16. a. Why does the level of the more-concentrated solution rise when two solutions of different concentrations are separated by a semipermeable membrane?
b. When does the level of the solution stop rising?
c. When the level stops rising, what is the net movement of water molecules across the membrane?

17. a. Compare the effects of nonvolatile electrolytes with the effects of nonvolatile nonelectrolytes on the freezing and boiling points of solvents in which they are dissolved.
b. Why are such differences observed?

18. Why does the actual freezing-point depression of an electrolytic solution differ from the freezing-point depression calculated on the basis of the concentration of particles?

PRACTICE PROBLEMS

19. Determine the freezing-point depression of H_2O in each of the following solutions. (Hint: See Sample Problem C.)
a. 1.50 *m* solution of $C_{12}H_{22}O_{11}$ (sucrose) in H_2O
b. 171 g of $C_{12}H_{22}O_{11}$ in 1.00 kg H_2O
c. 77.0 g of $C_{12}H_{22}O_{11}$ in 400. g H_2O

20. Given the following freezing-point depressions, determine the molality of each solution of an unknown nonelectrolyte in water. (Hint: See Sample Problem D.)
a. –0.930°C
b. –3.72°C
c. –8.37°C

21. A solution contains 20.0 g of $C_6H_{12}O_6$ (glucose) in 250. g of water.
a. What is the freezing-point depression of the solvent?
b. What is the freezing point of the solution?

22. How many grams of antifreeze, $C_2H_4(OH)_2$, would be required per 500. g of water to prevent the water from freezing at a temperature of –20.0°C?

23. Pure benzene, C_6H_6, freezes at 5.45°C. A solution containing 7.24 g $C_2Cl_4H_2$ in 115 g of benzene (specific gravity = 0.879) freezes at 3.55°C. Based on these data, what is the molal freezing-point constant for benzene?

24. If 1.500 g of a solute that has a molar mass of 125.0 g were dissolved in 35.00 g of camphor, what would be the resulting freezing point of the solution?

25. Determine the boiling-point elevation of H_2O in each of the following solutions. (Hint: See Sample Problem E.)
a. 2.5 *m* solution of $C_6H_{12}O_6$ (glucose) in H_2O
b. 3.20 g $C_6H_{12}O_6$ in 1.00 kg H_2O
c. 20.0 g $C_{12}H_{22}O_{11}$ (sucrose) in 500. g H_2O

26. Given the following boiling points, determine the molality of each water solution.
a. 100.25°C
b. 101.53°C
c. 102.805°C

27. Given 1.00 *m* aqueous solutions of each of the following electrolytic substances, determine the expected change in the freezing point of the solvent. (Hint: See Sample Problem F.)
a. KI
b. $CaCl_2$
c. $Ba(NO_3)_2$

28. What is the expected change in the freezing point of water for a 0.015 *m* aqueous solution of $AlCl_3$?

29. What is the expected freezing point of a solution containing 85.0 g NaCl dissolved in 450. g of water?

30. Determine the expected boiling point of a solution made by dissolving 25.0 g of barium chloride in 0.150 kg of water.

31. The change in the boiling point of water for an aqueous solution of potassium iodide is 0.65°C. Determine the molal concentration of potassium iodide.

32. The freezing point of an aqueous solution of barium nitrate is –2.65°C. Determine the molal concentration of barium nitrate.

33. Calculate the expected freezing point of a solution containing 1.00 kg H_2O and 0.250 mol NaCl.

34. Experimental data for a 1.00 *m* MgI_2 aqueous solution indicate an actual change in the freezing point of water of –4.78°C. Find the expected change in the freezing point of water. Suggest a possible reason for the discrepancy between the experimental and expected values.