

Homework A

Instructor: Yoonseok Lee

Submit only HW's. EX's are additional problems that I encourage you to work on.

(**a.b**) means problem number **b** of chapter **a** in *Introduction to Solid State Physics* (8th ed.) by Kittel.

Due January 23

EX: (1.1)

EX: (1.2)

HW 1: Packing fraction is the maximum fraction of volume (area) that identical spheres (circles) cover in three (two) dimensional arrays. For example, for two dimensional square lattice, the packing fraction $f = (\pi a^2)/(2a^2) = \pi/4$.

- (a) What is the packing fraction of two dimensional triangular lattice?
- (b) What is the packing fractions of the bcc and fcc?

HW 2: Show that in an ideal hexagonal close packed (*hcp*) structure, the ratio c/a is given by

$$\frac{c}{a} = \left(\frac{8}{3}\right)^{1/2} = 1.633.$$

EX: Verify all the numbers in Table 1 of Chapter 1 excluding the first three rows.

HW 3: The Miller indices are defined so that all equivalent, parallel planes are represented by the same set of indices. For example, in a *sc* structure with a lattice spacing a , the planes whose intercepts are (a, a, a) ; $(2a, 2a, 2a)$; $(-3a, -3a, -3a)$ are all represented by (111). Therefore a set of Miller indices specifies an infinite set of equivalent parallel planes.

- (a) What is the interplanar distance between the adjacent (111) planes (d_{111}) in a *sc* lattice with a lattice spacing a ?
- (b) What is the interplanar distance between the adjacent (121) planes (d_{121}) in a P orthorhombic lattice with lattice spacing a , $2a$, and a ?

(c) Show that in an orthorhombic lattice,

$$d_{hkl} = \frac{n}{\sqrt{\frac{h^2}{a^2} + \frac{k^2}{b^2} + \frac{l^2}{c^2}}},$$

where n is the common factor used to reduce the indices to the smallest integer possible, and a , b , and c are the lattice spacings.

HW 4: α -Co has an *hcp* structure with $a = 2.51\text{\AA}$ and $c = 4.07\text{\AA}$, and β -Co has an *fcc* structure with a cubic lattice spacing 3.55\AA . What is the density ratio between two forms of Co? Assume that the in-plane packing is ideal close packing.

HW 5: The main building blocks of cuprate superconductors (high T_c superconductors) are CuO_2 layers as shown in the figure below. The copper atoms are arranged in a square lattice with a spacing a .

(a) The simplest model for cuprates is that Cu and O atoms are arranged perfectly in 2D plane as shown in (A). Sketch the Bravais lattice. Indicate primitive lattice vectors, primitive cell, and the basis.

(b) Detailed studies revealed that not all oxygen atoms are arranged in the plane defined by Cu atoms. Figure (B) shows a more realistic arrangements of a CuO_2 layer with oxygen atoms moved a small amount out of the Cu plane (up or down symmetrically) in an alternating fashion. What is the primitive cell, primitive lattice vectors, and the basis?

