# Exercise-sheet 1

## I. Space lattices

**(I.1)** Primitive and unit cell
A single-crystal is represented two-dimensionally in Figure 1.
(a) List the unit cell(s) from the small volume A-F of the crystal.
(b) List the primitive cell(s) from the small volume A-F of the crystal.

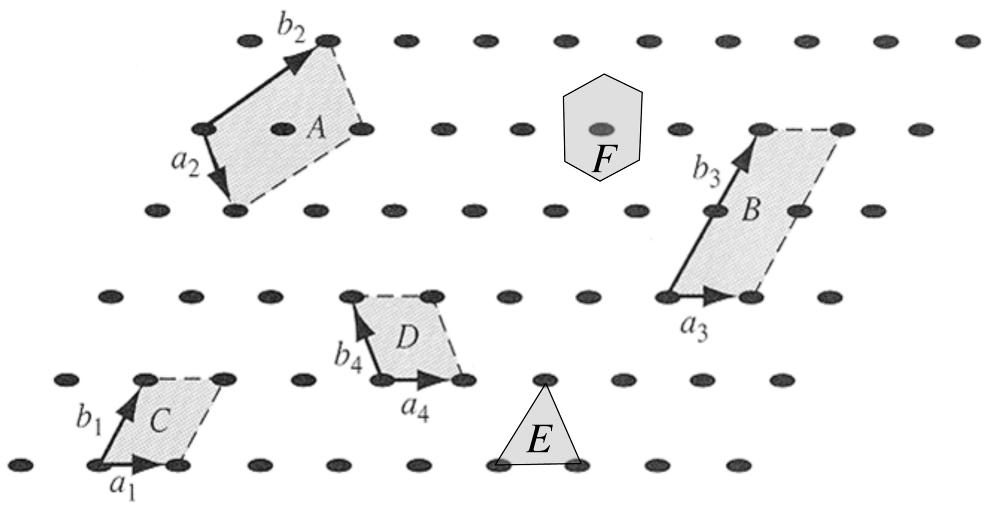



Figure 1: Two-dimensional representation of a single-crystal lattice

**(I.2)** Determine the number of atoms per unit cell in (a) face-centered cubic, (b) body-centered cubic, and (c) diamond lattice.

**(I.3)** Determine the volume density of the atom in crystals with (a) simple-cubic, (b) body-centered cubic and (c) face-centered cubic crystal structures with a lattice constant $a$=5Å.

**(I.4)** Figure 2 gives the unit-cell of a crystal.
a. What is the crystal structure?
b. The lattice constant is 5.45 Å. Determine the volume density of the atom.

**(I.5)** (a) The lattice constant of GaAs is 5.65Å. Determine the number of Ga atoms and As atoms per $cm^3$. (b) Determine the volume density of germanium atoms in a germanium semiconductor. The lattice constant of germanium is 5.65Å.

**(I.6)** Assume that each atom is a hard sphere with the surface of each atom in contact with the surface of its nearest neighbor. Determine the percentage of total unit cell volume (density of atoms) that is occupied in (a) a simple cubic lattice, (b) a face-centered cubic lattice, (c) a body-centered cubic lattice, and (d) diamond lattice.

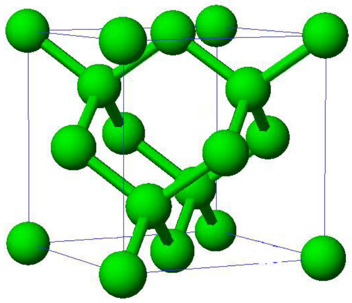


Figure 2: a crystal structure

**(I.7)** If the lattice constant of Si is 5.43Å, calculate (a) the distance from the center of one Si atom to the center of its nearest neighbor, (b) the number density of Si atoms (per $cm^3$), and (c) the mass density (gram per $cm^3$) of Si.

**(I.8)** Consider a three-dimensional cubic lattice with a lattice constant equal to $a$. (a) Sketch the following planes: (i) (100), (ii) (110), (iii) (310) and (iv) (230). (b) Sketch the following directions (i) [100], (ii) [110], (iii) [310] and (iv) [230].

**(I.9)** Determine the surface density of atoms for Si on the (a) (100) plane, (b) (110) plane, and (c) (111) plane.

## II. Imperfections and impurities in solids

**(II.1)** (a) If $2 \times 10^{16}$ boron atoms per $cm^3$ are added to Si as as substitutional impurity, determine what percentage of the Si atoms are displaced in the single crystal lattice. (b) Repeat part (a) for $10^{15}$ boron atoms per $cm^3$.

**(II.2)** $\boxed{1}$ is a common technique for purifying silicon ingot or boule. With a distribution coefficient (or it is called as segregation coefficient) of $\boxed{2}$, we can obtain pure silicon after the process.

$\boxed{1}$. Choose a correct term.

a. Czochralski method

b. Heteroepitaxy

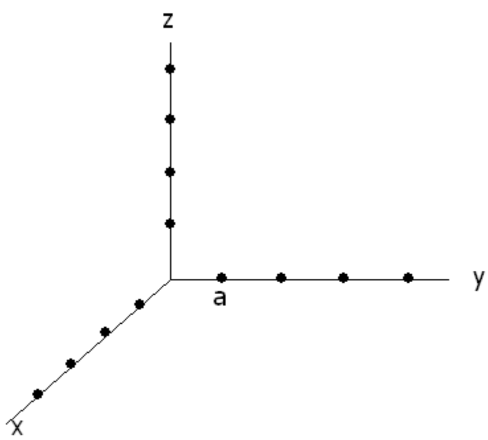
c. Zone refining

$\boxed{2}$. Choose a correct number.

0.8

1.0

1.2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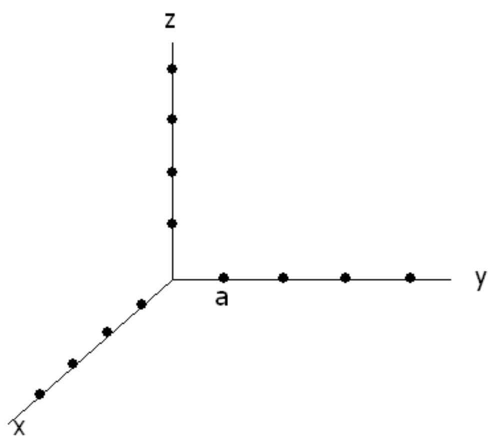
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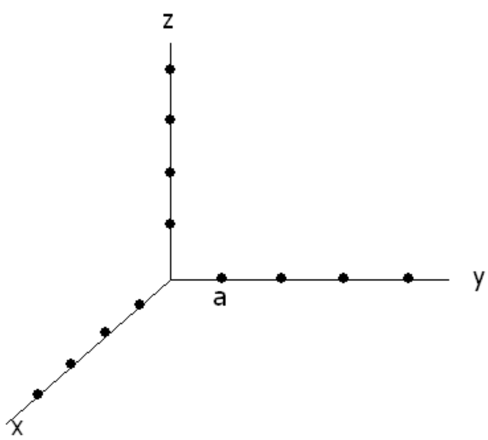
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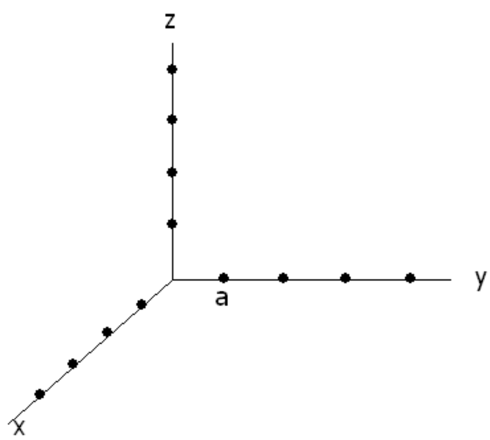
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