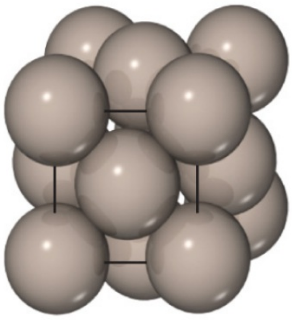
Lesson Overview
Structures of Solids

Objective: The student will be able to prove Avogadro's number through analysis of crystal cubic structures.

Characteristics of the Major Types of Crystalline Solids

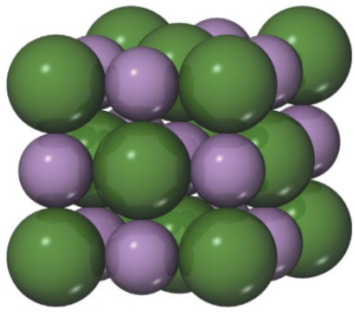
	Particles	Interparticle Forces	Physical Behavior	Examples (mp, ^0C)
Atomic	Atoms	Dispersion	Soft, very low mp, poor thermal & electrical conductors	Group 8A(18) [Ne-249 to Rn-71]
Molecular	Molecules	Dispersion, dipole-dipole, H bonds	Fairly soft, low to moderate mp, poor thermal & electrical conductors	***Nonpolar*** **-** O_2[-219], C_4H_{10}[-138], Cl_2 [-101], C_6H_{14}[-95] ***Polar*** - SO_2[-73], $CHCl_3$[-64], HNO_3[-42], H_2O[0.0]
Ionic	Positive & negative ions	Ion-ion attraction	Hard & brittle, high mp, good thermal & electrical conductors when molten	NaCl [801] CaF_2 [1423] MgO [2852]
Metallic	Atoms	Metallic bond	Soft to hard, low to very high mp, excellent thermal and electrical conductors, malleable and ductile	Na [97.8] Zn [420] Fe [1535]
Network	Atoms	Covalent bond	Very hard, very high mp, usually poor thermal and electrical conductors	

In what category does glass fall?



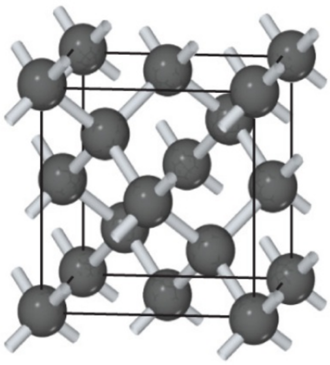
Metallic solids

Extended networks of atoms held together by metallic bonding (Cu, Fe)



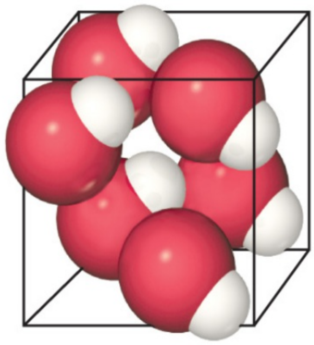
Ionic solids

Extended networks of ions held together by ion–ion interactions (NaCl, MgO)



Covalent-network solids

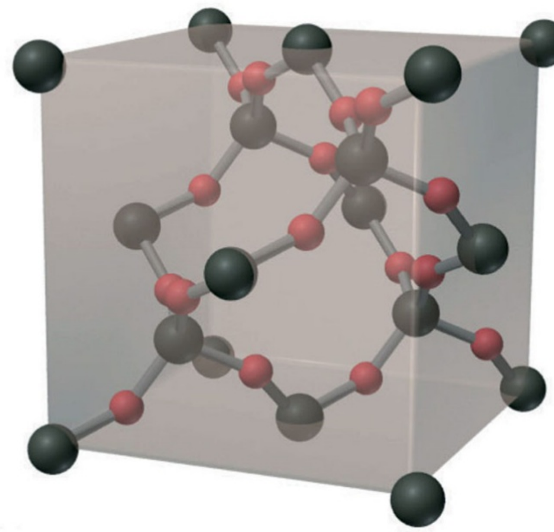
Extended networks of atoms held together by covalent bonds (C, Si)



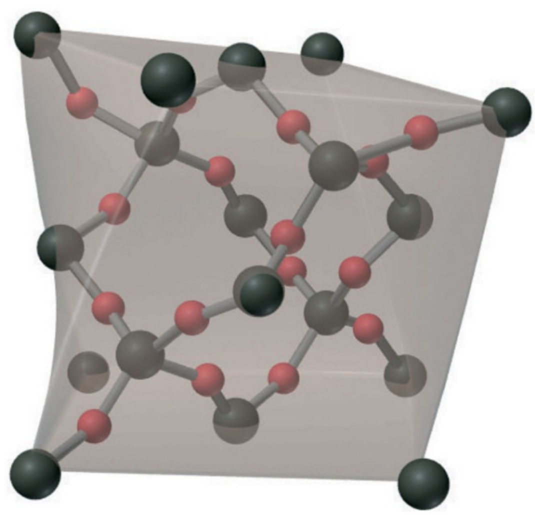
Molecular solids

Discrete molecules held together by intermolecular forces (HBr, H_2O)

Unique Solid Structures

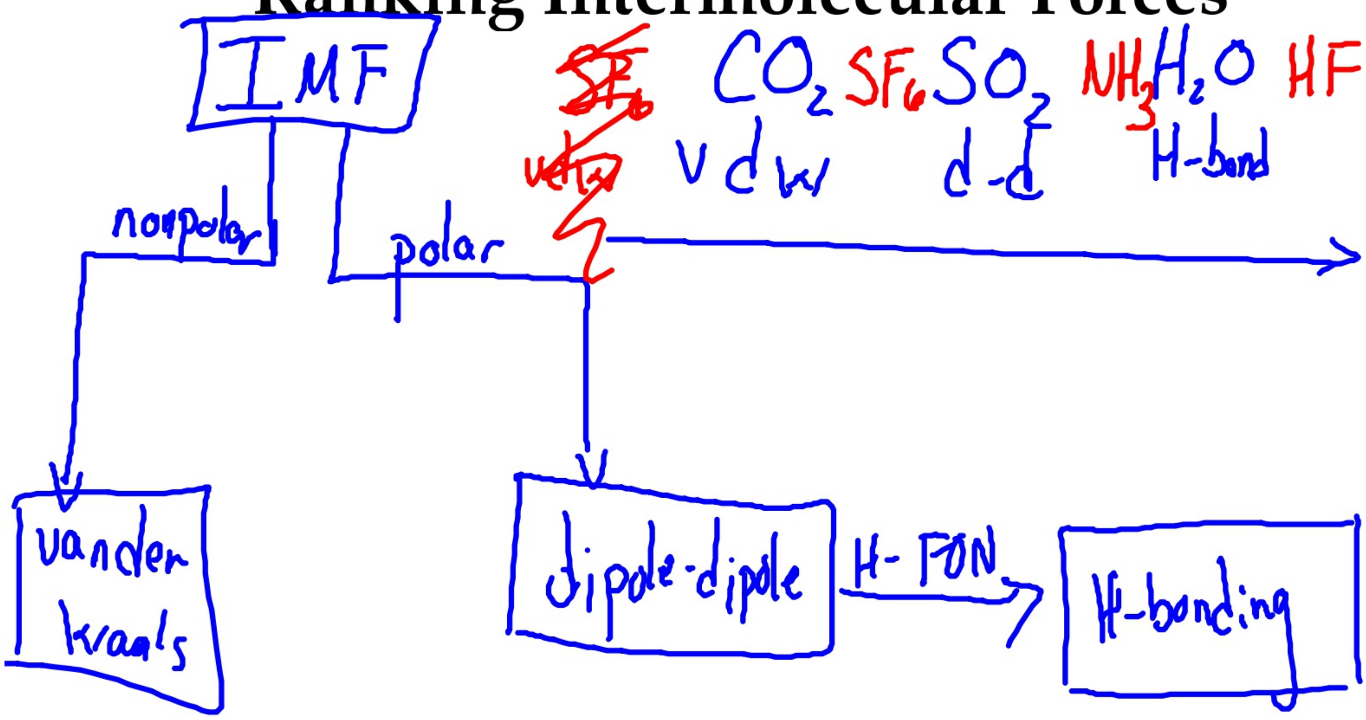


crystalline SiO_2



amorphous SiO_2
(glass)

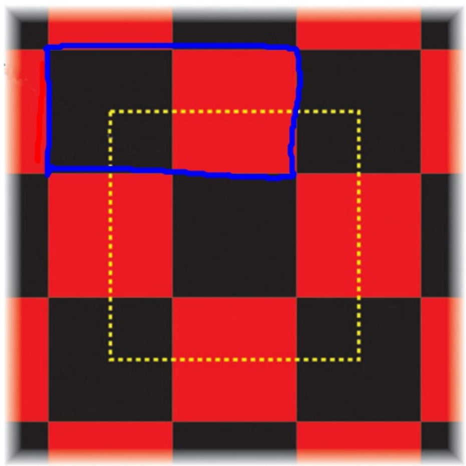
Ranking Intermolecular Forces



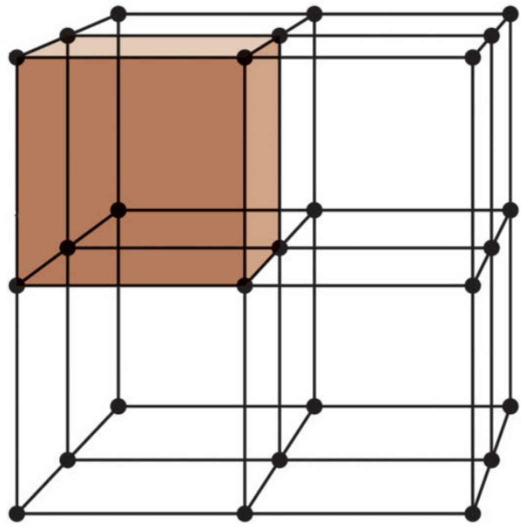
draw simplified IMF flowchart

Crystal Lattice

unit cell: the smallest portion that gives the crystal structure if it is repeated in all directions



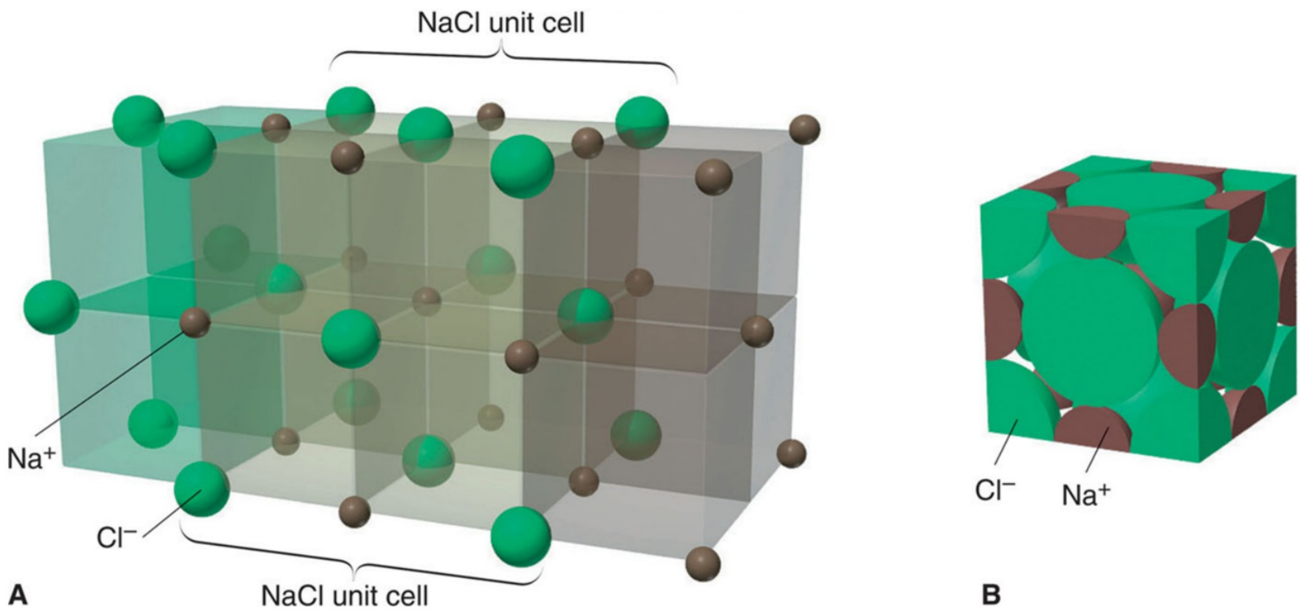
portion of a 2-D lattice



portion of a 3-D lattice

coordination number: the number of nearest neighbors to a particle

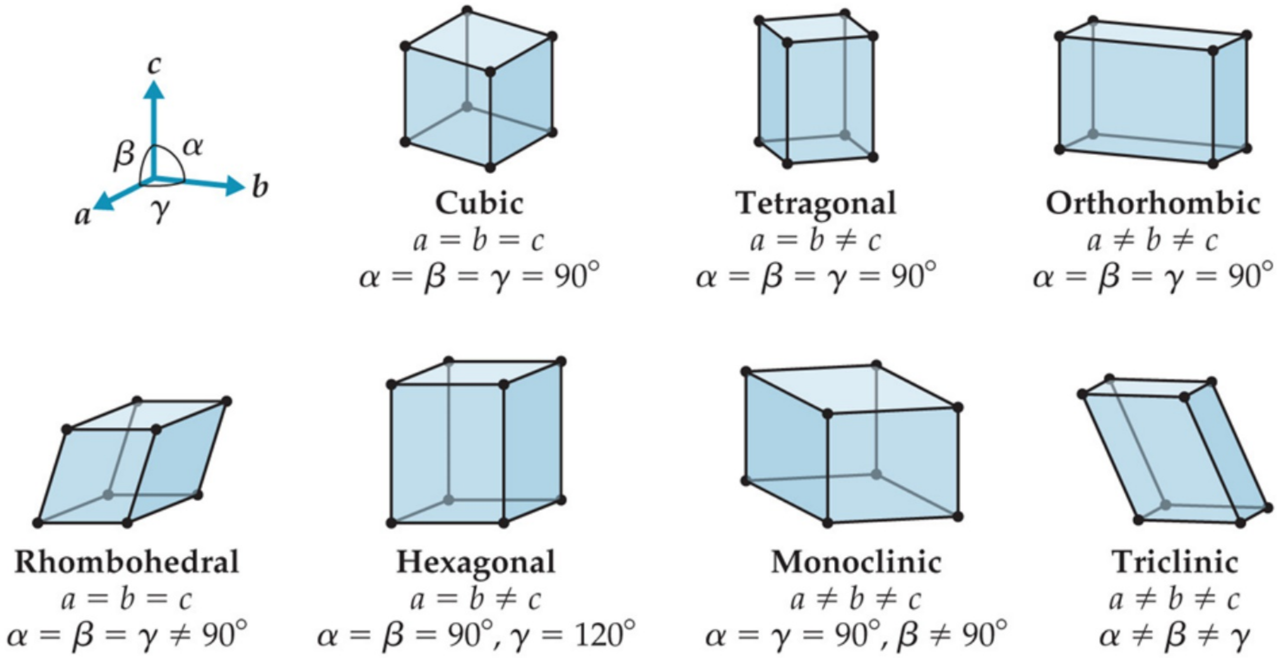
Structure of sodium chloride



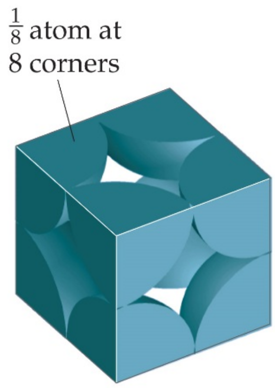
expanded view

space-filling

Types of Unit Cells



Types of Cubic Unit Cells

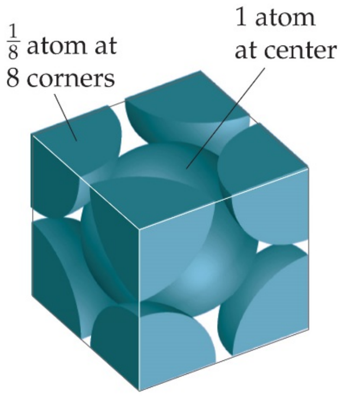


(a) Primitive cubic metal
1 atom per unit cell

CN = 6

$$A = 2r$$

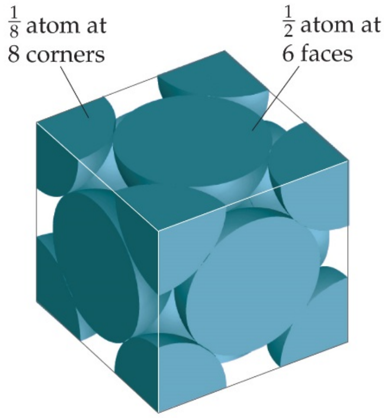
A = edge length



(b) Body-centered cubic metal
2 atoms per unit cell

CN = 8

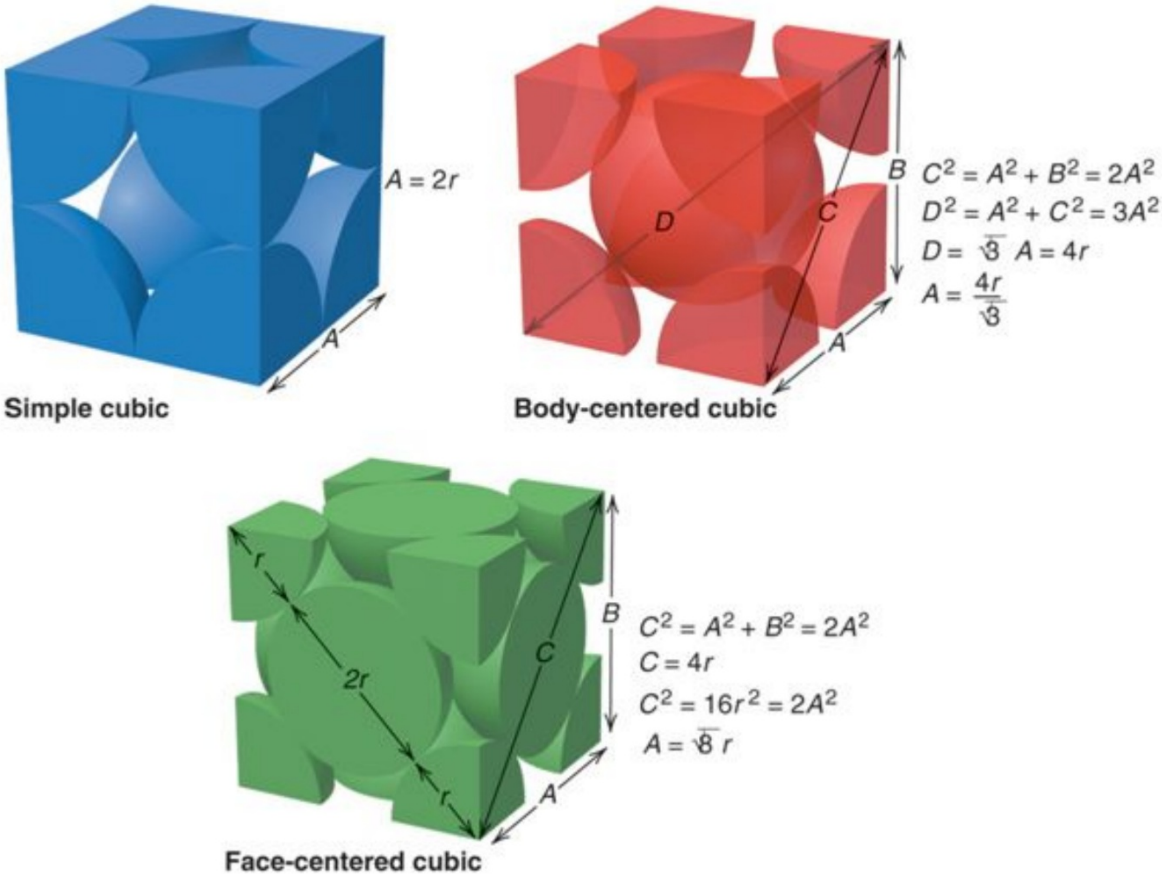
$$A = \frac{4r}{\sqrt{3}}$$



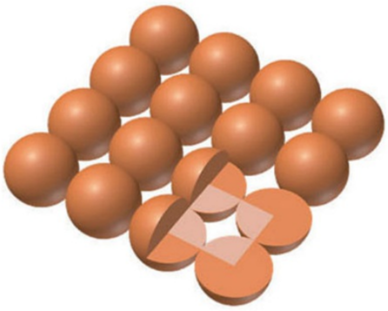
(c) Face-centered cubic metal
4 atoms per unit cell

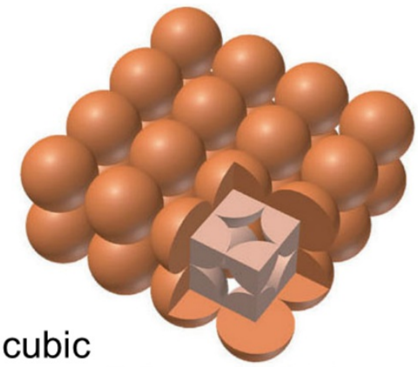
CN = 12

$$A = \sqrt{8} * r$$


A = 2r
A
Simple cubic
B
C
D
C² = A² + B² = 2A²
D² = A² + C² = 3A²
D = √3 A = 4r
A = 4r/√3
A
Body-centered cubic
r
2r
r
B
C
C² = A² + B² = 2A²
C = 4r
C² = 16r² = 2A²
A = √8 r
A
Face-centered cubic

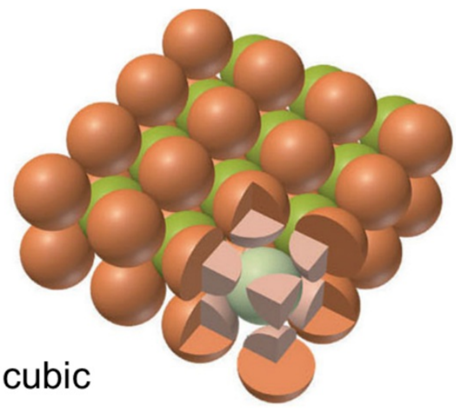
Closest Packing





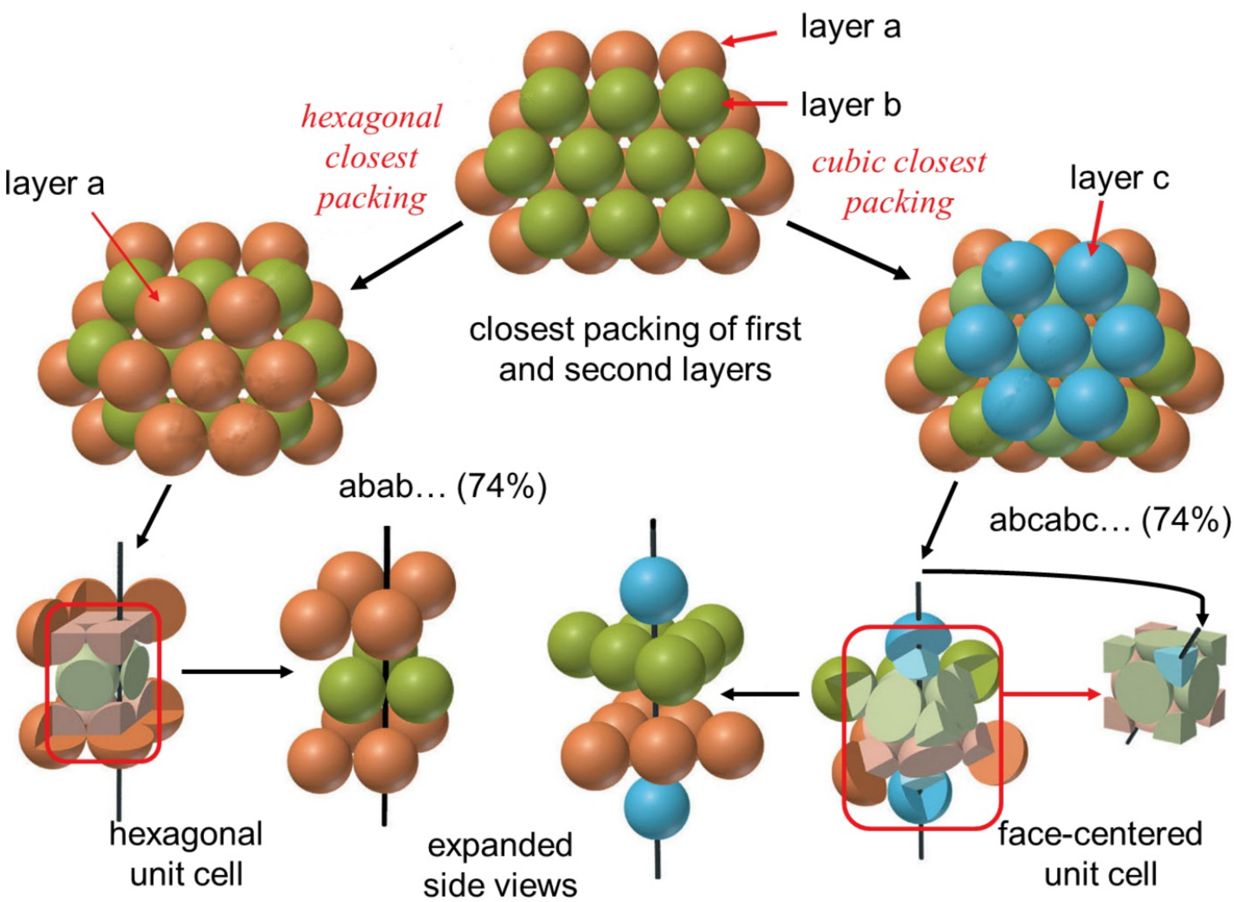
simple cubic

(52% packing efficiency)



body-centered cubic

(68% packing efficiency)



layer a
layer b
hexagonal closest packing
cubic closest packing
layer a
layer c
closest packing of first and second layers
abab… (74%)
abcabc… (74%)
hexagonal unit cell
expanded side views
face-centered unit cell

Sample Problem

What is the calculated density of a theoretical element M if its solid form exhibits FCC, its MW = 221.5 g/mole, and its atomic radius is 2.010 Angstroms?