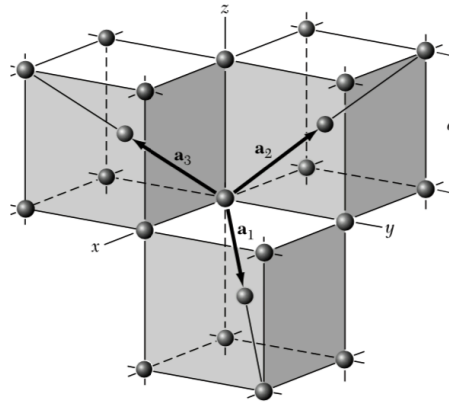


This series of homework is based on the first chapter of Introduction to solid state physics by Charles Kittel. Before answering the problems, make sure to study the related materials thoroughly from the two primary references. You may think and work on problems with your classmates, but **you must submit the answers you only write**; otherwise, you will receive no points. The last question is for bonus points.

Problem 1

The angles between the tetrahedral bonds of diamond are the same as the angles between the body diagonals of a cube, as in the figure below. Use elementary vector analysis to find the value of the angle.



Problem 2

a) Show that each lattice point in an fcc lattice has twelve nearest neighbors, each the same distance from the initial point. What is this distance if the conventional unit cell has lattice constant a ?

b) Now stretch the side length such that you obtain a face-centered orthorhombic lattice where the conventional unit cell has sides of length a , b , and c which are all different. What are the distances to these twelve neighboring points now? How many nearest neighbors are there?

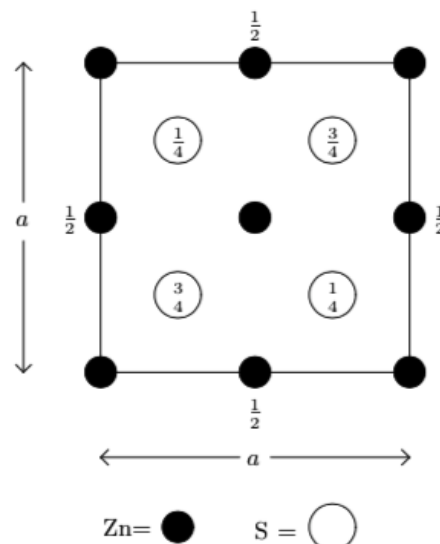
Problem 3

The diagram of the figure below shows a plan view of a structure of cubic ZnS (zincblende) looking down the z axis. The numbers attached to some atoms represent the heights of the atoms above the $z = 0$ plane expressed as a fraction of the cube edge a . Unlabeled atoms are at $z = 0$ and $z = a$.

a) What is the Bravais lattice type?

b) Describe the basis.

c) Given that $a = 0.541$ nm, calculate the nearest neighbor Zn–Zn, Zn–S, and S–S distances.



Problem 4

Calculate all the elements in the Table 2, page 10 of Charles Kittel, Introduction to Solid State Physics.

Bonus Problem

Construct the corresponding crystal structure from the following descriptions of the Bravais lattices and the bases:

1. One-dimension

(a) Bravais lattice: a line of length a . Basis: Two atoms of species A spaced by 0 and $1/4$.

2. Two-dimensions

(a) Bravais lattice: simple rectangle with $a = 4 \text{ \AA}$, $b = 3 \text{ \AA}$; Basis: one atom of species A located at $(0,0)$ and another atoms of species B located at $(1/2,1/2)$.

(b) The same parameters as in (a) but now using atoms A and B that are chemically the same ($A = B$). In addition to the crystal structure, state the basis vectors to the primitive lattice and specify the nature of the new Bravais lattice.

(c) Bravais lattice: hexagonal ($a = b$, $\gamma = 120^\circ$). Basis: two atoms of C, one located at $(0,0)$ and the other one at $(1/3, 2/3)$.

3. Three-dimensions

The Bravais lattice of (a) silicon, (b) GaAs, and (c) Mg_2Si are face-centered cubic. Their basis vectors are respectively located at:

(a) Two atoms of Si; one at $(0,0,0)$ and the other at $(1/4,1/4,1/4)$

(b) One atom of As located at $(0,0,0)$ and one atom of Ga located at $(1/4,1/4,1/4)$

(c) One atom of Si located at $(0,0,0)$; two atoms of Mg located at $(1/4,1/4,1/4)$ and $(3/4,1/4,1/4)$