# 6.11: Problems

1. C-centered Bravais lattices exist in the monoclinic and orthorhombic systems but not in the tetragonal system. That is because the C-centered tetragonal lattice is equivalent to one of the other Bravais lattices. Which one is it? Show with a drawing how that lattice is related to the C-centered tetragonal lattice. How many atoms are in the unit cell of that lattice?

2. Which of the following sequences of close packed layers fills space most efficiently? Explain your answer.

(a) ABACCABA...

(b) ABABAB...

(c) AABBAABB...

(d) ABACABAC...

3. Calculate the fraction of space that is occupied by packing spheres in the (a) simple cubic, (b) body-centered cubic structure, (c) face-centered cubic (cubic close packed) structures. Assume that nearest neighbor spheres are in contact with each other.

4. The hexagonal close packed (hcp) structure is shown below. If the radius of the spheres is R, what is the vertical distance between layers in units of R? What fraction of space is filled by the spheres in the hcp lattice?

HCP crystal structure.svg

5. Consider a one-dimensional chain of sodium atoms that contains N atoms, where N is a large number. The distance between atoms in the chain is the lattice constant **a**. In the highest occupied molecular orbital of the chain, what is the distance between nodes (in units of **a**)?

6. Starting from the left side of the periodic table, the melting and boiling points of the elements first increase, and then decrease. For example, the order of boiling points is Rb $<$ Sr $<$ Y $<$ Zr $<$ Nb $<$ Mo $>$ Tc $\approx$ Ru $>$ Rh $>$ Pd $>$ Ag. Briefly explain the reason for this trend.

7. Going across the periodic table from left to right starting from potassium, the bonding energies and heats of vaporization increase in the order K $<$ Ca $<$ Sc $<$ Ti $<$ V, but then decrease going from V to Mn (V $>$ Cr $>$ Mn). The heats of vaporization of V, Cr, and Mn are much less than those of Nb, Mo, and Tc, respectively. Explain these trends.

8. Some alloys of early and late transition metals (e.g., $ZrPt_3$) have much higher enthalpies of vaporization (per metal atom) than either pure metal. Why are such alloys unusually stable, relative to the pure metals?

9. Graphite is a semimetal composed of sheets of fused benzene rings. There are no bonds between sheets, only van der Waals interactions. What is the C-C bond order in graphite? Show why the C-C distance (1.42 Å) is different from that of benzene (1.40 Å).

10. Fe, Co, and Ni are ferromagnetic, whereas Ru, Ir, and Pt are diamagnetic. Explain why magnetic metals are found only among the 3d and 4f elements. Why are Sc and Ti, which are also 3d elements, diamagnetic?

11. The Curie temperature of cobalt is 1127•C, which is higher than that of Fe (770•C) or Ni (358•C). Why does Co have the highest Curie temperature?

12. Iron metal comes in magnetically “soft” and “hard” forms. Briefly explain the structural differences between them and draw magnetic hysteresis curves for each, indicating on your curves the coercive field and the remanent magnetization.

13. Aluminum metal has the fcc structure, a lattice constant of 4.046 Å, three valence electrons per atom, and an electron scattering time (at room temperature) of 11.8 fs. Use these values to calculate the room temperature resistivity (in ohm-cm) of Al metal.