1. *The state of subdivision of the solute.* A crushed aspirin tablet will dissolve in water more rapidly than a whole aspirin tablet. The more compact whole aspirin tablet has less surface area, and thus fewer solvent molecules can interact with it at a given time.
2. *The degree of agitation during solution preparation.* Stirring solution components disperses the solute particles more rapidly, increasing the possibilities for solute–solvent interactions. Hence the rate of solution formation is increased.
3. *The temperature of the solution components.* Solution formation occurs more rapidly as the temperature is increased. At a higher temperature, both solute and solvent molecules move more rapidly (Section 7.1) so more interactions between them occur within a given time period.

Figure 8.6 Oil spills can be contained to some extent by using trawlers and a boom apparatus because oil and water, having different polarities, are relatively insoluble in each other. The oil, which is of lower density, floats on top of the water.

8.4 SOLUBILITY RULES

In this section, we will present some rules for qualitatively predicting solute solubilities. These rules are based on polarity considerations—specifically, on the magnitude of the difference between the polarity of the solute and solvent. In general, it is found that the greater the difference in solute–solvent polarity, the less soluble is the solute. This means that *substances of like polarity tend to be more soluble in each other than substances that differ in polarity.* This conclusion is often expressed as the simple phrase "*like dissolves like.*" Polar substances, in general, are good solvents for other polar substances but not for nonpolar substances (see Figure 8.6). Similarly, nonpolar substances exhibit greater solubility in nonpolar solvents than in polar solvents.

The generalization "like dissolves like" is a useful tool for predicting solubility behavior in many, but not all, solute–solvent situations. Results that agree with this generalization are nearly always obtained in the cases of gas-in-liquid and liquid-in-liquid solutions and for solid-in-liquid solutions in which the solute is not an ionic compound. For example, NH_3 gas (a polar gas) is much more soluble in H_2O (a polar liquid) than is O_2 gas (a nonpolar gas).

In the common case of solid-in-liquid solutions in which the solute is an ionic compound, the rule "like dissolves like" is not adequate. Their polar nature would suggest that all ionic compounds are soluble in a polar solvent such as water, but this is not the case. The failure of the generalization for ionic compounds is related to the complexity of the factors involved in determining the magnitude of the solute–solute (ion–ion) and solvent–solute (solvent–ion) interactions. Among other things, both the charge and the size of the ions in the solute must be considered. Changes in these factors affect both types of interactions, but not to the same extent.

The generalization "like dissolves like" is not adequate for predicting the solubilities of *ionic compounds* in water. More detailed solubility guidelines are needed (see Table 8.2).

Some guidelines concerning the solubility of ionic compounds in water, which should be used in place of "like dissolves like," are given in Table 8.2.

TABLE 8.2
Solubility Guidelines for Ionic Compounds in Water

Soluble Compounds	Important Exceptions
Compounds containing the following ions are soluble with exceptions as noted.	
group IA (Li^+, Na^+, K^+, etc.)	none
ammonium (NH_4^+)	none
acetate ($C_2H_3O_2^-$)	none
nitrate (NO_3^-)	none
chloride (Cl^-), bromide (Br^-), and iodide (I^-)	Ag^+, Pb^{2+}, Hg_2^{2+}
sulfate (SO_4^{2-})	Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}
Insoluble Compounds*	**Important Exceptions**
Compounds containing the following ions are insoluble with exceptions as noted.	
carbonate (CO_3^{2-})	group IA and NH_4^+
phosphate (PO_4^{3-})	group IA and NH_4^+
sulfide (S^{2-})	groups IA and IIA and NH_4^+
hydroxide (OH^-)	group IA, Ca^{2+}, Sr^{2+}, Ba^{2+}

*All ionic compounds, even the least soluble ones, dissolve to some slight extent in water. Thus the "insoluble" classification really means ionic compounds that have very limited solubility in water.