AP Chemistry: Chapter 14 - Solutions and their Behavior
Problems: 1, 5, 9, 11, 13, 17, 19, 23, 25, 31, 35, 39, 48, 51, 55

14.1 $2.56\ \text{g} \cdot \dfrac{1\ \text{mol}\ C_2H_4(CO_2H)_2}{118.1\ \text{g}} = 0.0217\ \text{mol}\ C_2H_4(CO_2H)_2$

$500.\ \text{mL} \cdot \dfrac{1\ \text{cm}^3}{1\ \text{mL}} \cdot \dfrac{1.00\ \text{g}}{1\ \text{cm}^3} \cdot \dfrac{1\ \text{mol}\ H_2O}{18.02\ \text{g}} = 27.7\ \text{mol}\ H_2O$

(a) $m = \dfrac{\text{amount of solute}}{\text{kg of solvent}} = \dfrac{0.0217\ \text{mol}\ C_2H_4(CO_2H)_2}{500.\ \text{g}} \cdot \dfrac{10^3\ \text{g}}{1\ \text{kg}} = 0.0434\ m$

(b) $X_{\text{acid}} = \dfrac{0.0217\ \text{mol}}{0.0217\ \text{mol} + 27.7\ \text{mol}} = 0.000781$

(c) $\text{Weight \%} = \dfrac{2.56\ \text{g}}{2.56\ \text{g} + 500.\ \text{g}} \cdot 100\% = 0.509\%$

14.5 $\dfrac{0.200\ \text{mol}\ Na_2CO_3}{1\ \text{kg}\ H_2O} \cdot \dfrac{106.0\ \text{g}}{1\ \text{mol}\ Na_2CO_3} \cdot \dfrac{125\ \text{g}\ H_2O}{10^3\ \text{g}/1\ \text{kg}} = 2.65\ \text{g}\ Na_2CO_3$

$X_{Na_2CO_3} = \dfrac{0.200\ \text{mol}\ Na_2CO_3}{0.200\ \text{mol}\ Na_2CO_3 + \left(10^3\ \text{g} \cdot \dfrac{1\ \text{mol}\ H_2O}{18.02\ \text{g}}\right)} = 0.00359$

14.9 (a) $\text{Mass of solution} = 1\ \text{L} \cdot \dfrac{1000\ \text{mL}}{1\ \text{L}} \cdot \dfrac{1.18\ \text{g}}{\text{mL}} = 1180\ \text{g solution}$

$\text{Mass of HCl} = 1\ \text{L} \cdot \dfrac{12.0\ \text{mol HCl}}{1\ \text{L}} \cdot \dfrac{36.46\ \text{g}}{1\ \text{mol HCl}} = 438\ \text{g HCl}$

$\text{Mass of}\ H_2O = 1180\ \text{g} - 438\ \text{g} = 742\ \text{g}\ H_2O$

$m = \dfrac{12.0\ \text{mol HCl}}{0.742\ \text{kg}\ H_2O} = 16.2\ m$

(b) $\text{Weight \%} = \dfrac{438\ \text{g HCl}}{1180\ \text{g solution}} \cdot 100\% = 37.1\%$

14.11 $\dfrac{0.18\ \text{g}\ Li^+}{1 \times 10^6\ \text{g}\ H_2O} \cdot \dfrac{1\ \text{mol}\ Li^+}{6.941\ \text{g}} \cdot \dfrac{10^3\ \text{g}}{1\ \text{kg}} = 2.6 \times 10^{-5}\ m$

14.13 (b) C_6H_6 and CCl_4 both are nonpolar molecules

(c) H_2O and CH_3CO_2H both are polar molecules

14.17 (c) Raise the temperature of the solution and add some NaCl

14.19 (a) LiF Lithium ions are smaller than rubidium ions

(b) $Ca(NO_3)_2$ Calcium has a larger positive charge (+2) than potassium (+1)

(c) $CuBr_2$ Cu has a larger positive charge (+2) than cesium (+1) and it is a smaller ion

14.23 $P_{CO_2} = \dfrac{S_{CO_2}}{k_H} = \dfrac{0.0506\ \text{M}}{4.48 \times 10^{-5}\ \text{M/mm Hg}} = 1130\ \text{mm Hg}\ (1.49\ \text{atm})$

14.25 $35.0\ \text{g} \cdot \dfrac{1\ \text{mol HOCH}_2\text{CH}_2\text{OH}}{62.07\ \text{g}} = 0.564\ \text{mol HOCH}_2\text{CH}_2\text{OH}$

$500.0\ \text{g} \cdot \dfrac{1\ \text{mol H}_2\text{O}}{18.02\ \text{g}} = 27.75\ \text{mol H}_2\text{O}$

$X_{\text{H}_2\text{O}} = \dfrac{27.75\ \text{mol}}{27.75\ \text{mol} + 0.564\ \text{mol}} = 0.980$

$P_{\text{H}_2\text{O}} = X_{\text{H}_2\text{O}} P^{\circ}_{\text{H}_2\text{O}}$

$P_{\text{H}_2\text{O}} = (0.980)(35.7\ \text{mm Hg}) = 35.0\ \text{mm Hg}$

14.31 $m_{\text{C}_{12}\text{H}_{10}} = \dfrac{0.515\ \text{g} \cdot \dfrac{1\ \text{mol C}_{12}\text{H}_{10}}{154.2\ \text{g}}}{0.0150\ \text{kg CHCl}_3} = 0.223\ m$

$\Delta T_{\text{bp}} = (3.63\ ^{\circ}\text{C}/m)(0.223\ m) = 0.808\ ^{\circ}\text{C}$

$T_{\text{bp}} = 61.70\ ^{\circ}\text{C} + 0.808\ ^{\circ}\text{C} = 62.51\ ^{\circ}\text{C}$

14.35 (a) $m_{\text{ethanol}} = \dfrac{\Delta T_{\text{fp}}}{K_{\text{fp}}} = \dfrac{-16.0\ ^{\circ}\text{C}}{-1.86\ ^{\circ}\text{C}/m} = 8.60\ m$

(b) $8.60\,\text{mol C}_2\text{H}_5\text{OH} \cdot \dfrac{46.07\ \text{g}}{1\ \text{mol C}_2\text{H}_5\text{OH}} = 396\ \text{g C}_2\text{H}_5\text{OH}$

$\text{Weight \%} = \dfrac{396\ \text{g C}_2\text{H}_5\text{OH}}{396\ \text{g C}_2\text{H}_5\text{OH} + (1.00 \times 10^3\ \text{g H}_2\text{O})} \cdot 100\% = 28.4\%$

14.39 $\Delta T_{\text{bp}} = 80.26\ ^{\circ}\text{C} - 80.10\ ^{\circ}\text{C} = 0.16\ ^{\circ}\text{C}$

$m_{\text{solute}} = \dfrac{\Delta T_{\text{bp}}}{K_{\text{bp}}} = \dfrac{0.16\ ^{\circ}\text{C}}{2.53\ ^{\circ}\text{C}/m} = 0.063\ m$

$\dfrac{0.063\ \text{mol solute}}{1\ \text{kg benzene}} \cdot 0.01112\ \text{kg benzene} = 7.0 \times 10^{-4}\ \text{mol solute}$

$\dfrac{0.255\ \text{g}}{7.0 \times 10^{-4}\ \text{mol}} = 360\ \text{g/mol}$

$\dfrac{360\ \text{g/mol}}{184\ \text{g/mol}} = 2$ The molecular formula is $(\text{C}_{10}\text{H}_8\text{Fe})_2$ or $\text{C}_{20}\text{H}_{16}\text{Fe}_2$

14.48 $m_{\text{NaCl}} = \dfrac{\Delta T_{\text{fp}}}{K_{\text{fp}} \cdot i} = \dfrac{-10.\ ^{\circ}\text{C}}{(-1.86\ ^{\circ}\text{C}/m)(1.85)} = 2.9\ m$

$\dfrac{2.9\ \text{mol NaCl}}{1\ \text{kg H}_2\text{O}} \cdot \dfrac{58.5\ \text{g}}{1\ \text{mol NaCl}} \cdot 3.0\ \text{kg H}_2\text{O} = 510\ \text{g NaCl}$

14.51 $3.00\,\text{g } C_9H_{11}NO_2 \cdot \dfrac{1\text{ mol } C_9H_{11}NO_2}{165.2\text{ g}} = 0.0182\text{ mol } C_9H_{11}NO_2$

$$m_{C_9H_{11}NO_2} = \frac{0.0182\text{ mol } C_9H_{11}NO_2}{0.09700\text{ kg } H_2O} = 0.187\ m$$

(a) $\Delta T_{fp} = K_{fp} m_{C_9H_{11}NO_2} = (-1.86\ ^\circ\text{C}/m)(0.187\ m) = -0.348\ ^\circ\text{C}$

$T_{fp} = -0.348\ ^\circ\text{C}$

(b) $\Delta T_{bp} = K_{bp} m_{C_9H_{11}NO_2} = (0.5121\ ^\circ\text{C}/m)(0.187\ m) = 0.0959\ ^\circ\text{C}$

$T_{bp} = 100.0959\ ^\circ\text{C}$

(c) $\Pi = cRT = \left(\dfrac{0.0182\text{ mol}}{0.09700\text{ L}}\right)(0.082057\text{ L}\cdot\text{atm/K}\cdot\text{mol})(298\text{ K}) = 4.58\text{ atm}$

The osmotic pressure is large and can be measured with the least experimental error.

14.55 (a) $BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2\ NaCl(aq)$

(b) Initially the $BaSO_4$ particles form a colloidal suspension.

(c) Over time the particles of solid $BaSO_4$ grow and precipitate.