

## 16.4

# CALCULATIONS INVOLVING COLLIGATIVE PROPERTIES

## Section Review

### Objectives

- Calculate the molality and mole fraction of a solution
- Describe how the freezing-point depression and boiling-point elevation are related to molality

### Vocabulary

- molality ( $m$ )
- mole fraction
- molal freezing-point depression constant ( $K_f$ )
- molal boiling-point elevation constant ( $K_b$ )

### Key Equations

- Molality =  $\frac{\text{moles of solute}}{\text{kilogram of solvent}}$
- mole fractions:  $X_A = \frac{n_A}{n_A + n_B}$        $X_B = \frac{n_B}{n_A + n_B}$   
 where  $n_A$  = moles of solute  
 $n_B$  = moles of solvent
- $\Delta T_b = K_b \times m$
- $\Delta T_f = K_f \times m$

### Part A Completion

Use this completion exercise to check your understanding of the concepts and terms that are introduced in this section. Each blank can be completed with a term, short phrase, or number.

Molality is an expression of concentration involving the ratio of 1 particles to 2 particles. Molality is expressed as moles of solute per 3 of solvent.

Another expression of concentration is 4, in which concentrations are expressed as the ratio of moles of solute to the total number of moles of solvent and solute. Each solvent has a characteristic 5 elevation constant and molal freezing-point 6 constant. The elevation in boiling point of a solution can be calculated by multiplying the 7 concentration of the solution by the boiling-point 8 constant of the solvent.

## Part B True-False

Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

- \_\_\_\_\_ 9. It is possible to calculate the molar mass of a solute if you know the  $K_b$  or  $K_f$  of a solvent.
- \_\_\_\_\_ 10. Molal concentration is the same as molar concentration.
- \_\_\_\_\_ 11. The depression in freezing point of a solution is proportional to the molal concentration of solute.
- \_\_\_\_\_ 12. The sum of  $X_A$  and  $X_B$  for any solution is always 1.

## Part C Matching

Match each description in Column B to the correct term in Column A.

### Column A

- \_\_\_\_\_ 13. molality
- \_\_\_\_\_ 14. mole fraction
- \_\_\_\_\_ 15. molal freezing-point depression constant
- \_\_\_\_\_ 16. molal boiling-point elevation constant
- \_\_\_\_\_ 17. molar mass

### Column B

- a. a constant for a given solvent equal to the change in boiling point for a  $1m$  solution
- b. number of moles of solute dissolved in 1 kilogram of solvent
- c. mass of one mole of a substance
- d. a constant for a given solvent equal to the change in freezing point for a  $1m$  solution
- e. ratio of moles of solute in solution to the total number of moles of solute and solvent

## Part D Problem

Solve the following problem in the space provided. Show your work.

18. What is the freezing point of a solution that contains 2.0 mol of  $\text{CaCl}_2$  in 800.0 g of water?  $K_f$  for water =  $1.86^\circ\text{C}/m$