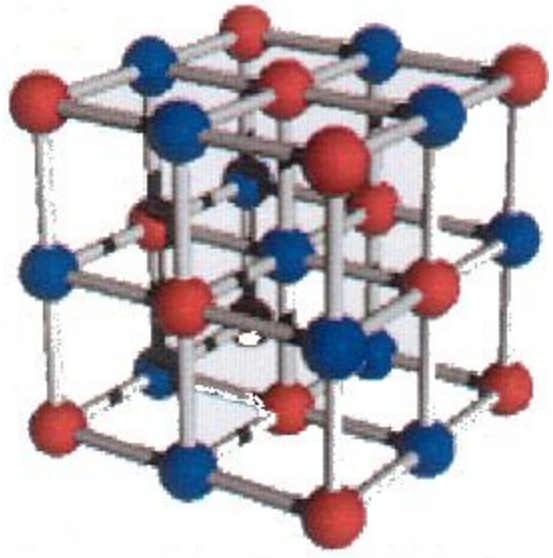
Table 12.2.1: Summary of Cubic Unit Cells

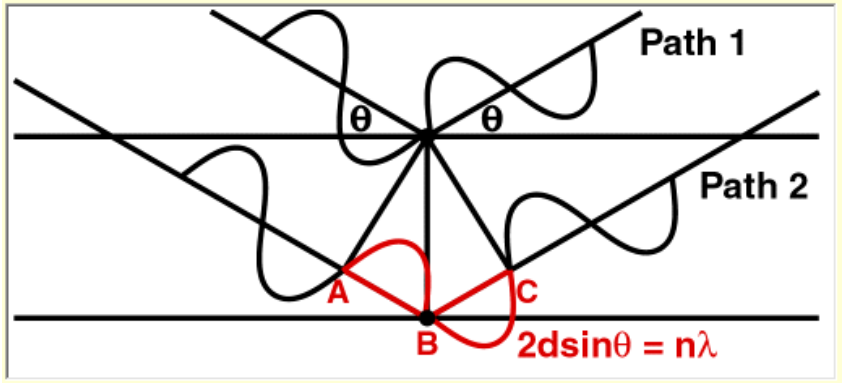
Lattice	Atoms per Unit Cell	Edge Length–Atomic Radius Relationship	Coordination Number	% Occupied Space
Simple cubic	1	$a = 2r$	6	52.4
Body-centered cubic	2	$a = \frac{4r}{\sqrt{3}}$	8	68.0
Face-centered cubic	4	$a = \frac{4r}{\sqrt{2}}$	12	74.0

X-Ray Diffraction: Determining the distance between planes of atoms

X-rays and atoms
Orders of diffraction
Bragg's Law

$$2d\sin\theta = n\lambda$$





Using X-Ray Diffraction: Bragg's Law

Silver metal crystallizes in an FCC lattice. Monochromatic x-radiation from a copper target has a wavelength of 154 pm. If this radiation is used in a diffraction experiment with a silver crystal, a second-order diffracted beam is observed at a theta value of 22.18°. If the spacing between these planes corresponds to the unit cell length ($d = a$), what is the d-spacing between the planes that gave rise to this reflection?
What is the metallic radius of a silver atom?

$$2d\sin\theta = n\lambda$$