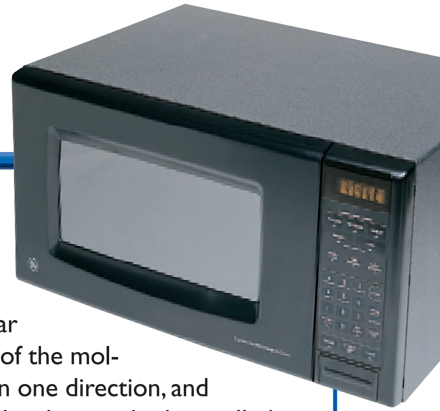
Why it Matters

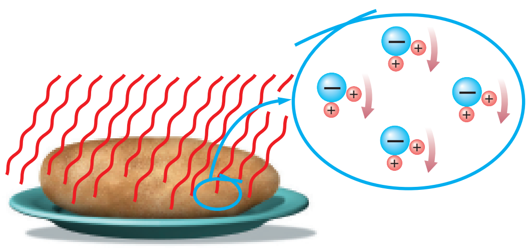


Microwave Ovens

It would be hard to find a town in America that does not have a microwave oven. Most homes, convenience stores, and restaurants have this marvelous invention that somehow heats only the soft parts of the food and leaves the inorganic and hard materials, like ceramic and the surfaces of bone, at approximately the same temperature. A neat trick, indeed, but how is it done?

Microwave ovens take advantage of a property of water molecules called *bipolarity.* Water molecules are considered bipolar because each molecule has a positive and a negative end. In other words, more of the electrons in these molecules are at one end of the molecule than the other.

Because microwaves are a high-frequency form of electromagnetic radiation, they supply an electric field that changes polarity billions of times a second. As this electric field passes a bipolar molecule, the positive side of the molecule experiences a force in one direction, and the negative side of the molecule is pushed or pulled in the other direction. When the field changes polarity, the directions of these forces are reversed. Instead of tearing apart, the molecules swing around and line up with the electric field.



As the bipolar molecules swing around, they rub against one another, producing friction. This friction in turn increases the internal energy of the food. Energy is transferred to the food by radiation (the microwaves) as opposed to conduction from hot air, as in a conventional oven.

Depending on the microwave oven's power and design, this rotational motion can generate up to about 3 J of internal energy each second in 1 g of water. At this rate, a top-power microwave oven can boil a cup (250 mL) of water in 2 min using about 0.033 kW•h of electricity.

Items such as dry plates and the air in the oven are unaffected by the fluctuating electric field because they are not polarized. Because energy is not wasted on heating these nonpolar items, the microwave oven cooks food faster and more efficiently than other ovens.

SECTION REVIEW

1. Find the electric field at a point midway between two charges of $+40.0 \times 10^{-9}$ C and $+60.0 \times 10^{-9}$ C separated by a distance of 30.0 cm.

2. Two point charges are a small distance apart.

a. Sketch the electric field lines for the two if one has a charge four times that of the other and if both charges are positive.

b. Repeat **(a),** but assume both charges are negative.

3. Interpreting Graphics **Figure 14** shows the electric field lines for two point charges separated by a small distance.

a. Determine the ratio q_1/q_2.

b. What are the signs of q_1 and q_2?

4. Critical Thinking Explain why you're more likely to get a shock from static electricity by touching a metal object with your finger instead of with your entire hand.

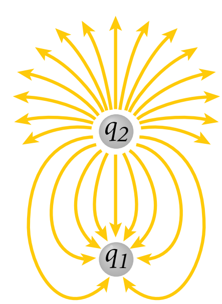


Figure 14