SAMPLE PROBLEM C

For more help, go to the Math Tutor at the end of this chapter.

What is the freezing-point depression of water in a solution of 17.1 g of sucrose, $C_{12}H_{22}O_{11}$, in 200. g of water? What is the actual freezing point of the solution?

SOLUTION

1 ANALYZE

Given: solute mass and chemical formula = 17.1 g $C_{12}H_{22}O_{11}$
solvent mass and identity = 200. g water

Unknown: **a.** freezing-point depression
b. freezing point of the solution

2 PLAN

Find the molal freezing-point constant, K_f, for water in **Table 2.** To use the equation for freezing-point depression, $\Delta t_f = K_f m$, you need to determine the molality of the solution.

$$\text{mass of solute (g)} \times \frac{\text{1 mol solute}}{\text{molar mass of solute (g)}} = \text{amount of solute (mol)}$$

$$\frac{\text{amount of solute (mol)}}{\text{mass of solvent (g)}} \times \frac{\text{1000 g water}}{\text{1 kg water}} = \text{molality}$$

$$\Delta t_f = K_f m$$

$$\text{f.p. solution} = \text{f.p. solvent} + \Delta t_f$$

3 COMPUTE

$$17.1\ \cancel{\text{g } C_{12}H_{22}O_{11}} \times \frac{1\text{ mol } C_{12}H_{22}O_{11}}{342.34\ \cancel{\text{g } C_{12}H_{22}O_{11}}} = 0.0500\text{ mol } C_{12}H_{22}O_{11}$$

$$\frac{0.0500\text{ mol } C_{12}H_{22}O_{11}}{200.\ \cancel{\text{g water}}} \times \frac{1000\ \cancel{\text{g water}}}{\text{kg water}} = \frac{0.250\text{ mol } C_{12}H_{22}O_{11}}{\text{kg water}} = 0.250\ m$$

a. $\Delta t_f = 0.250\ \cancel{m} \times (-1.86°\text{C}/\cancel{m}) = -0.465°\text{C}$

b. f.p. solution = 0.000°C + (−0.465°C) = −0.465°C

SAMPLE PROBLEM D

For more help, go to the Math Tutor at the end of this chapter.

A water solution containing an unknown quantity of a nonelectrolyte solute is found to have a freezing point of −0.23°C. What is the molal concentration of the solution?

SOLUTION

1 ANALYZE

Given: freezing point of solution = −0.23°C

Unknown: molality of the solution

2 PLAN

Water is the solvent, so you will need the value of K_f, the molal-freezing-point constant for water, from **Table 2.** The Δt_f for this solution is the difference between the f.p. of water and the f.p. of the solution. Use the equation for freezing-point depression to calculate molality.

$$\Delta t_f = \text{f.p. of solution} - \text{f.p. of pure solvent}$$

$$\Delta t_f = K_f m \qquad \text{Solve for molality, } m.$$

$$m = \frac{\Delta t_f}{K_f}$$