3.6 PUTTING PRECIPITATION TO WORK

We can make insoluble compounds by choosing starting solutions that will result in a precipitate of the desired insoluble compound when they are mixed. Then we can separate it from the reaction mixture by filtration. This strategy is commonly used in environmental monitoring, where it may be necessary to find out how much lead or mercury is in a sample of water. Precipitating the lead or mercury ions as insoluble compounds allows us to separate them and measure their amounts. The **solubility** rules given in Table 3.1 summarize the observed solubility patterns of common ionic compounds in water. Notice that all nitrates and all compounds of the common Group 1 metals are soluble, so they make useful starting solutions.

Any spectator ions can be used, provided they remain in solution and do not otherwise react. For example, the table shows that mercury(I) iodide, Hg_2I_2, is insoluble. It is formed as a precipitate whenever solutions containing Hg_2^{2+} ions and I^- ions are mixed:

The mercury(I) ion is Hg_2^{2+}, with two Hg^+ ions bonded together.

$$Hg_2^{2+}(aq) + 2\,I^-(aq) \longrightarrow Hg_2I_2(s)$$

Mercury(I) nitrate, $Hg_2(NO_3)_2$, is soluble (like all nitrates) and potassium iodide, KI, is soluble (like all common compounds of Group 1 metals), so we can predict that mixing solutions of mercury(I) nitrate and potassium iodide will result in the precipitation of mercury(I) iodide (Fig. 3.14). The chemical equation for this reaction is

$$Hg_2(NO_3)_2(aq) + 2\,KI(aq) \longrightarrow Hg_2I_2(s) + 2\,KNO_3(aq)$$

and the complete ionic equation is

$$Hg_2^{2+}(aq) + 2\,NO_3^-(aq) + 2\,K^+(aq) + 2\,I^-(aq) \longrightarrow Hg_2I_2(s) + 2\,NO_3^-(aq) + 2\,K^+(aq)$$

The K^+ and NO_3^- ions are spectators and remain in solution. The same precipitate results when we mix *any* soluble mercury(I) compound with *any* soluble iodide, because in every case the mercury(I) and iodide ions will form insoluble mercury(I) iodide. For example, we could also form mercury(I) iodide from aqueous solutions of mercury(I) acetate and sodium iodide, both of which are soluble:

$$Hg_2(CH_3CO_2)_2(aq) + 2\,NaI(aq) \longrightarrow Hg_2I_2(s) + 2\,NaCH_3CO_2(aq)$$

This chemical equation has the same net ionic equation as the equation for the reaction of $Hg_2(NO_3)_2$ and KI:

$$Hg_2^{2+}(aq) + 2\,I^-(aq) \longrightarrow Hg_2I_2(s)$$



FIGURE 3.14 Another example of a precipitation reaction. This time, a solution of mercury(I) nitrate is being added to a solution of potassium iodide, and the insoluble product, mercury(I) iodide, is precipitated.

EXAMPLE 3.3 Predicting the outcome of a precipitation reaction

Predict the likely product when aqueous solutions of sodium phosphate, Na_3PO_4, and lead(II) nitrate, $Pb(NO_3)_2$, are mixed. Write the net ionic equation for the reaction.

STRATEGY Decide which ions are present in the mixed solutions and consider all possible combinations. Use the solubility rules to decide which combination corresponds to an insoluble compound, and write the net ionic equation to match.