$$Ba(NO_3)_2(s) \longrightarrow Ba^{2+}(aq) + 2NO_3^-(aq)$$

Each formula unit of barium nitrate yields three ions in solution.

$$\frac{0.239 \cancel{\text{mol Ba(NO}_3)_2}}{\cancel{\text{kg H}_2\text{O}}} \times \frac{3 \cancel{\text{mol ions}}}{\cancel{\text{mol Ba(NO}_3)_2}} \times \frac{-1.86°\text{C} \cdot \cancel{\text{kg H}_2\text{O}}}{\cancel{\text{mol ions}}} = -1.33°\text{C}$$

4 *EVALUATE* The units cancel properly to give the desired answer in °C. The answer is correctly given to three significant digits. The mass of the solute is approximately one-fourth its molar mass and would give 0.75 mol of ions in the 1 kg of solvent, so the estimated answer of 0.75 × (–1.86°C) = –1.4°C supports our computation.

PRACTICE *Answers in Appendix E*

1. What is the expected freezing-point depression for a solution that contains 2.0 mol of magnesium sulfate dissolved in 1.0 kg of water?
2. What is the expected boiling-point elevation of water for a solution that contains 150 g of sodium chloride dissolved in 1.0 kg of water?
3. The freezing point of an aqueous sodium chloride solution is –0.20°C. What is the molality of the solution?

extension

Go to **go.hrw.com** for more practice problems that ask you to calculate the freezing-point depression and boiling-point elevation for electrolyte solutions.

Keyword: HC6IONX

Actual Values for Electrolyte Solutions

It is important to remember that the values just calculated are only *expected* values. As stated earlier, a 0.1 *m* solution of sodium chloride lowers the freezing point *nearly* twice as much as a 0.1 *m* solution of sucrose. The actual values of the colligative properties for all strong electrolytes are *almost* what would be expected based on the number of particles they produce in solution. Some specific examples are given in **Table 3.** The freezing-point depression of a compound that produces two ions per formula unit is almost twice that of a nonelectrolytic solution. The freezing-point depression of a compound that produces three ions per formula unit is almost three times that of a nonelectrolytic solution.

TABLE 3 ***Molal Freezing-Point Depressions for Aqueous Solutions of Ionic Solutes***

Solute	Concentration (m)	Δt_f, observed (°C)	Δt_f, nonelectrolyte solution (°C)	$\frac{\Delta t_f\text{, observed}}{\Delta t_f\text{, nonelectrolyte solution}}$
KCl	0.1	−0.345	−0.186	1.85
	0.01	−0.0361	−0.0186	1.94
	0.001	−0.00366	−0.00186	1.97
$MgSO_4$	0.1	−0.225	−0.186	1.21
	0.01	−0.0285	−0.0186	1.53
	0.001	−0.00338	−0.00186	1.82
$BaCl_2$	0.1	−0.470	−0.186	2.53
	0.01	−0.0503	−0.0186	2.70
	0.001	−0.00530	−0.00186	2.84