

12.12 Silicon is the fundamental component of integrated circuits. Si has the same structure as diamond. **(a)** Is Si a molecular, metallic, ionic, or covalent-network solid? **(b)** Silicon readily reacts to form silicon dioxide, SiO_2 , which is quite hard and is insoluble in water. Is SiO_2 most likely a molecular, metallic, ionic, or covalent-network solid?

12.43 For each of the following alloy compositions, indicate whether you would expect it to be a substitutional alloy, an interstitial alloy, or an intermetallic compound:

(a) $\text{Fe}_{0.97}\text{Si}_{0.03}$, **(b)** $\text{Fe}_{0.60}\text{Ni}_{0.40}$, **(c)** SmCo_5 .

12.44 For each of the following alloy compositions, indicate whether you would expect it to be a substitutional alloy, an interstitial alloy, or an intermetallic compound:

(a) $\text{Cu}_{0.66}\text{Zn}_{0.34}$, **(b)** Ag_3Sn , **(c)** $\text{Ti}_{0.99}\text{O}_{0.01}$.

12.59 Galena, also called lead glance, is a mineral composed of lead(II) sulfide (PbS). The mineral adopts the rock salt structure. The length of an edge of the PbS unit cell is 0.593 nm at 25 °C. Determine the density of PbS in g/cm^3 .

12.60 Silver chloride (AgCl) adopts the rock salt structure. The density of AgCl at 25 °C is 5.56 g/cm^3 . Calculate the length of an edge of the AgCl unit cell.

- 12.77** The semiconductor gallium nitride (GaN) has a band gap of 3.4 eV. What wavelength of light would be emitted from an LED made from GaN? What region of the electromagnetic spectrum is this?
- 12.78** The first LEDs were made from GaAs, which has a band gap of 1.43 eV. What wavelength of light would be emitted from an LED made from GaAs? What region of the electromagnetic spectrum does this light correspond to: ultraviolet, visible, or infrared?
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- 12.79** GaAs and GaP make solid solutions that have the same crystal structure as the parent materials, with As and P randomly distributed throughout the crystal. $\text{GaP}_x\text{As}_{1-x}$ exists for any value of x . If we assume that the band gap varies linearly with composition between $x = 0$ and $x = 1$, estimate the band gap for $\text{GaP}_{0.8}\text{As}_{0.2}$. (GaAs and GaP band gaps are 1.43 eV and 2.26 eV, respectively.) What wavelength of light does this correspond to?
- 12.80** Orange light-emitting diodes are made from GaAs and GaP solid solutions, $\text{GaP}_x\text{As}_{1-x}$ (see Exercise 12.79). The original orange LEDs emitted light with a wavelength of 590 nm. If we assume that the band gap varies linearly with composition between $x = 0$ and $x = 1$, estimate the composition (the value of x) that is used in these LEDs.

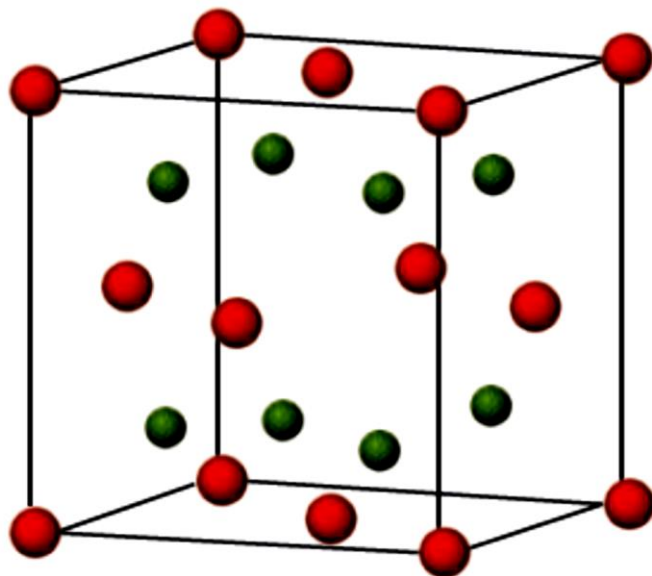
12.110 What type of lattice—primitive cubic, body-centered cubic, or face-centered cubic—does each of the following structure types possess: **(a)** NaF, **(b)** Ag, **(c)** Fe, **(d)** CsCl,

[12.114] Energy bands are considered continuous due to the large number of closely spaced energy levels. The range of energy levels in a crystal of copper is approximately 1×10^{-19} J. Assuming equal spacing between levels, the spacing between energy levels may be approximated by dividing the range of energies by the number of atoms in the crystal. **(a)** How many copper atoms are in a piece of copper metal in the shape of a cube with edge length 0.5 mm? The density of copper is 8.96 g/cm^3 . **(b)** Determine the average spacing in J between energy levels in the copper metal in part (a). **(c)** Is this spacing larger, substantially smaller, or about the same as the 1×10^{-18} J separation between energy levels in a hydrogen atom?

[12.115] Unlike metals, semiconductors increase their conductivity as you heat them (up to a point). Suggest an explanation.

12.121 Germanium has the same structure as silicon, but the unit cell size is different because Ge and Si atoms are not the same size. If you were to repeat the experiment described in the previous problem but replace the Si crystal with a Ge crystal, would you expect the X rays to be diffracted at a larger or smaller angle θ ?

12.116 Sodium oxide (Na_2O) adopts a cubic structure with Na atoms represented by green spheres and O atoms by red spheres.



- (a) How many atoms of each type are there in the unit cell?
- (b) Determine the coordination number and describe the shape of the coordination environment for the sodium ion.
- (c) The unit cell edge length is 555 pm. Determine the density of Na_2O .

12.124 The karat scale used to describe gold alloys is based on mass percentages. (a) If an alloy is formed that is 75 mol% silver and 25 mol% gold, what is the karat number of the alloy? Use Figure 12.18 to estimate the color of this alloy. (b) If an alloy is formed that is 75 mol% copper and 25 mol% gold, what is the karat number of the alloy? What is the color of this alloy?