Chapter 4

METALLIC BONDING

Exercises

4.2  (a) The repeating array of atoms in the crystal.
     (b) The number of neighboring (touching) atoms around a central atom.
     (c) The combination of one liquid metal with one or more solid metals.

4.4  Iron, copper, aluminum, and zinc.

4.6

4.8  Potassium has the electron configuration [Ar]4s\(^1\). By pairing to form K\(_2\) molecules in the gas phase, a single covalent bond can be formed.

4.10 It is the placing of the third layer that distinguishes the two hexagonal-based packing arrangements. In the hexagonal close-packed, the third layer is placed over the first layer, while in the cubic close-packed, the third layer is placed over the holes in the first and second layers.
4.12 The body-centered cubic unit cell contains \([4 \times \frac{1}{2} + 1]\) atoms; that is, two atoms.

4.14 Potassium has a much greater metallic radius than zinc (227 pm versus 133 pm); they adopt different packing (potassium is body-centered cubic while zinc is hexagonal close-packed); potassium is very reactive, forming a 1+ ion, while zinc is much less reactive, forming a 2+ ion.

**Beyond the Basics**

4.16 If we take the radius of an atom as \(r\), then, as the atoms touch through the diagonal through the cell center, the diagonal length will be \(4r\). Thus the side length of a unit cell for the body-centered cubic lattice will be \([4/(\sqrt[3]{3})]r = 2.31r\) (using Pythagoras's theorem). The volume of the atoms will be \(2 \times (\frac{4}{3} \pi r^3)\), while the volume of the cube will be \((2.31r)^3\). The ratio of these gives 0.69. Thus the empty space expressed as a percentage will be 31 percent.

4.18 The diagonal length through the center of the unit cell will be \(4r\). Using Pythagoras's theorem, the length of the unit cell edge will be \([4/(\sqrt[3]{3})]r = 2.31r\).

4.20 A body-centered cubic unit cell contains two atoms. Thus

\[
\text{Mass} = \frac{2 \times 137.3 \text{ g} \cdot \text{mol}^{-1}}{6.02 \times 10^{23} \text{ mol}^{-1}} = 4.56 \times 10^{-22} \text{ g}
\]

\[
\text{Volume} = \frac{4.56 \times 10^{-22} \text{ g}}{3.50 \text{ g} \cdot \text{cm}^{-3}} = 1.30 \times 10^{-22} \text{ cm}^3 = 1.30 \times 10^8 \text{ pm}^3
\]

Length of side = \(\frac{3}{2} \sqrt[3]{(1.30 \times 10^8 \text{ pm}^3)} = 507 \text{ pm}\)

Using the result from 4.18, radius of barium atom = 507 pm/2.31
= 219 pm.

4.22 If the surfaces were clean at the molecular level, they would fuse together.
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