Chapter 8 Exercises

1. What is a unit cell?

2. How many unit cells are shown in Figure 8.15a?

3. How many unit cells are shown in Figure 8.15b?

4. What distinguishes a crystalline solid from an amorphous solid?

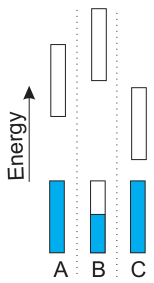
5. What is the Fermi level?

6. How do valence bands differ from conduction bands?

7. What is a band gap?

8. Use band theory to explain the difference between a conductor, a semiconductor, and an insulator.

9. The band structures of a conductor, a semiconductor and an insulator are shown below. Identify each.

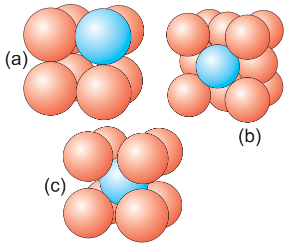


10. Suggest a reason why the band gap decreases in the order C > Si > Ge. Refer to Figure 2.6 and the valence electron configurations of the atoms.

11. Gold crystallizes in a face-centered cubic geometry that is 4.08 Å on each side.

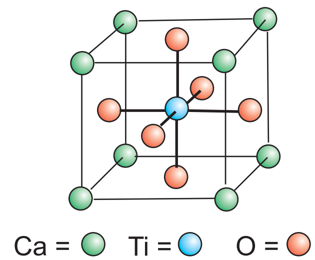
- **a)** Draw a picture showing the face of the unit cell. What atomic radius of gold is required for this geometry?
- **b)** How many gold atoms are present in the unit cell?
- **c)** What is the volume of the unit cell in $Å^3$?
- **d)** What is the volume occupied by the atoms in the unit cell?
- **e)** Based on your results to c and d, what is the packing efficiency of the unit cell? How does this compare with the packing efficiency expected for a fcc unit cell?

12. Use the three unit cells shown below to answer the questions.



- **a)** Which arrangement has the best packing efficiency?
- **b)** What is the coordination number of the blue sphere in each case?
- **c)** What fraction of each blue sphere is in each unit cell?
- **d)** How many spheres are in each unit cell?

13. Calcium titanate, which is composed of calcium, titanium, and oxygen, crystallizes in the *perovskite* structure shown below. Ca (green spheres) resides on the corners of the unit cell, Ti (blue sphere) resides in the body center, and O (red spheres) resides on each of the cell faces. What is the formula of calcium titanate?



14. Calculate Avogadro's number given that silver crystallizes in a face-centered cubic unit cell with a 4.09 Å side and has a density of 10.5 g/cm^3.

15. Calculate the atomic radius and density of copper if it crystallizes in a fcc unit cell that is 3.61 Å on a side.

16. Metallic nickel crystallizes in a fcc unit cell. What is its density if its atomic radius is 1.24 Å.

17. How does the cesium chloride structure differ from a body-centered-cubic structure?

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18. KF crystallizes in the sodium chloride structure with a 5.39 Å unit cell edge. Calculate the density of KF.

19. Use the method employed in Example 8.4 to calculate the packing efficiency of a simple cubic unit cell.

20. Use the ionic radii in Table 8.3 to calculate the packing efficiencies of the following salts. Assume direct contact between anions and cations is along the edge of the unit cell.

a) LiI **b)** NaCl

21. Consider the structure of CsCl shown in Figure 8.15a

a) Do the ions touch along the edge, face diagonal, or body diagonal?

b) Use the ionic radii in Table 8.3 to determine the unit cell edge length.

c) What is the volume of the unit cell?

d) What is the volume occupied by the ions?

e) What is the packing efficiency of the unit cell? How does this packing efficiency compare to that of a simple cubic unit cell?

22. Consider the structure of CsCl shown in Figure 8.15b.

a) Do the ions touch along the edge, face diagonal, or body diagonal?

b) What is the length of the body diagonal?

c) What is the edge length of the unit cell?

d) What is the void space on the edge formed by the chloride ions?

e) What is the volume of the unit cell?

f) What volume is occupied by the ions?

g) What is the packing efficiency of the unit cell? How does it compare to the packing efficiency of a bcc unit cell?

23. Explain at the molecular level why graphite can be used as a lubricant but diamond cannot.

24. What is buckyball? How is its structure related to that of graphite?

25. Describe nanotubes and explain why they are important. How is the structure of a nanotube related to that of graphite?

26. Describe the features that make zeolites so useful and explain how they function as water softeners and molecular sieves.

27. What are clays? Why do some clays swell in the presence of water while other do not?

28. Indicate the substance in each pair that has the higher melting point. Explain your choice.

a) AlF_3 or PF_3 **b)** NaCl or BeO **c)** Si or Kr

29. Indicate the substance with the higher melting point in each pair. Explain your choice.

a) CsBr or AlN **b)** CaF_2 or CS_2 **c)** ZnS or H_2S

30. Each of the following substances is a solid at room temperature. Indicate whether each is a molecular, metallic, ionic, or covalent solid.

a) $C_{12}H_{22}O_{11}$ **b)** MgO **c)** ZnS

31. Each of the following substances is a solid at room temperature. Indicate whether each is a molecular, metallic, ionic, or covalent solid.

a) Si **b)** Ag **c)** I_2