Chapter

7

Solubility and Reactions

In this chapter, you will be able to

- describe the effect of temperature on the solubility of solids, liquids, and gases in water;
- explain hardness of water, its consequences, and water-softening methods;
- predict combinations of aqueous solutions that produce precipitates and represent these reactions using net ionic equations;
- describe the technology and the major steps involved in the purification of water and the treatment of waste water;
- perform qualitative and quantitative analyses of solutions.

It is easier to handle a great many chemicals when they are in solution, particularly those that are toxic, corrosive, or gaseous. Both in homes and at worksites, transporting, loading, and storing chemicals are more convenient and efficient when the chemicals are in solution rather than in solid or gaseous states. Also, performing a reaction in solution can change the rate (speed), the extent (completeness), and the type (kind of product) of the chemical reaction.

Solutions make it easy to

- handle chemicals—a solid or gas is dissolved in water for ease of use or transportation;
- complete reactions—some chemicals do not react until in a solution where there is increased contact between the reacting entities;
- control reactions—the rate, extent, and type of reactions are much more easily controlled when one or more reactants are in solution.

These three points all apply to the liquid cleaning solution in **Figure 1**. The cleaning solution is easy to handle, and the fact that it is sold in a spray bottle adds to its convenience. Spraying a solution is an effective way of handling a chemical that is dissolved in water. Secondly, the solution allows a reaction to occur between the cleaning chemicals and the dirty deposit, whereas a pure gas or solid would not react well with a solid. Thirdly, the manufacturer can control the rate of the reaction (and thus the safety) by choosing the ideal concentration of the cleaning solution. Having the chemical in solution rather than in its pure state increases our ability to handle and control it.

In this chapter we will examine several concepts, including the extent to which one substance will dissolve in another, and the effect of temperature on the extent of dissolving. In chemical reactions we often wish to produce a product that is more or less soluble than the reactants. In fact, this is one of the most common techniques used for separating chemical substances. This chapter will help you understand how to do this.

Reflect on your Learning

1. A liquid you are using at home or in the laboratory may be a solution or a pure substance. Which is most likely? How would you test the liquid to determine whether it is a solution or a pure substance?
2. When dissolving a chemical in water, the rate of dissolving is often confused with the extent of dissolving. How do you speed up the rate of dissolving of a solute? How do you know if no more solute will dissolve?
3. Reactions in solution are common. If two aqueous solutions are mixed, what evidence would indicate that a reaction has occurred? How would you know if the change was just a physical change rather than a chemical change?

Figure 1
The low solubility of the soap deposit is overcome by a chemical reaction.

Try This Activity

Measuring the Dissolving Process

Are there different kinds of salt? How much salt can you get to dissolve? What happens to the volume of a solution when a solute is added to it? This quick activity will help you to think about the answers to these questions.

Materials: distilled or deionized water, table salt, coarse pickling salt (pure $NaCl_{(s)}$), a measuring teaspoon (5 mL), two 250-mL Erlenmeyer flasks, with stoppers, one 100-mL graduated cylinder or measuring cup

- Place a level teaspoonful of table salt into 100 mL of pure water at room temperature in a 250-mL Erlenmeyer flask. Swirl the flask's contents thoroughly for a minute or two. Record your observations.
- Repeat with pickling salt, again recording your observations.

(a) What does the result, with common table salt as a solute, show about the nature of the substance being used? Compare it with the solution in the second flask.
(b) List the ingredients in common table salt, according to the package label, and explain your observations of the contents of the first flask.

- Add a further teaspoon of pickling salt to the second flask, and swirl until the solid is again completely dissolved. Keeping track of how much pickling salt you add, continue to dissolve level teaspoons of salt until no amount of swirling will make all of the solid crystals disappear.

(c) How many level teaspoons of pickling salt (pure $NaCl_{(s)}$) could you get to dissolve in 100 mL of $H_2O_{(l)}$ in the second flask?
(d) What is the final volume of your $NaCl_{(aq)}$ solution in the second flask?
(e) If you dissolve 20.0 mL of $NaCl_{(s)}$ in 100.0 mL of liquid water, what do you suppose the volume of the solution would be? Can you think of a way to test this? The answer is very interesting.