

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Physics Department

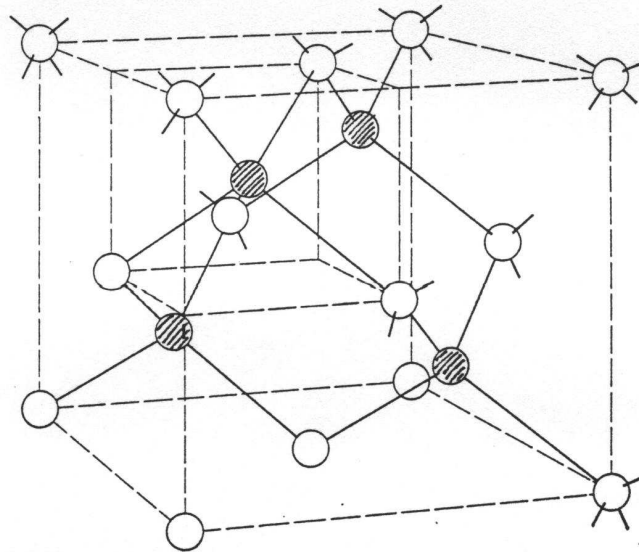
8.231, Physics of Solids I

Due in Ses #6

Problem Set #1

Problem 1: Gallium Arsenide

A conventional (cubic) unit cell of gallium arsenide, GaAs, is shown below. Note the similarity to the diamond structure. The gallium atoms are indicated by shaded circles and the arsenic atoms by open circles.



- How many atoms of each type are contained in the conventional cell?
- To which space lattice type does this crystal lattice belong?
- Give a set of fundamental translation vectors ( $\vec{a}$ ,  $\vec{b}$ ,  $\vec{c}$ ) which can be used to define the primitive unit cell. Express your answer in cartesian coordinates ( $\hat{x}$ ,  $\hat{y}$ ,  $\hat{z}$ ). How many atoms are there in the primitive cell?

**Problem 2: Calcium Fluoride**

Calcium fluoride,  $\text{CaF}_2$ , has a structure based on the fcc lattice and a basis with Ca at 000 and F's at  $\frac{1}{4} \frac{1}{4} \frac{1}{4}$  and  $\frac{3}{4} \frac{3}{4} \frac{3}{4}$ . Draw a projection diagram and sketch one conventional (cubic) unit cell of the structure.

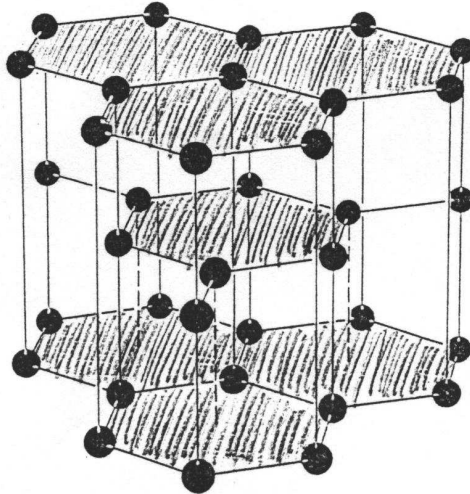
**Problems 3, 4 and 5:** Problems 1, 2 and 3 in Chapter 1.

**Problem 6: Packing Fraction**

Show that the maximum proportion of the available volume which may be filled by hard spheres arranged on various lattices is: simple cubic, 0.52; body-centered cubic, 0.68; face-centered cubic, 0.74; diamond, 0.34.

**Problem 7: Graphite**

Graphite, a form of elemental carbon, is made up of planes of atoms as shown below.



In each plane the atoms are at the corners of open hexagons. The odd-numbered layers are all identical when viewed from above. All even-numbered layers are also identical, but they are shifted with respect to the odd layers. Half of the atoms in the even layer occur exactly below the center of each hexagon of the odd layer. Describe this structure by giving the lattice type, the primitive unit cell, and the basis.