

NORTHERN ILLINOIS UNIVERSITY

PHYSICS DEPARTMENT

Physics 580 – Solid State Physics

Fall 2022

Quiz #2 --- Take Home

Problem Set Due: Tues., Oct. 18, 2022

Read Kittel: Chapter 1 & 2

1. Finish *Problem #5* in **Problem Set #4** using the method outlined in class by Sebastian Osorio (some photos of the blackboard are posted on Blackboard—making the online lecture was not successful). Basically, use the relation that for $h + k + l =$ an integer:

$$e^{-i\pi(h+k+l)} = \cos[\pi(h+k+l)] - i \sin[\pi(h+k+l)] = (-1)^{h+k+l}$$

$$e^{-i\frac{\pi}{2}(h+k+l)} = \cos\left[\frac{\pi}{2}(h+k+l)\right] - i \sin\left[\frac{\pi}{2}(h+k+l)\right] = (-i)^{h+k+l}$$

Use this technique in Problem 2 (e) below as well.

Problem 2 follows on the next page

2. Indium crystallized in a body centered tetragonal lattice. For the conventional unit cell, the lattice parameters are $a = 3.244 \text{ \AA}$ $c = 4.938 \text{ \AA}$, and the basis is (000) and $\frac{1}{2} \frac{1}{2} \frac{1}{2}$. The primitive translation vectors are

$$\vec{a} = (a/2)(\hat{x} + \hat{y}) + (c/2)\hat{z}$$

$$\vec{b} = (a/2)(\hat{x} + \hat{y}) - (c/2)\hat{z}$$

$$\vec{c} = (a/2)(\hat{x} - \hat{y}) - (c/2)\hat{z}$$

- (a) Make a careful sketch of the primitive unit cell defined by the above vectors (use Vesta). What is its volume?
- (b) Find and make a careful sketch of the Wigner-Seitz cell. Note that $c > a\sqrt{2}$.
- (c) Find the primitive translation vectors of the reciprocal lattice. What lattice type is the reciprocal lattice?
- (d) Find, make a careful sketch, and label your sketch of the first Brillouin zone.
- (e) Find an expression for the structure factor for this lattice in terms of the indices of the various points of the reciprocal lattice (h, k, l) . Evaluate this expression for the points (100), (200), (300), (110), (111), (112), and (221). What is the condition h , k , and l must satisfy for allowed and forbidden reflections?