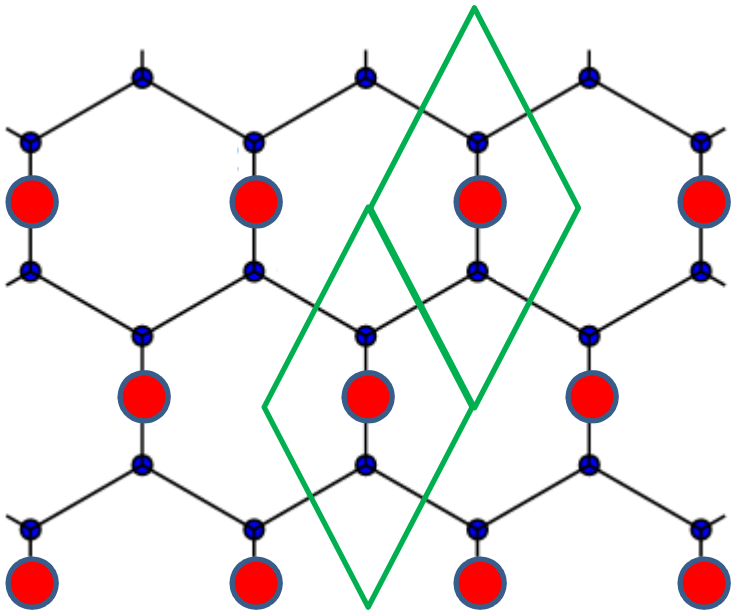
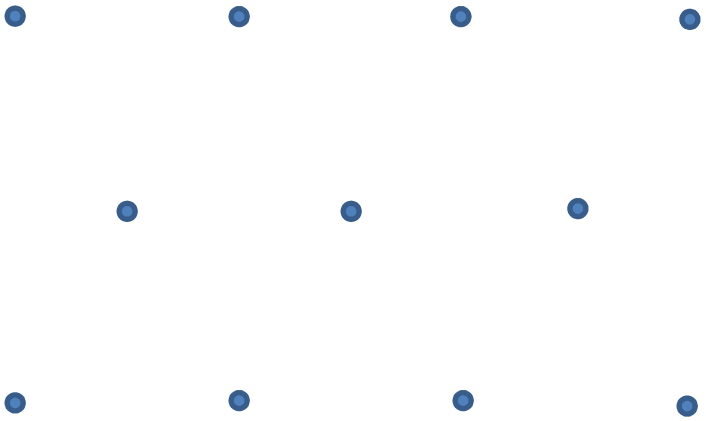
Slides
Condensed Matter Physics
Lecture 10

Unit cell
of the
honeycomb





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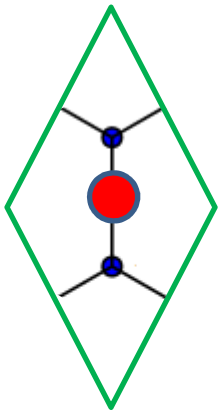
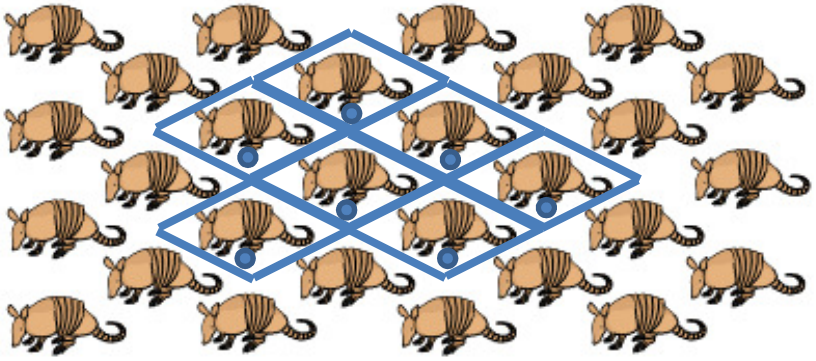


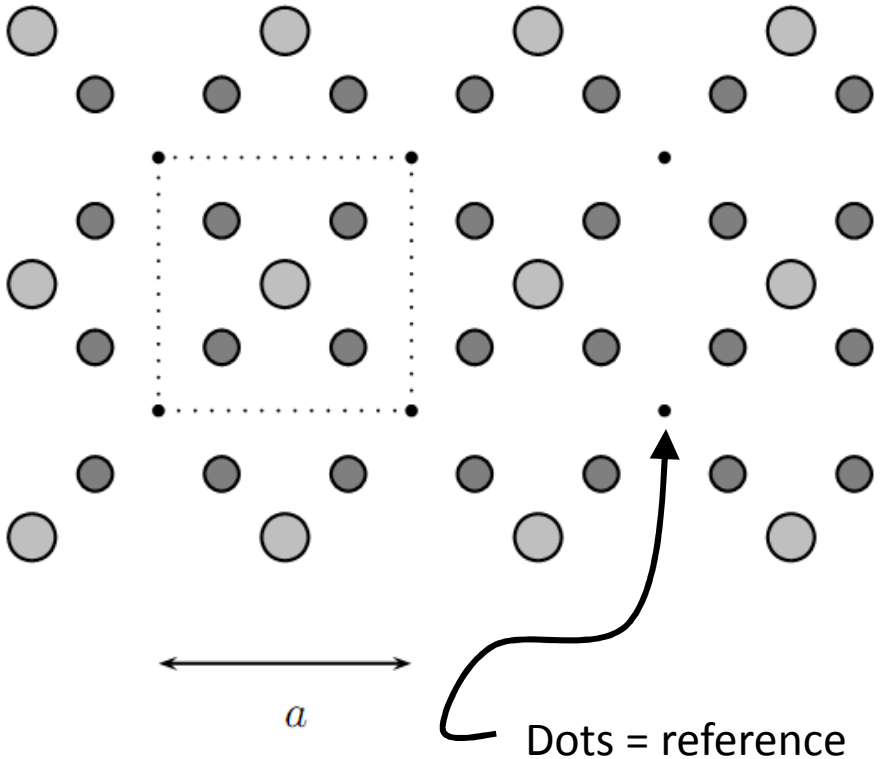
Periodic Structure



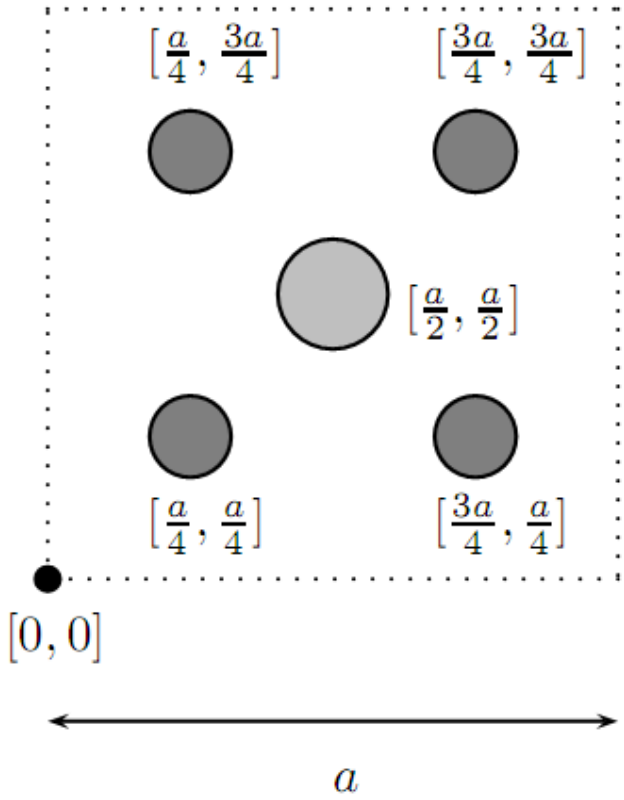
Unit Cell

Basis is a description of the unit cell
With respect to a reference lattice

Crystal



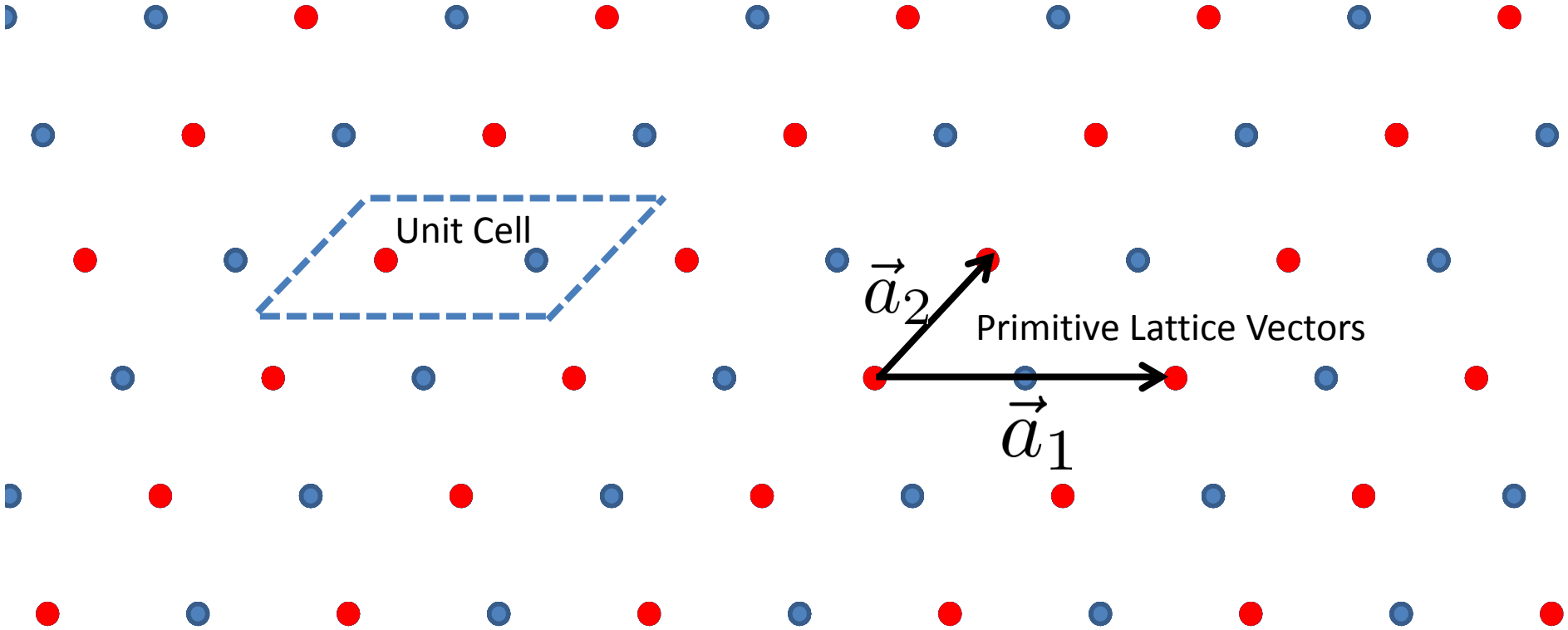
Unit Cell



Basis =

Large Light Gray Atom	Position=	$[a/2, a/2]$
Small Dark Gray Atoms	Position=	$[a/4, a/4]$ $[a/4, 3a/4]$ $[3a/4, a/4]$ $[3a/4, 3a/4]$

Reference Lattice is often taken coincident with some atom

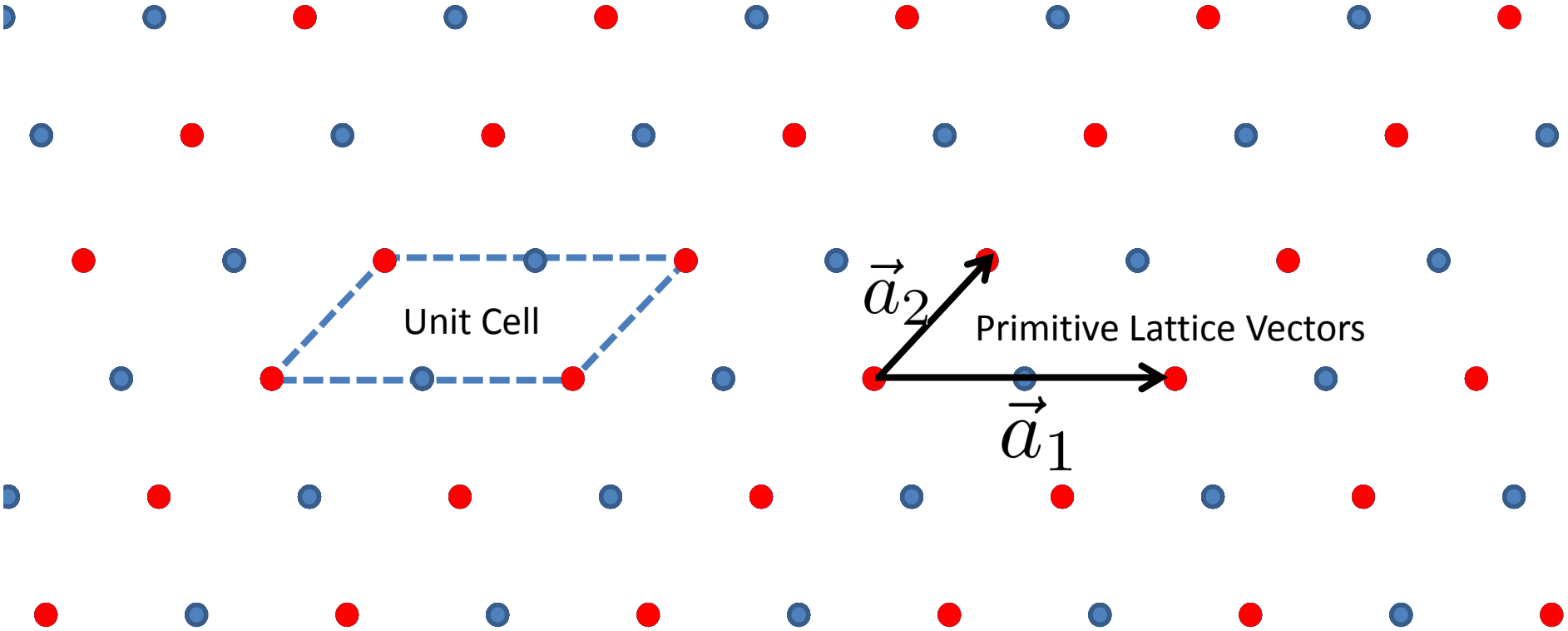


Put Reference Lattice on the Red Atoms:

Basis is: Red atom at [0,0]
Blue atom at [1/2,0]

note [1/2,0] = $(1/2)\vec{a}_1$

Reference Lattice is often taken coincident with some atom

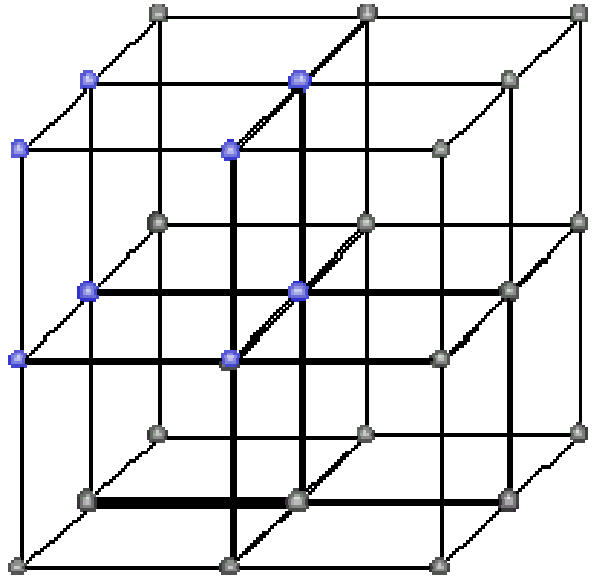


Put Reference Lattice on the Red Atoms:

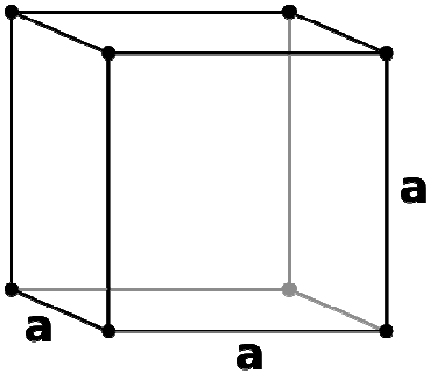
Basis is: Red atom at [0,0]
Blue atom at [1/2,0]

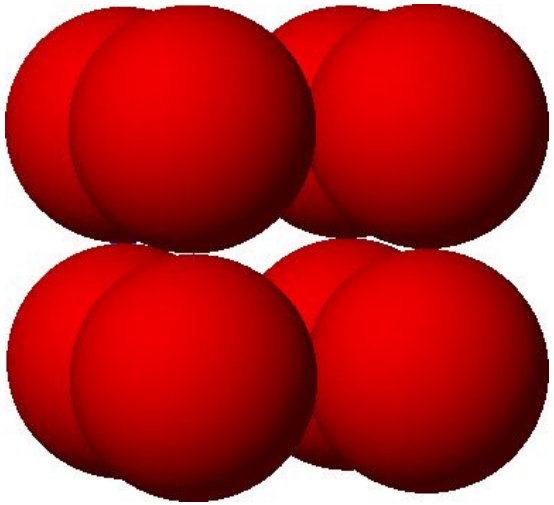
note [1/2,0] = $(1/2)\vec{a}_1$

Simple (Primitive) Cubic Lattice

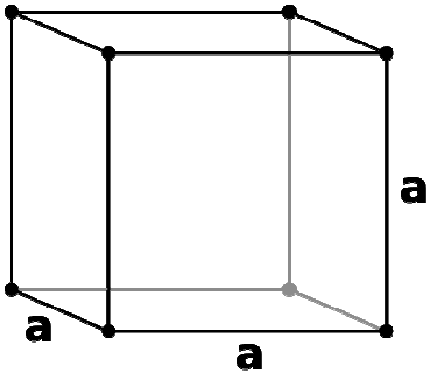


Simple Cubic Unit Cell

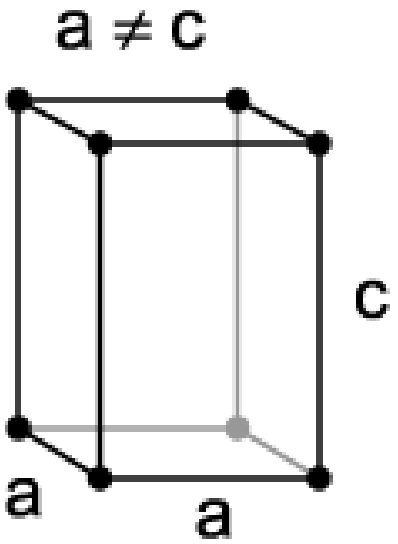




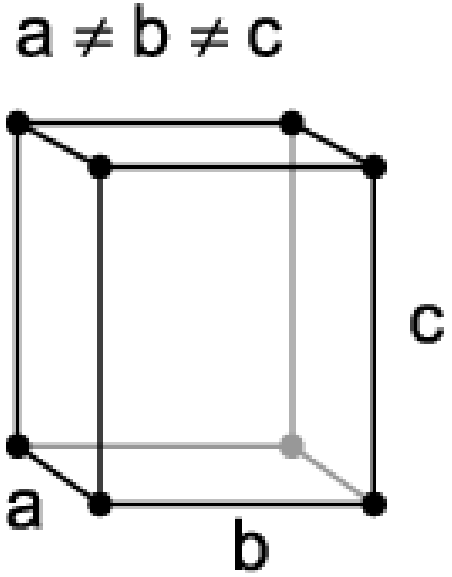
Atoms arranged in Simple Cubic Lattice (very unusual)



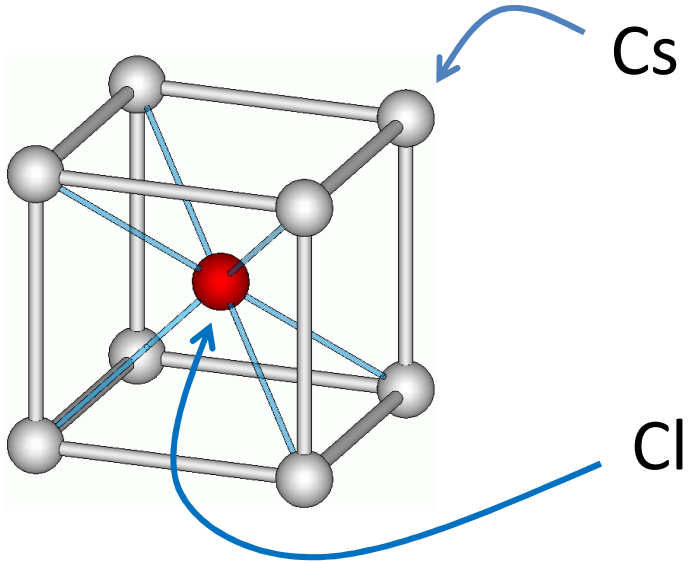
Simple Cubic Unit Cell



Simple Tetragonal Unit Cell



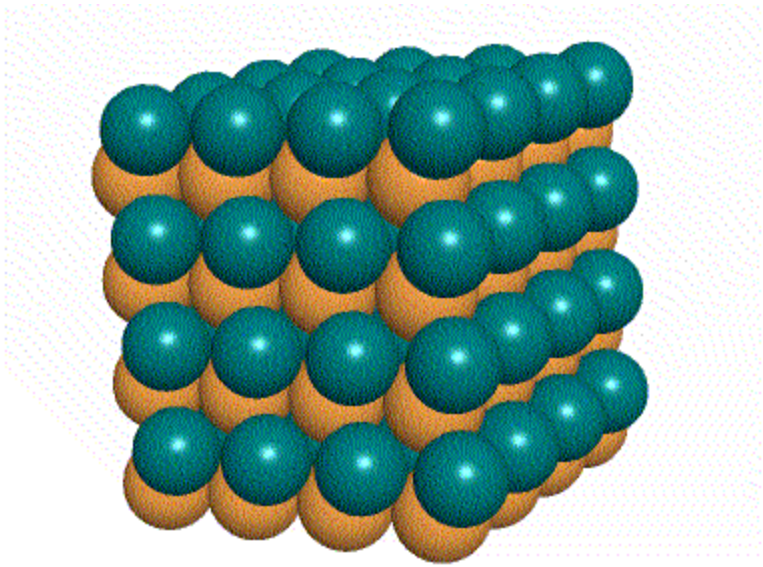
Simple Orthorhombic Unit Cell

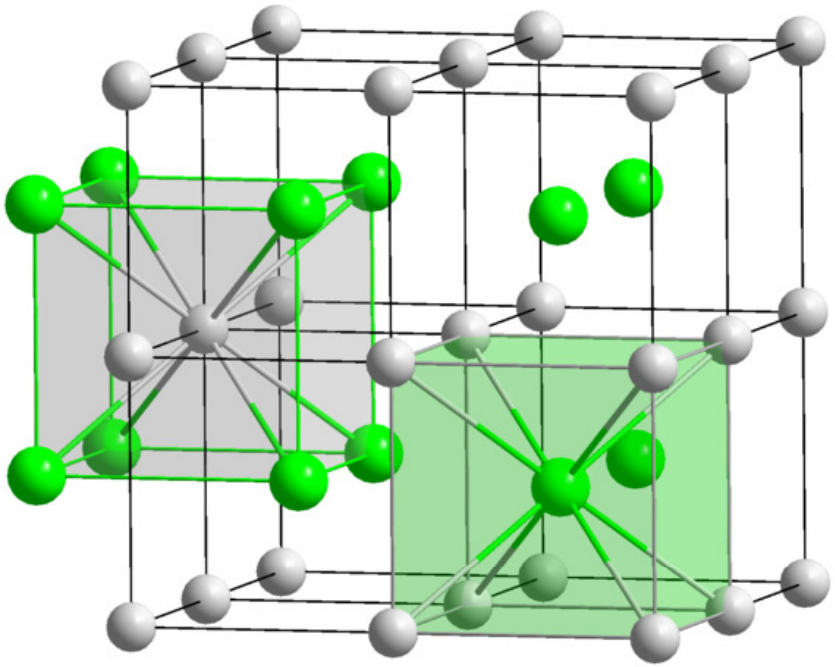


Cesium Chloride (CsCl): A simple cubic Lattice with a Basis

Basis:

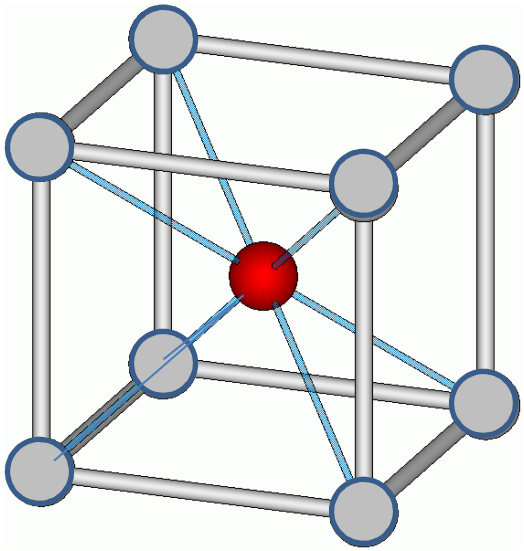
Cs at[0, 0, 0] (i.e., on the simple cubic)
Cl at [½, ½, ½] (i.e., in the middle of each cube)





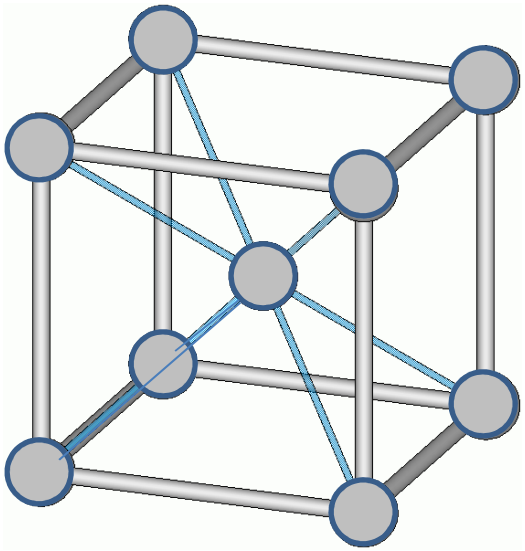
Two depictions of the CsCl lattice structure =

Two interlocking simple cubics



CsCl =Simple Cubic with Basis

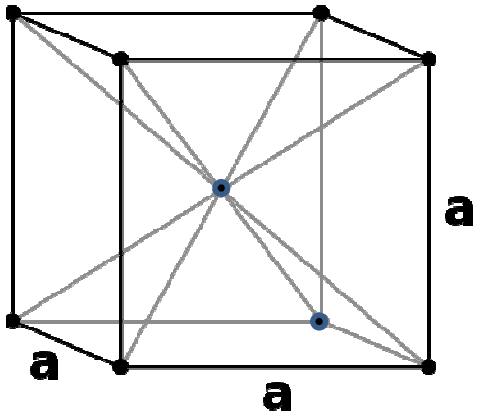
Cs at [0, 0, 0]
Cl at [½, ½, ½]



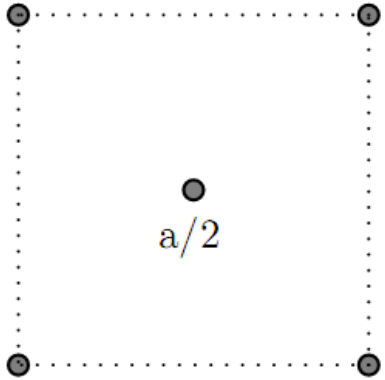
Cs = Simple Cubic with Basis

Cs at [0, 0, 0]
Cs at [½, ½, ½]

Unit cell of Body Centered Cubic Lattice (BCC) (Notated cubic-I)

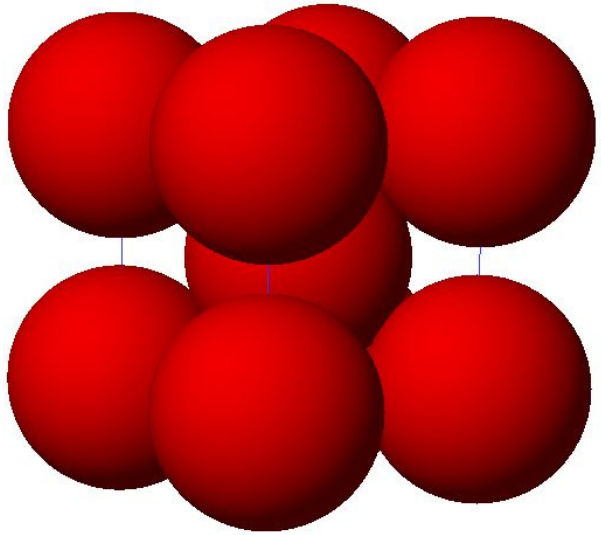


Conventional Unit Cell

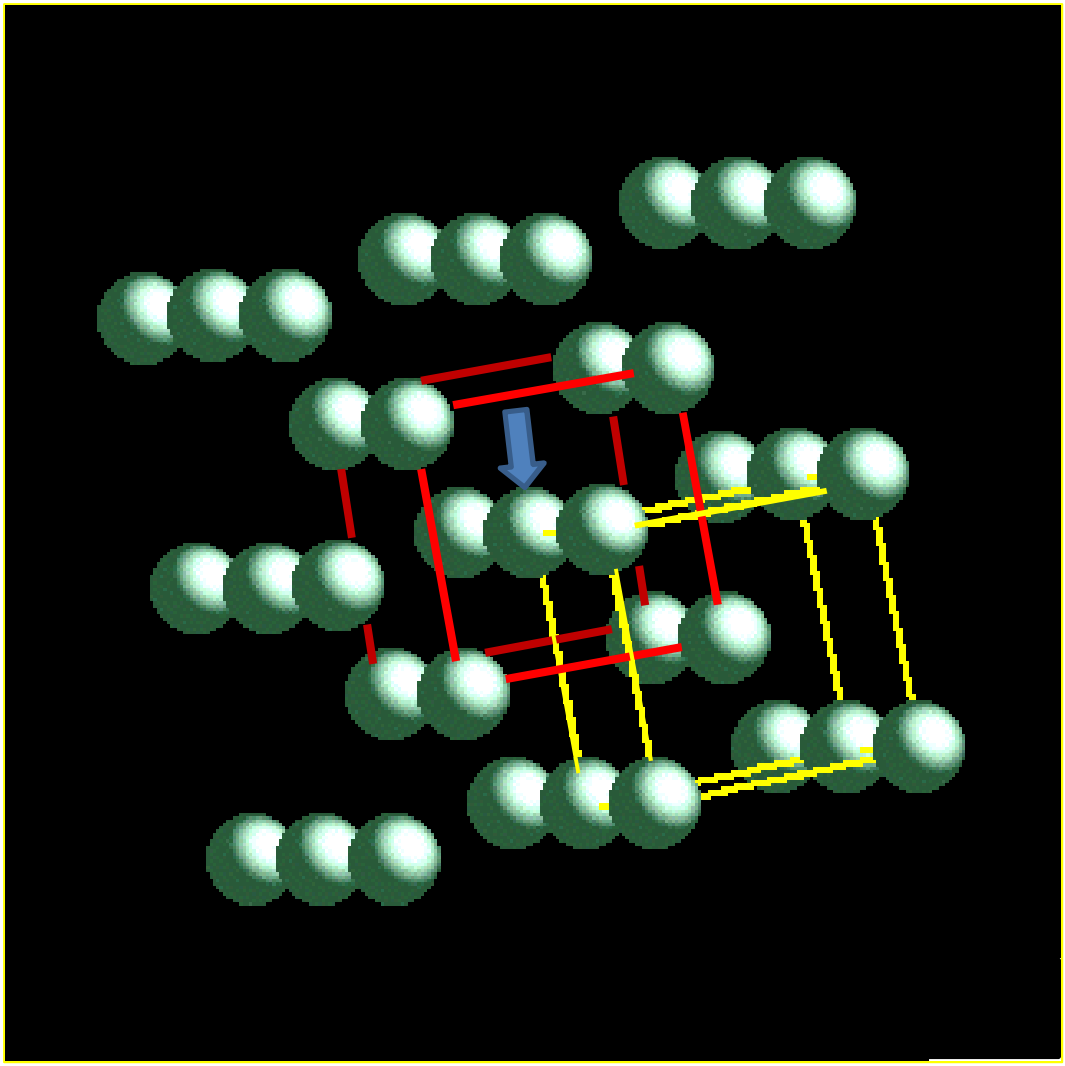


Plan View

(unlabeled points at height 0 and a)

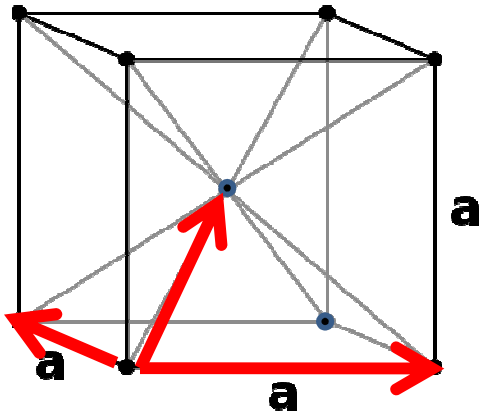


(More efficient sphere packing)

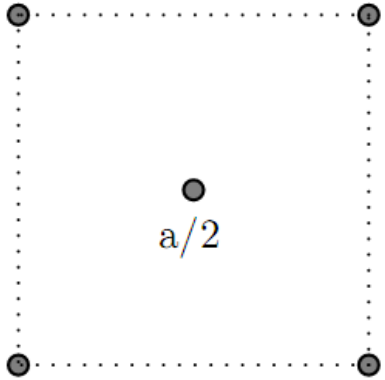


BCC Lattice

Unit cell of Body Centered Cubic Lattice (BCC) (Notated cubic-I)



Conventional Unit Cell



Plan View

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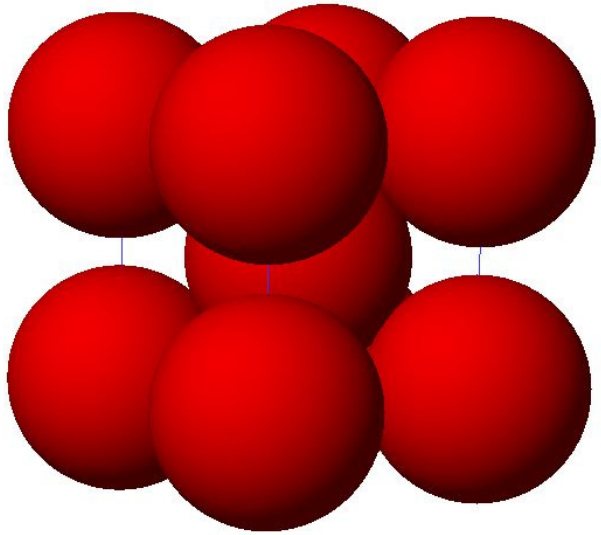

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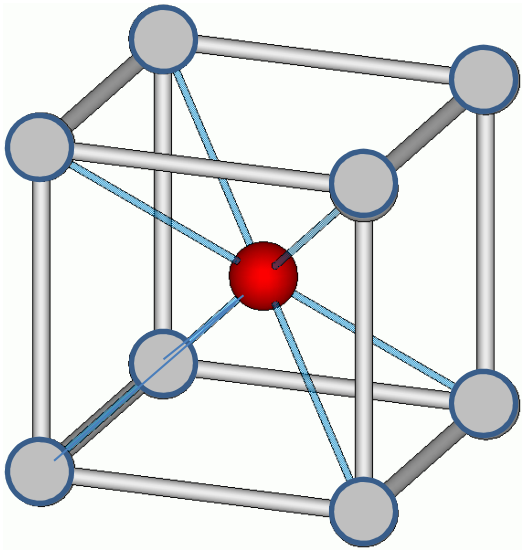
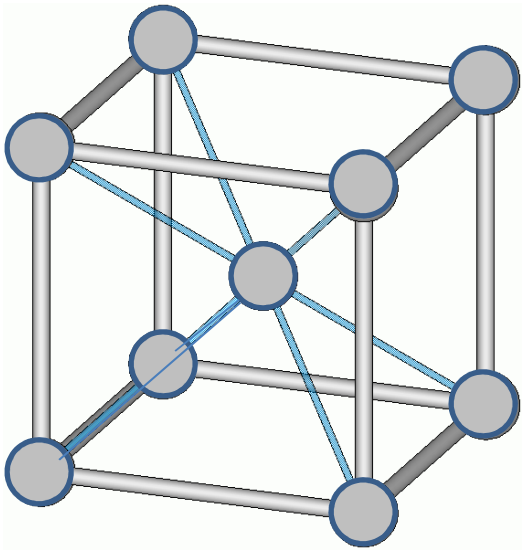


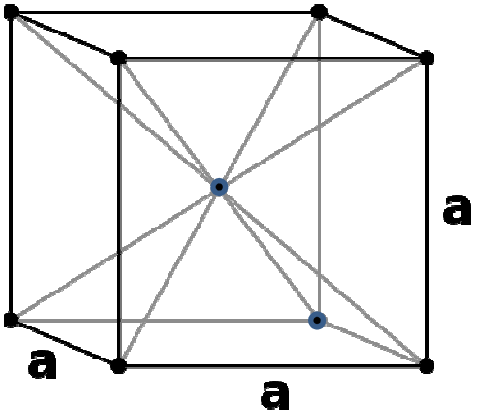
CsCl =Simple Cubic with Basis

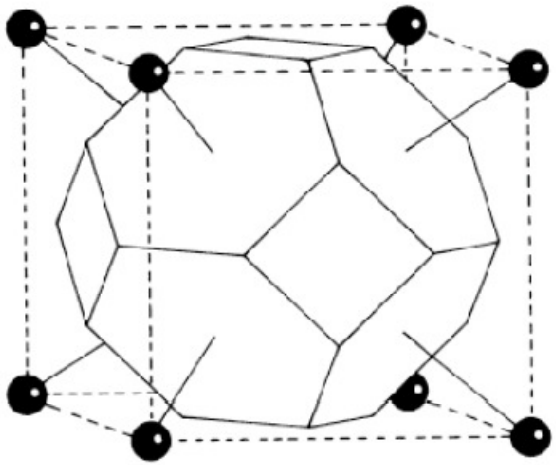
Cs at [0, 0, 0]
Cl at [½, ½, ½]



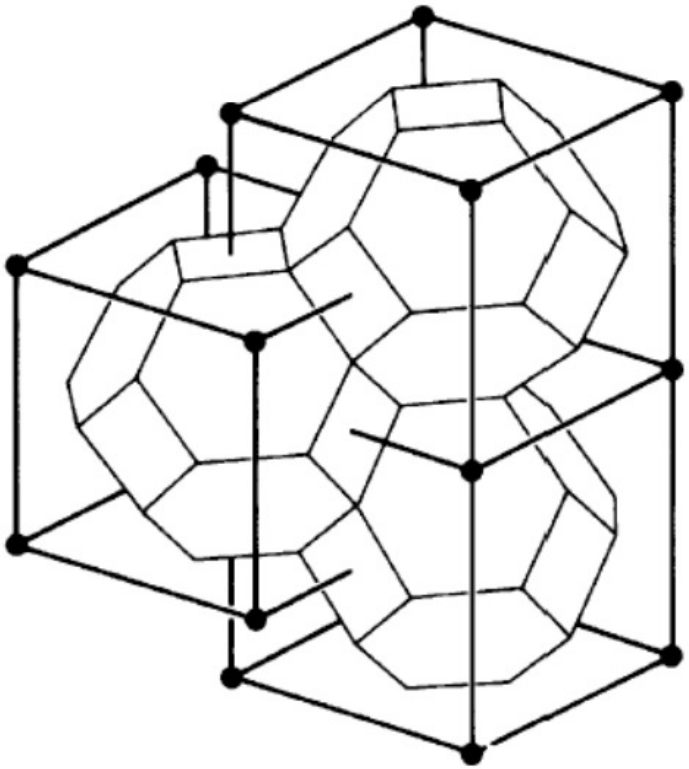
Cs = Simple Cubic with Basis

Cs at [0, 0, 0]
Cs at [½, ½, ½]

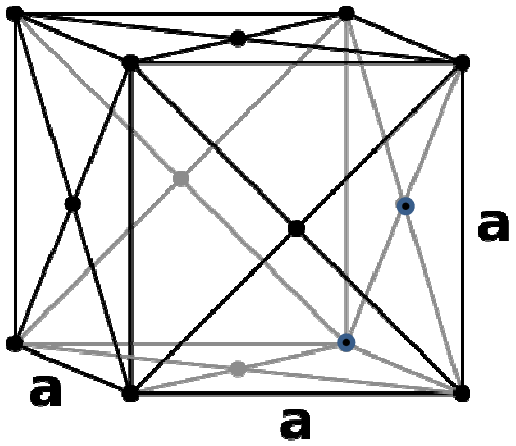




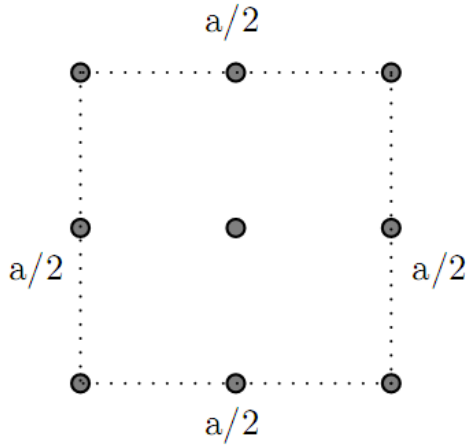
The Wigner-Seitz (Primitive) Unit Cell for the BCC lattice



Unit cell of Face Centered Cubic Lattice (FCC) (Notated cubic-F)

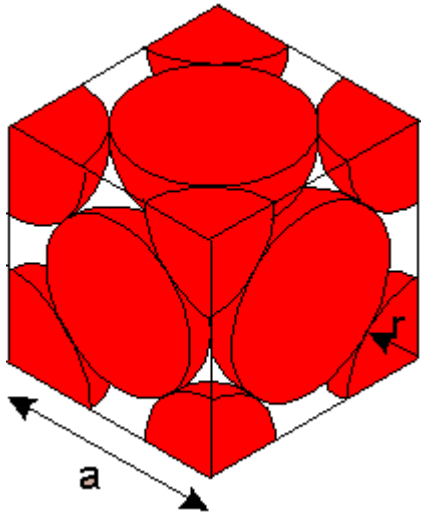


Conventional Unit Cell



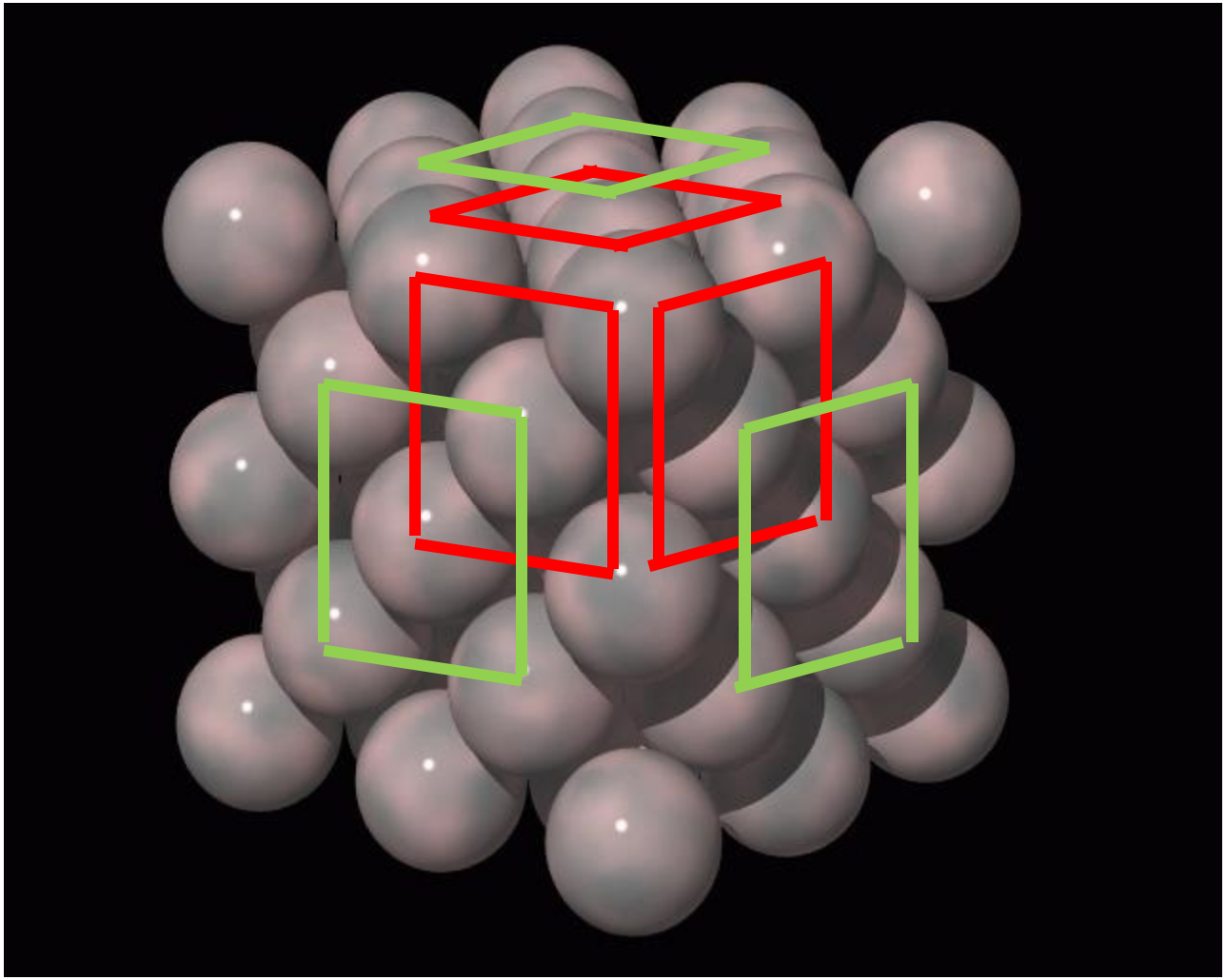
Plan View

(unlabeled points at height 0 and a)

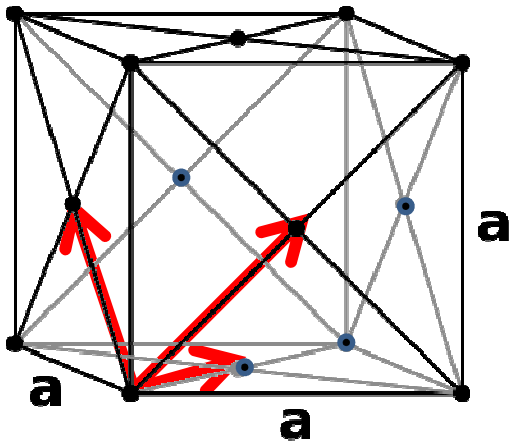


Most efficient sphere packing

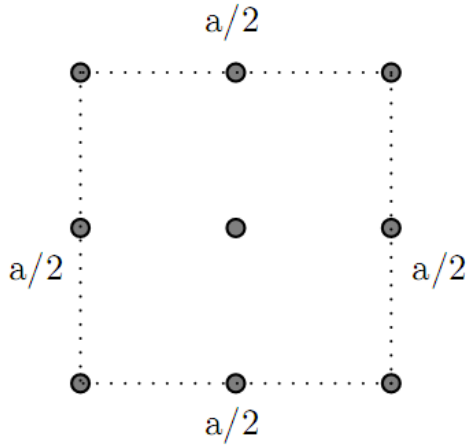
same density as “hcp” packing which we don’t’ learn this year



Unit cell of Face Centered Cubic Lattice (FCC) (Notated cubic-F)



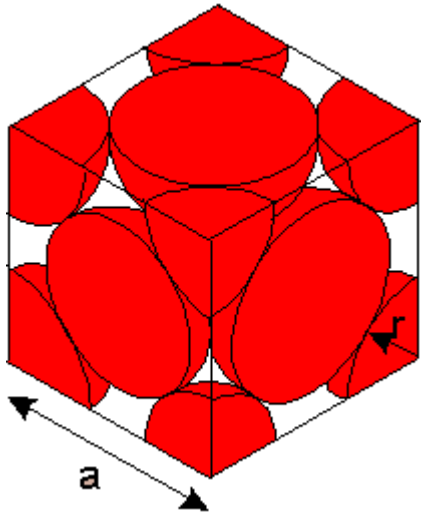
Conventional Unit Cell



Plan View

(unlabeled points at height 0 and a)

FCC lattice



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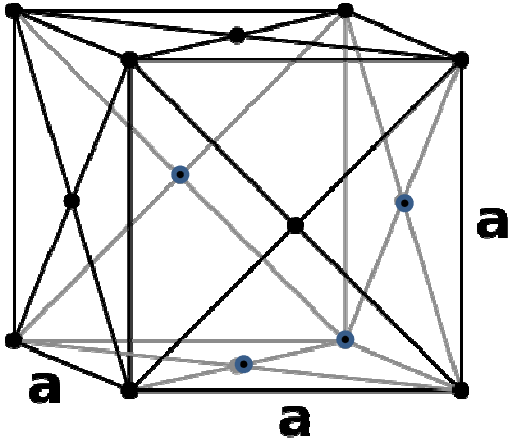
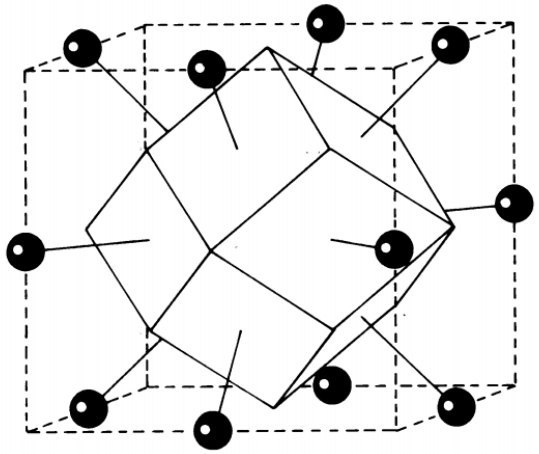


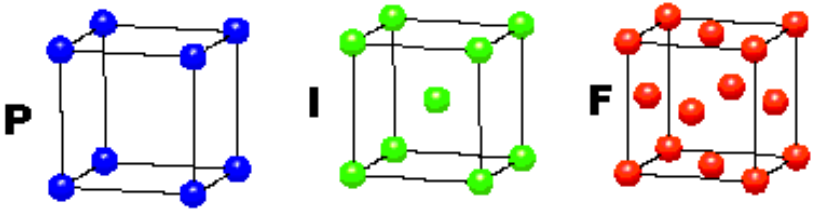


The Wigner-Seitz (Primitive) Unit Cell for the FCC lattice

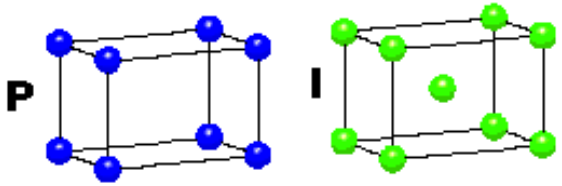
Packing Wigner Seitz cells to fill space

The 14 Bravais Lattice Types

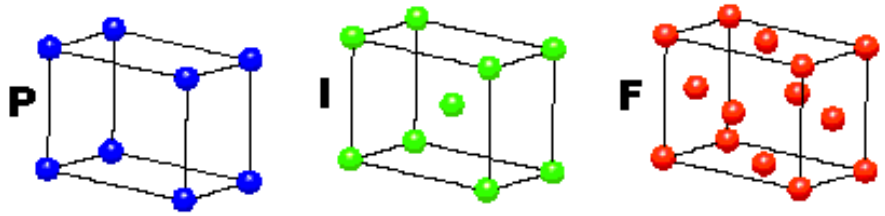
CUBIC
$a = b = c$
$\alpha = \beta = \gamma = 90°$



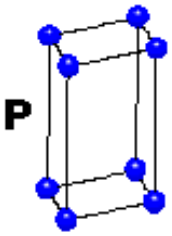
TETRAGONAL
$a = b \neq c$
$\alpha = \beta = \gamma = 90°$



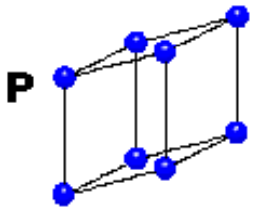
ORTHORHOMBIC
$a \neq b \neq c$
$\alpha = \beta = \gamma = 90°$



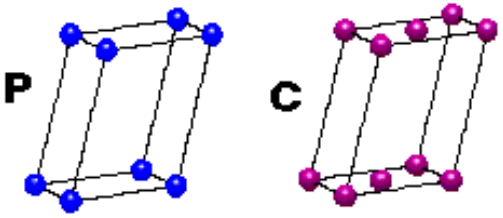
HEXAGONAL
$a = b \neq c$
$\alpha = \beta = 90°$
$\gamma = 120°$



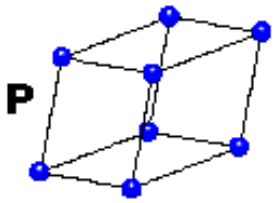
TRIGONAL
$a = b = c$
$\alpha = \beta = \gamma \neq 90°$



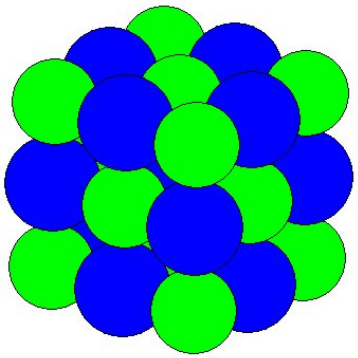
MONOCLINIC
$a \neq b \neq c$
$\alpha = \gamma = 90°$
$\beta \neq 120°$

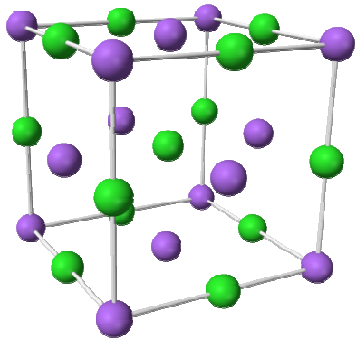


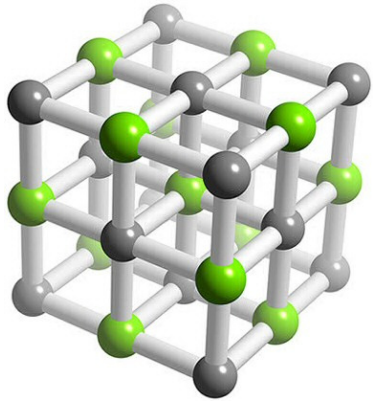
TRICLINIC
$a \neq b \neq c$
$\alpha \neq \beta \neq \gamma \neq 90°$



4 Types of Unit Cell
P = Primitive
I = Body-Centred
F = Face-Centred
C = Side-Centred
+
7 Crystal Classes
→ 14 Bravais Lattices







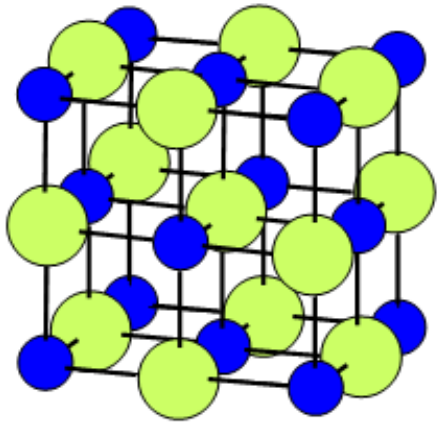
sodium chloride (NaCl)

lattice: cubic F

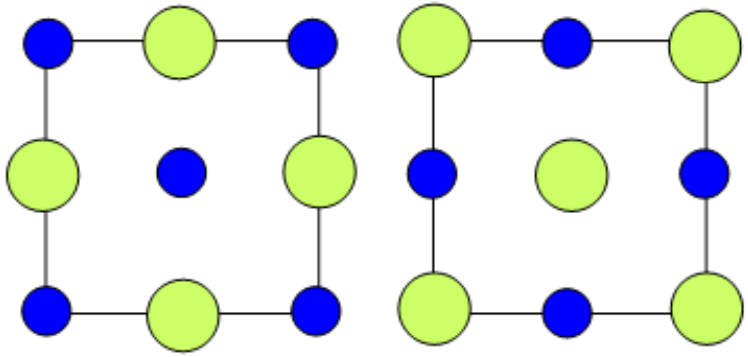
basis :

Na 000

Cl ½½½



Plan view



$z = 0$ layer

$z = ½$ layer

Na forms FCC lattice.

Cl is displaced (1/2,1/2,1/2) from each Na

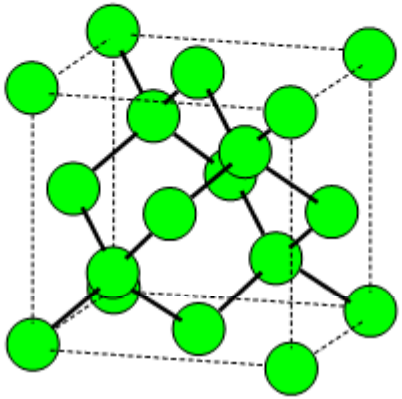
diamond (C) — also Si, Ge

lattice: cubic F

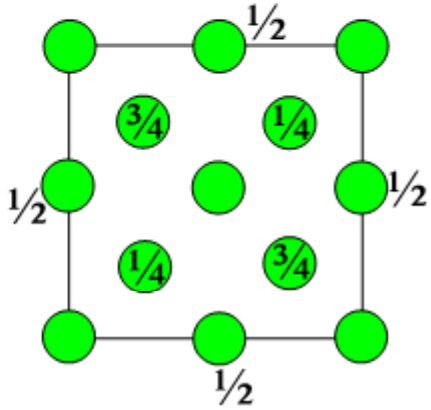
basis :

C 000

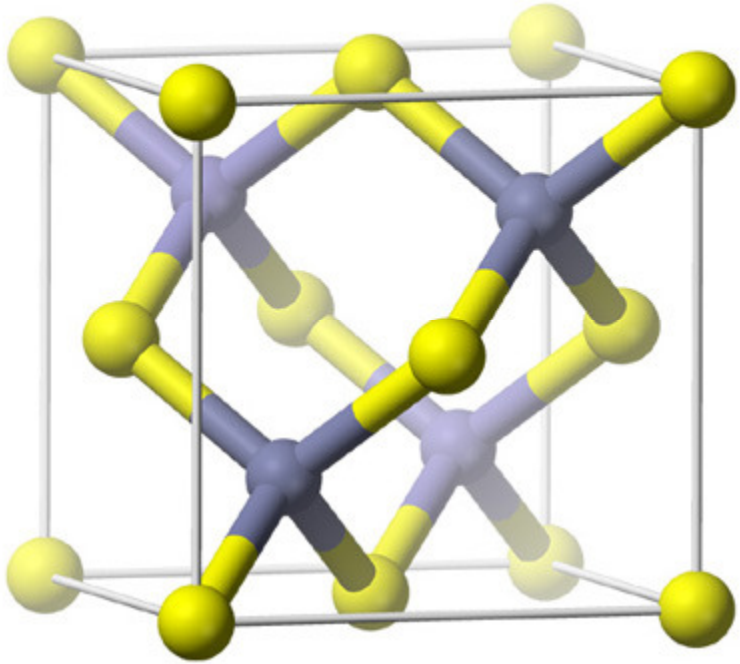
C ¼¼¼



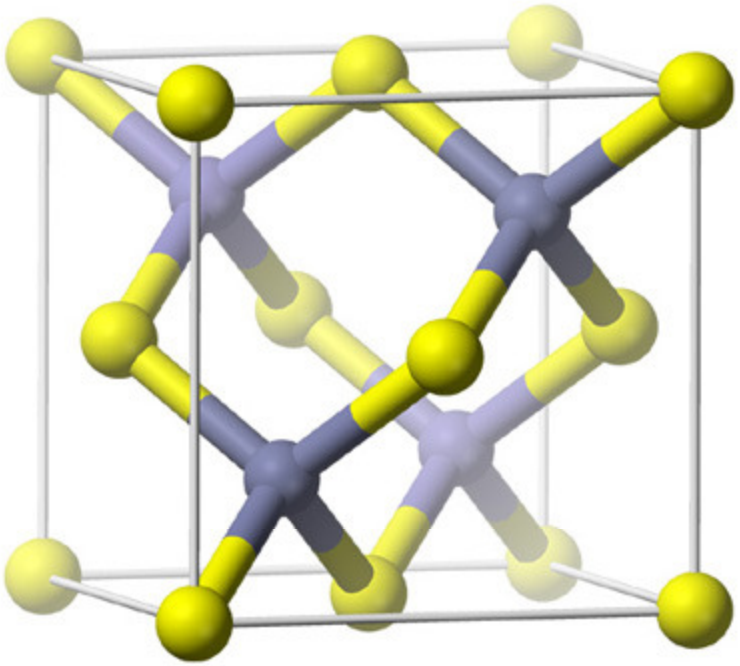
Plan view



GaAs Structure…



GaAs Structure…



FCC:

Basis: Yellow at (0,0,0)

Blue at (1/4,1/4,1/4)