PROBLEM 73 (cont.)

The true charges are actually $1.602 \times 10^{-19}$ C for every unit of charge. Using this and the calculated distance, I can calculate the interaction energy between a single Na$^+$ ion and a Cl$^-$ ion.

$$E = k \frac{Q_1 Q_2}{d}$$

$$= (8.99 \times 10^9 \text{J} \cdot \text{m/C}^2) \left( \frac{1.602 \times 10^{-19} \text{C}}{2.78 \times 10^{-10} \text{m}} \text{C} \right)$$

$$= -8.30 \times 10^{-19} \text{J}$$

For a mole of such pairs the energy would be

$$E = (-8.30 \times 10^{-19} \text{J})(6.02 \times 10^{23} \text{mol}) = -5.00 \times 10^5 \text{ J/mol}$$

$$E = -500 \text{ kJ/mol}$$

This number does not match the lattice energy of NaCl = 788 kJ/mol (note: The sign convention is to write lattice energy as a positive value, NaCl(s) → Na$^+$(g) + Cl$^-$ (g), but make no mistake bringing the ions together to form a solid will release energy and be exothermic).

The discrepancy with the experimentally determined lattice energy arises for several reasons:

1. We have neglected the crystal structure of NaCl where each Na$^+$ is surrounded by 6 Cl$^-$ and vice versa.
2. We have neglected the repulsive energy of the Na$^+$ - Na$^+$ and Cl$^-$ - Cl$^-$ interactions.
3. True charges in ionic compounds are actually less than the oxidation state values (in this case of +1 and -1).