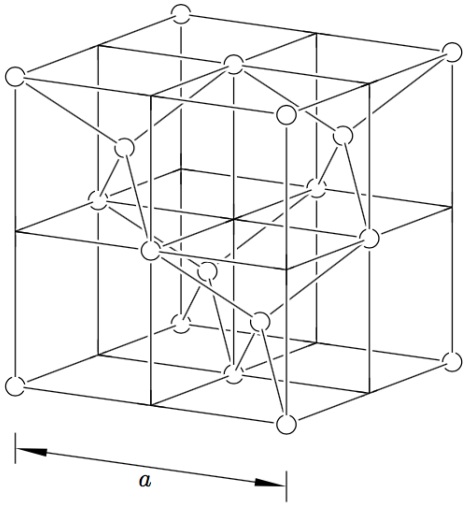
Physics 323, Section 1, Fall Semester 2019
Instructor: Lance Nelson
Exam #2
Nov 6 – Nov 12

This exam is open book. Please complete all questions on your own, without the help of any external source. This includes Google, another person and any previous work on these problems. This exam is **NOT TIMED**.

1. What is meant by the Bravais lattice of a crystal? (One short sentence)

2. What does the d in Bragg's law, $2d\sin\theta = n\lambda$, stand for? (One short sentence. Choose your words wisely!)

3. Consider a Germanium (Ge) crystal, which forms in the diamond crystal structure with $a = 5.65$ Å. (pictured at right)

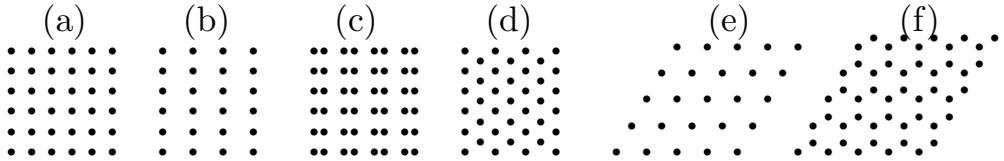


   (a) What is the volume of the primitive unit cell. Think carefully about which atoms are equivalent.

(b) What is the density of Ge. (The mass of one germanium atom is: $m = 72.6$ u, where 1 u$= 1.661 \times 10^{-27}$ kg)

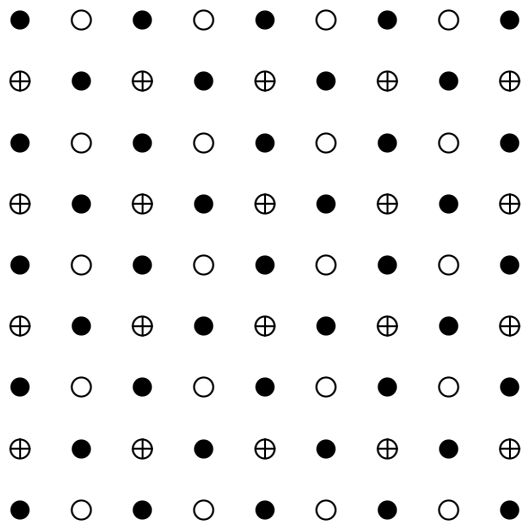
(c) What is the distance between nearest neighbor atoms in germanium. Mark these atoms in the picture.

4. The figure below shows several lattices with lattice points shown as black dots. Which of the lattices are *Bravais* lattices? Mark *all* that apply. (Technically, lattices are infinite, of course, so we can't really draw a *whole* lattice. Imagine that each of the pictures repeats everywhere in two dimensions.)



5. Consider the following reciprocal lattice vector in Cu: $\vec{k} = 2.3094(\hat{i} + \hat{j} + \hat{k})$. Is this vector inside the first Brillouin zone? If not, find the equivelant point that is inside the first Brillouin zone.

6. Consider the two-dimensional crystal shown to the right. The three different symbols refer to three different types of atoms.



   (a) Are the • atoms in equivalent positions?

   (b) Are the ∘ atoms in equivalent positions?

   (c) Use x's to indicate the Bravais lattice sites.

   (d) Draw the primitive unit cell.

   (e) How many • atoms are in a primitive unit cell?

7. The space group of a certain crystal is P $m\bar{3}m$. The lattice is cubic P and the crystal class is $m\bar{3}m$. The space group is symmorphic. A lithium atom is located at $(0, 0, 0)$ and a platinum atom is located at $(1/4, 0, 0)$. Find all of the positions of the lithiums and platinums in the unit cell. Find the chemical formula for the compound.

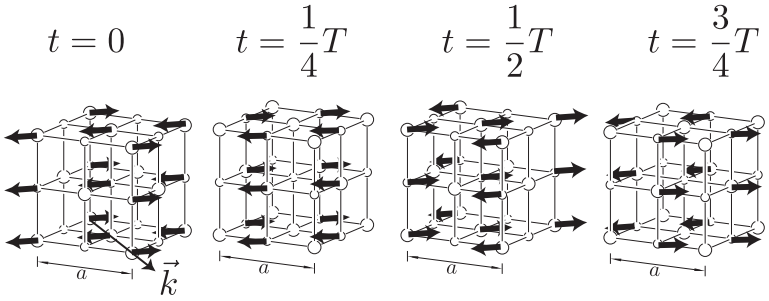
The following three questions are related to the x-ray diffraction in a crystal of iron (Fe) using x-rays of wavelength 1.542 Å.

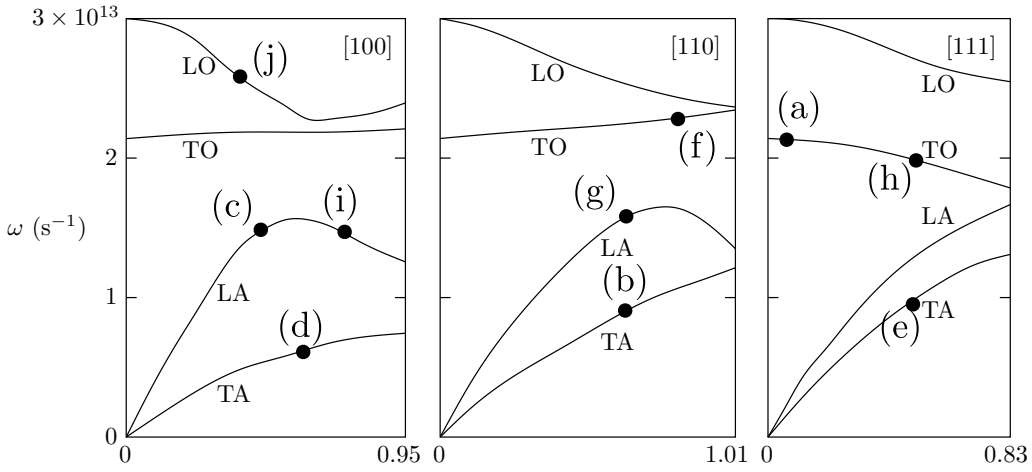
8. Find all of the possible Bragg angles for reflections of the x rays from the (100) planes. How many are there and what are the Bragg angles?

9. Are there any peaks associated with (110) planes? If so how many and what are the associated Bragg angles?

10. Are there any peaks associated with (310) planes? If so, how many and what are the associated Bragg angles?

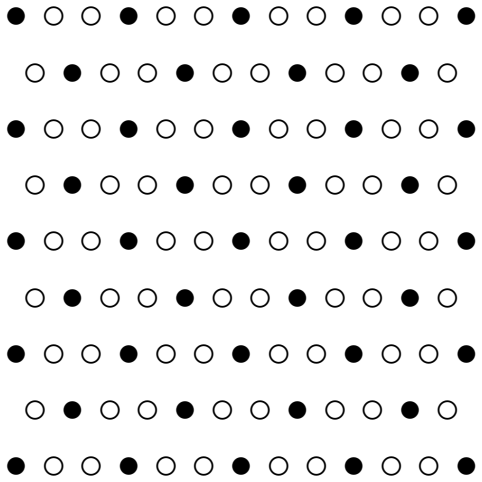
11. In the top figure below, a phonon in a crystal of KBr is depicted. The wave vector lies in the x-y plane and points at an angle halfway between the $\hat{x}$ and $\hat{y}$ directions, as shown. In this problem you are to identify the possible values of $\omega(k)$ and polarization for this phonon, as marked on the dispersion curves shown in the bottom figure. Pick the point or points that are consistent with the depicted phonon. (On the dispersion curves, the labels on the branches indicate the following: L=longitudinal, T=transverse, A=acoustic, O=optical.) Note that the lattice parameter of KBr is on the equation sheet.





12. What is the Bravais lattice for a crystal of CsCl? (a) simple cubic, (b) face-centered cubic, (c) body-centered cubic, (d) hexagonal close-packed, (e) tetragonal.

13. Draw a primitive unit cell for this crystal.



14. Separately, draw a Wigner-Seitz cell for this crystal, centered on a ∘ atom. Mark the lattice points and show your work for constructing the Wigner-Seitz cell. Label the primitive unit cell and Wigner-Seitz cell so the grader knows which is which.

15. In reciprocal space, this is a picture of what (be specific)? (I.e., what is it called?) Explain why it is important.