Chapter 4

METALLIC BONDING

Exercises

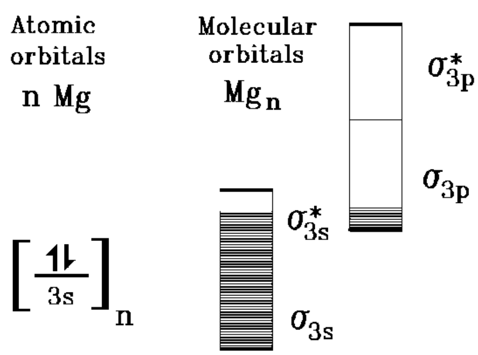
4.1 (a) A model in which it is assumed that the metal consists of metal ions with free electrons.

(b) The smallest fragment of a crystal lattice that, if repeated, will re-create the entire structure.

(c) The combination of two or more solid metals.

4.3 High electrical conductivity, high thermal conductivity, high reflectivity, and high boiling point (any three).

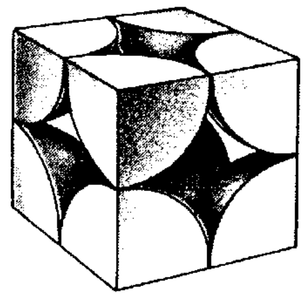
4.5 The overlap of the 3*s* and 3*p* bands means that electrons in the full 3*s* band can "spill over" into the 3*p* band, enabling electron mobility through the crystal lattice.



4.7 For metallic behavior, the orbitals of the atoms must overlap. In the gas phase, metal atoms are moving freely as single atoms or as discrete molecules, such as dilithium, Li_2.

4.9 Cubic and hexagonal, hexagonal being the closer packed.

4.11 The simple cubic unit cell contains $4 \times \frac{1}{4}$ atoms; that is, one atom.



4.13 The atoms must be about the same size, they must adopt the same structure, and they must have similar chemical properties.

Beyond the Basics

4.15 If we take the radius of an atom as r, then the side length of a unit cell for the simple cubic lattice will be $2r$. The volume of the atom will be $^{4}/_{3}\pi r^3$, while the volume of the cube will be $(2r)^3$. The ratio of these gives 0.52. Thus the empty space, expressed as a percentage, will be 48 percent.

4.17 The face diagonal length will be $4r$. Using Pythagoras's theorem, the length of the unit cell edge will be $[4/(2)^{\frac{1}{2}}]r = 2.83r$.

4.19 (a) Using the answer to 4.18, the metallic radius of chromium will be 288/2.31 pm = 125 pm.

(b) The density can be calculated from $\dfrac{\text{unit cell mass}}{\text{unit cell volume}}$.

The unit cell volume will be $(288 \times 10^{-10}\ \text{cm})^3 = 2.39 \times 10^{-23}\ \text{cm}^3$

Each unit cell contains two atoms, thus mass = $\dfrac{2 \times 52.0\ \text{g} \cdot \text{mol}^{-1}}{6.02 \times 10^{23}\ \text{mol}^{-1}}$

$= 1.73 \times 10^{-22}$ g.

Density = $\dfrac{1.73 \times 10^{-22}\, g}{2.39 \times 10^{-23}\, cm^3}$ = 7.24 g·cm^{-3}.

4.21 A face-centered cubic unit cell contains four atoms.

Thus mass = $\frac{4 \times 107.9 \text{ g} \cdot \text{mol}^{-1}}{6.02 \times 10^{23} \text{ mol}^{-1}}$ = 7.17×10^{-22} g

Volume = $\frac{7.17 \times 10^{-22} \text{ g}}{10.50 \text{ g} \cdot \text{cm}^{-3}}$ = 6.83×10^{-23} cm^3 = 6.83×10^7 pm^3

Length of side = $\sqrt[3]{(6.83 \times 10^7 \text{ pm}^3)}$ = 409 pm

Using the result from 4.17, radius of silver atom = (409 pm)/(2.83)
= 145 pm.

4.23 Among the most unusual properties, a suspension of gold nanoparticles has a red color.