Coulomb's Law and the Ionic Bond

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

Coulombs 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 ε is the dielectric constant (ε = 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 $F = \frac{(+1)(-1)}{(280)^2} = -1.28 \times 10^{-5}$ (showing no units since it's a relative number)

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

The forces are negative since unlike charges attract.

The ratio of the Coulombic attractions are

$$ratio = \frac{-8.90 \times 10^{-5}}{-1.28 \times 10^{-5}} = 7.4$$

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