Problem 12-58

Use Coulomb’s law to verify the conclusion concerning the relative strengths of the attractive forces in the ion pairs Na\(^+\)Cl\(^-\) and Mg\(^{2+}\)O\(^2-\) presented in Figure 12-36 of the textbook.

**Solution**

Coulomb's Law is

\[
F = \frac{q_1 q_2}{\varepsilon r^2}
\]

where \(q\) is the charge of each particle in the attraction or repulsion, \(r\) is the distance from charge centers, and \(\varepsilon\) is the dielectric constant (\(\varepsilon = 1\) for a vacuum).

Figure 12-36 shows the internuclear distance for NaCl to be 280 pm and 212 pm for MgO.

Let’s calculate the relative bond strength for each bond:

NaCl \[ F = \frac{(+1)(-1)}{(280)^2} = -1.28 \times 10^{-5} \text{ (showing no units since it’s a relative number)} \]

MgO \[ F = \frac{(+2)(-2)}{(212)^2} = -8.90 \times 10^{-5} \text{ (showing no units since it’s a relative number)} \]

The forces are negative since unlike charges attract.

The ratio of the Coulombic attractions are

\[
\text{ratio} = \frac{-8.90 \times 10^{-5}}{-1.28 \times 10^{-5}} = 7.4
\]

The MgO bond is about 7x stronger than the NaCl bond.