28. molality = $\frac{40.0 \text{ g EG}}{60.0 \text{ g } H_2O} \times \frac{1000 \text{ g}}{\text{kg}} \times \frac{1 \text{ mol EG}}{62.07 \text{ g}}$ = 10.7 mol/kg where EG = ethylene glycol ($C_2H_6O_2$)

molarity = $\frac{40.0 \text{ g EG}}{100.0 \text{ g solution}} \times \frac{1.05 \text{ g}}{\text{cm}^3} \times \frac{1000 \text{ cm}^3}{\text{L}} \times \frac{1 \text{ mol}}{62.07 \text{ g}}$ = 6.77 mol/L

40.0 g EG × $\frac{1 \text{ mol}}{62.07 \text{ g}}$ = 0.644 mol EG; 60.0 g H_2O × $\frac{1 \text{ mol}}{18.02 \text{ g}}$ = 3.33 mol H_2O

$\chi_{EG} = \frac{0.644}{3.33 + 0.644}$ = 0.162 = mole fraction ethylene glycol

34. $\frac{1.00 \text{ mol acetone}}{1.00 \text{ kg ethanol}}$ = 1.00 molal; 1.00 × 10^3 g C_2H_5OH × $\frac{1 \text{ mol}}{46.07 \text{ g}}$ = 21.7 mol C_2H_5OH

$\chi_{acetone} = \frac{1.00}{1.00 + 21.7}$ = 0.0441

1 mol CH_3COCH_3 × $\frac{58.08 \text{ g } CH_3COCH_3}{\text{mol } CH_3COCH_3} \times \frac{1 \text{ mL}}{0.788 \text{ g}}$ = 73.7 mL CH_3COCH_3

1.00 × 10^3 g ethanol × $\frac{1 \text{ mL}}{0.789 \text{ g}}$ = 1270 mL; Total volume = 1270 + 73.7 = 1340 mL

molarity = $\frac{1.00 \text{ mol}}{1.34 \text{ L}}$ = 0.746 *M*

40. a. water b. water c. hexane d. water

48. $P_{C_2H_5OH} = \chi_{C_2H_5OH} P^\circ_{C_2H_5OH}$; $\chi_{C_2H_5OH} = \frac{\text{mol } C_2H_5OH \text{ solution}}{\text{total mol in solution}}$

53.6 g $C_3H_8O_3$ × $\frac{1 \text{ mol } C_3H_8O_3}{92.09 \text{ g}}$ = 0.582 mol $C_3H_8O_3$

133.7 g C_2H_5OH × $\frac{1 \text{ mol } C_2H_5OH}{46.07 \text{ g}}$ = 2.90 mol C_2H_5OH; total mol = 0.582 + 2.90 = 3.48 mol

113 torr = $\frac{2.90 \text{ mol}}{3.48 \text{ mol}} \times P^\circ_{C_2H_5OH}$, $P^\circ_{C_2H_5OH}$ = 136 torr

54. $P_{tol} = \chi^L_{tol} P^\circ_{tol}$; $P_{ben} = \chi^L_{ben} P^\circ_{ben}$; For the vapor, $\chi^V_A = P_A/P_{total}$. Since the mole fractions of benzene and toluene are equal in the vapor phase, then $P_{tol} = P_{ben}$.

$\chi^L_{tol} P^\circ_{tol} = \chi^L_{ben} P^\circ_{ben} = (1.00 - \chi^L_{tol}) P^\circ_{ben}$, χ^L_{tol}(28 torr) = $(1.00 - \chi^L_{tol})$95 torr

123 χ^L_{tol} = 95, χ^L_{tol} = 0.77; χ^L_{ben} = 1.00 − 0.77 = 0.23

60. $\Delta T_b = 77.85°C - 76.50°C = 1.35°C$; $m = \frac{\Delta T_b}{K_b} = \frac{1.35°C}{5.03°C\ kg/mol} = 0.268\ mol/kg$

$$\text{mol biomolecule} = 0.0150\ \text{kg solvent} \times \frac{0.268\ \text{mol hydrocarbon}}{\text{kg solvent}} = 4.02 \times 10^{-3}\ \text{mol}$$

From the problem, 2.00 g biomolecule was used which must contain 4.02×10^{-3} mol biomolecule. The molar mass of the biomolecule is:

$$\frac{2.00\ g}{4.02 \times 10^{-3}\ mol} = 498\ g/mol$$

66. empirical formula mass ≈ 7(12) + 4(1) + 16 = 104 g/mol

$$\Delta T_f = K_f m,\ m = \frac{\Delta T_f}{K_f} = \frac{22.3°C}{40.°C/molal} = 0.56\ molal$$

$$\text{mol anthraquinone} = 0.0114\ \text{kg solvent} \times \frac{0.56\ \text{mol anthraquinone}}{\text{kg solvent}} = 6.4 \times 10^{-3}\ \text{mol}$$

$$\text{molar mass} = \frac{1.32\ g}{6.4 \times 10^{-3}\ mol} = 210\ g/mol$$

$$\frac{\text{molar mass}}{\text{empirical formula mass}} = \frac{210}{104} = 2.0;\ \text{molecular formula} = C_{14}H_8O_2$$

72. The solutions of $C_{12}H_{22}O_{11}$, NaCl and $CaCl_2$ will all have lower freezing points, higher boiling points and higher osmotic pressures than pure water. The solution with the largest particle concentration will have the lowest freezing point, the highest boiling point and the highest osmotic pressure. The $CaCl_2$ solution will have the largest effective particle concentration since it produces three ions per mol of compound.

a. pure water b. $CaCl_2$ solution c. $CaCl_2$ solution

d. pure water e. $CaCl_2$ solution

74. $NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$, i = 2.0

$$\pi = iMRT = 2.0 \times \frac{0.10\ mol}{L} \times \frac{0.08206\ L\ atm}{mol\ K} \times 293\ K = 4.8\ atm$$

A pressure greater than 4.8 atm should be applied to insure purification by reverse osmosis.

76. a. $MgCl_2$, i(observed) = 2.7

$\Delta T_f = iK_f m = 2.7 \times 1.86°C/\text{molal} \times 0.050 \text{ molal} = 0.25°C$; $T_f = -0.25°C$

$\Delta T_b = iK_b m = 2.7 \times 0.51°C/\text{molal} \times 0.050 \text{ molal} = 0.069°C$; $T_b = 100.069°C$

b. $FeCl_3$, i(observed) = 3.4

$\Delta T_f = iK_f m = 3.4 \times 1.86\ °C/\text{molal} \times 0.050 \text{ molal} = 0.32°C$; $T_f = -0.32°C$

$\Delta T_b = iK_b m = 3.4 \times 0.51°C/\text{molal} \times 0.050 \text{ molal} = 0.087°C$; $T_b = 100.087°C$

84. $m = \dfrac{24.0 \text{ g} \times \dfrac{1 \text{ mol}}{58.0 \text{ g}}}{0.600 \text{ kg}} = 0.690 \text{ mol/kg}$; $\Delta T_b = K_b m = 0.51°C \text{ kg/mol} \times 0.690 \text{ mol/kg} = 0.35°C$

$T_b = 99.725°C + 0.35°C = 100.08°C$