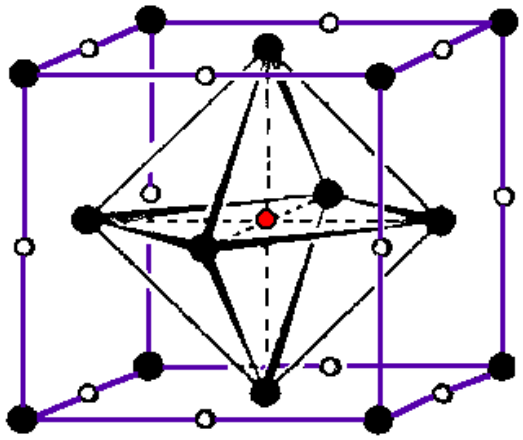
MATRL 100A: Structure and Properties I, Problem Set 4

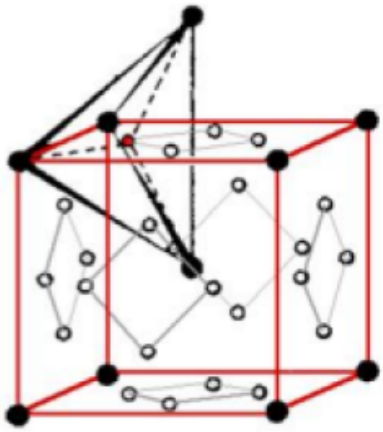
This problem set is due in lecture on **Wednesday, Oct 31st** in hard copy. Write neatly, show your work clearly, and include units in all answers. While you are free to discuss this problem set with your classmates, the product that you turn in must be your own work. Do not copy or paraphrase each other's work.

Chapter 4

1. For both FCC and BCC crystal structures, there are two different types of interstitial sites. In each case the sites can be occupied by impurity/interstitial atoms. In FCC, one of the sites is located at the center of each edge of the unit cell and in the middle of the cell; it is termed an *octahedral interstitial site*. In BCC, one of the sites is found at $0\frac{1}{2}\frac{1}{4}$ positions – that is, lying on (100) faces and situated midway between two unit cell edges on this face and one-quarter of the distance between the other two unit cell edges; it is termed a *tetrahedral interstitial site*. For these two sites (in FCC and BCC respectively), compute the maximum radius r of an impurity atom that can fit into one of these sites without straining the crystal lattice, in terms of the radius. Put your answer in terms of R, the radius of the host atoms. [6]



FCC octahedral interstitial site



BCC tetrahedral interstitial site

2. Consider a sample of AISI 5160 steel which has the following composition.

Element	Weight%
Fe	97.6
Mn	1
Cr	0.7
C	0.66
P	0.04

   (a) Determine whether atoms of each element will substitute iron atoms in the iron BCC lattice or if they will fill interstitial sites. Explain your reasoning. [2]

   (b) Convert the given composition in weight % to atom %. [1]

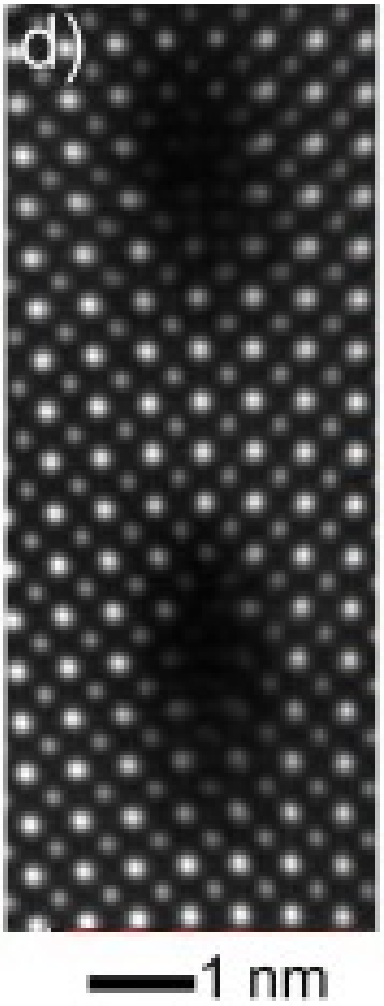
   (c) Assuming the interstitial atoms only fill tetrahedral interstitial sites, calculate the fraction of tetrahedral interstitial sites that are full. [1]

3. What are the relative orientations of the Burgers vector to the dislocation line for edge and screw dislocations? [2]

4. Consider the following high-angle annular dark-field scanning transmission electron microscopy (HAADF STEM) image of a low-angle grain boundary in strontium titanate.

   (a) How many dislocation cores are in this image? [1]

   (b) Use a Burger's circuit and the resulting Burger's vector to classify each dislocation as either an edge, screw, or point dislocation (point dislocations have a burgers vector of 0). [2]



5. (a) Briefly describe a twin and a twin boundary. [2]

   (b) Name two ways that twin boundaries can be formed in materials. [2]

6. For each of the following stacking sequences found in FCC metals, cite the type of planar defect that exists:

   (a) . . . *A B C A B C B A C B A* . . . [2]

   (b) . . . *A B C A B C B C A B C* . . . [2]

   Now, copy the stacking sequences and indicate the position(s) of planar defect(s) with a vertical dashed line.