Chapter 8 Solutions

Solutions to In-Chapter Problems

8.1 A heterogeneous mixture does not have a uniform composition throughout a sample. A solution is a homogeneous mixture that contains small particles. Liquid solutions are transparent. A colloid is a homogeneous mixture with larger particles, often having an opaque appearance.

a. Cherry Garcia ice cream: heterogeneous mixture  
b. mayonnaise: colloid  
c, d, e. seltzer water, nail polish remover, and brass: solutions

8.2 A substance that conducts an electric current in water is called an electrolyte. If a solution contains ions, it will conduct electricity. A substance that does not conduct an electric current in water is called a nonelectrolyte. If a solution contains neutral molecules, it will not conduct electricity.

a. KCl in H₂O: electrolyte  
b. sucrose (C₁₂H₂₂O₁₁) in H₂O: nonelectrolyte  
c. KI in H₂O: electrolyte

8.3 Use the general solubility rule: “Like dissolves like.” Generally, ionic and polar compounds are soluble in water. Nonpolar compounds are soluble in nonpolar solvents.

a. NaNO₃: ionic compound—water soluble  
b. CH₄: nonpolar compound—NOT water soluble  
c. HO—C—C—OH: polar compound—water soluble  
d. KBr: ionic compound—water soluble  
e. NH₂OH: polar compound—water soluble

8.4 a. Benzene (C₆H₆) and hexane (C₆H₁₄): both nonpolar compounds—would form a solution.  
b. Na₂SO₄ and H₂O: one ionic compound and one polar compound—would form a solution.  
c. NaCl and hexane (C₆H₁₄): one ionic and one nonpolar compound—cannot form a solution.  
d. H₂O and CCl₄: one polar and one nonpolar compound—cannot form a solution.

8.5 Identify the cation and anion and use the solubility rules to predict if the ionic compound is water soluble.

a. Li₂CO₃: cation Li⁺ with anion CO₃²⁻—water soluble.  
b. MgCO₃: cation Mg²⁺ with anion CO₃²⁻—water insoluble.  
c. KBr: cation K⁺ with anion Br⁻—water soluble.  
d. PbSO₄: cation Pb²⁺ with anion SO₄²⁻—water insoluble.  
e. CaCl₂: cation Ca²⁺ with anion Cl⁻—water soluble.  
f. MgCl₂: cation Mg²⁺ with anion Cl⁻—water soluble.
8.6 Magnesium salts are not water soluble unless the anion is a halide, nitrate, acetate, or sulfate. The interionic forces between Mg$^{2+}$ and OH$^-$ must be stronger than the forces of attraction between the ions and water. Therefore, milk of magnesia is a heterogeneous mixture, rather than a solution.

8.7 A soft drink becomes “flat” when CO$_2$ escapes from the solution. CO$_2$ comes out of solution faster at room temperature than at the cooler temperature of the refrigerator because the solubility of gases in liquids decreases as the temperature increases.

8.8 For most ionic and molecular solids, solubility generally increases as temperature increases. The solubility of gases decreases with increasing temperature. Pressure changes do not affect the solubility of liquids and solids. The higher the pressure, the higher the solubility of a gas in a solvent.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Na$_2$CO$_3$(s)</th>
<th>N$_2$(g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. increasing temperature</td>
<td>increased solubility</td>
<td>decreased solubility</td>
</tr>
<tr>
<td>b. decreasing temperature</td>
<td>decreased solubility</td>
<td>increased solubility</td>
</tr>
<tr>
<td>c. increasing pressure</td>
<td>no change</td>
<td>increased solubility</td>
</tr>
<tr>
<td>d. decreasing pressure</td>
<td>no change</td>
<td>decreased solubility</td>
</tr>
</tbody>
</table>

8.9 Use the formula in Example 8.2 to solve the problem; 525 mg = 0.525 g bismuth subsalicylate.

\[
(w/v)\% = \frac{0.525 \text{ g bismuth}}{15 \text{ mL solution}} \times 100\% = 3.5\% \text{ (w/v) bismuth subsalicylate}
\]

Answer

8.10 Use the formula in Example 8.2 to solve the problems.

\[
(w/v)\% = \frac{4.3 \text{ g ethanol}}{30 \text{ mL solution}} \times 100\% = 14\% \text{ (w/v) ethanol}
\]

Answer

\[
(w/v)\% = \frac{0.021 \text{ g antiseptic}}{30 \text{ mL solution}} \times 100\% = 0.070\% \text{ (w/v) antiseptic}
\]

Answer

8.11 Use the formula in Example 8.3 to solve the problem.

\[
(v/v)\% = \frac{21 \text{ mL ethanol}}{250 \text{ mL mouthwash}} \times 100\% = 8.4\% \text{ (v/v) ethanol}
\]

Answer
8.12 Use the stepwise analysis in Example 8.4 to solve the problem.

<table>
<thead>
<tr>
<th>Known quantities</th>
<th>Desired quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.0% (v/v) mouthwash</td>
<td>? mL ethanol</td>
</tr>
<tr>
<td>30. mL</td>
<td>100 mL mouthwash</td>
</tr>
</tbody>
</table>

\[
\frac{8.0 \text{ mL ethanol}}{100 \text{ mL mouthwash}} \times \frac{30 \text{ mL mouthwash}}{100 \text{ mL mouthwash}} = 2.4 \text{ mL ethanol}
\]

8.13 Use the stepwise analysis in Example 8.5 to solve the problem.

<table>
<thead>
<tr>
<th>Known quantities</th>
<th>Desired quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.50% (w/v) vitamin C</td>
<td>? mL solution</td>
</tr>
<tr>
<td>1.000. mg vitamin C</td>
<td>100 mL solution</td>
</tr>
</tbody>
</table>

\[
\frac{1000 \text{ mg}}{1 \text{ g}} \times \frac{1 \text{ g}}{1000 \text{ mg}} = 1 \text{ g vitamin C}
\]

\[
\frac{1 \text{ g vitamin C}}{100 \text{ mL solution}} \times \frac{0.50 \text{ g vitamin C}}{100 \text{ mL solution}} = 2.0 \times 10^2 \text{ mL solution}
\]

8.14 Use the stepwise analysis in Example 8.4 to solve the problem.

<table>
<thead>
<tr>
<th>Known quantities</th>
<th>Desired quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.20% (w/v) dextromethorphan</td>
<td>? mg of each drug</td>
</tr>
<tr>
<td>2.0% (w/v) guaifenisin</td>
<td>3.0 tsp = 15 mL cough syrup</td>
</tr>
</tbody>
</table>

\[
\frac{15 \text{ mL cough syrup}}{30 \text{ mg dextromethorphan}} = \frac{30 \text{ mg dextromethorphan}}{1 \text{ g}}
\]

\[
\frac{15 \text{ mL cough syrup}}{2.0 \text{ g guaifenisin}} = \frac{3.0 \times 10^2 \text{ mg guaifenisin}}{1 \text{ g}}
\]
8.15 Use the formula, ppm = (g of solute)/(g of solution) \times 10^6 to calculate parts per million as in Example 8.6.

a. \(0.042 \text{ mg DDT} \times \frac{1 \text{ g}}{1000 \text{ mg}} = 0.000 042 \text{ g DDT} \quad \frac{0.000 042 \text{ g DDT}}{1,400 \text{ g plankton}} \times 10^6 = 0.030 \text{ ppm DDT}

Answer

b. \(1.0 \text{ kg tissue} \times \frac{1000 \text{ g}}{1.0 \text{ kg}} = 1,000 \text{ g tissue} \quad \frac{5 \times 10^{-4} \text{ g DDT}}{1,000 \text{ g tissue}} \times 10^6 = 0.5 \text{ ppm DDT}

Answer

c. \(2.0 \text{ mg DDT} \times \frac{1 \text{ g}}{1000 \text{ mg}} = 0.0020 \text{ g DDT} \quad \frac{0.0020 \text{ g DDT}}{1,000 \text{ g tissue}} \times 10^6 = 2.0 \text{ ppm DDT}

Answer

d. \(225 \text{ µg DDT} \times \frac{1 \text{ g}}{1,000,000 \text{ µg}} = 0.000 225 \text{ g DDT} \quad \frac{0.000 225 \text{ g DDT}}{1.0 \times 10^3 \text{ g breast milk}} \times 10^6 = 0.23 \text{ ppm DDT}

Answer

8.16 Calculate the molarity of each aqueous solution as in Example 8.7.

a. \(M = \frac{\text{moles of solute (mol)}}{V \text{ (L)}} = \frac{1.0 \text{ mol NaCl}}{0.50 \text{ L solution}} = 2.0 \text{ M}

Answer

b. \(2.0 \text{ mol NaCl} \div 0.25 \text{ L solution} = 8.0 \text{ M}

Answer

c. \(0.050 \text{ mol NaCl} \div 0.0050 \text{ L solution} = 10. \text{ M}

Answer

d. \(0.205 \text{ mol NaCl} \div 2.0 \text{ L solution} = 0.10 \text{ M}

Answer

e. \(0.418 \text{ mol NaCl} \div 0.35 \text{ L solution} = 1.2 \text{ M}

Answer

f. \(1.03 \text{ mol NaCl} \div 0.75 \text{ L solution} = 1.4 \text{ M}

Answer
8.17 Calculate the molarity of each solution to determine which has the higher concentration.

\[
\text{10.0 g NaOH} \times \frac{1 \text{ mol NaOH}}{40.00 \text{ g NaOH}} = 0.250 \text{ mol NaOH}
\]

\[
150 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} = 0.15 \text{ L}
\]

\[
M = \frac{0.250 \text{ mol NaOH}}{0.15 \text{ L solution}} = 1.7 \text{ M}
\]

Answer more concentrated

\[
\text{15.0 g NaOH} \times \frac{1 \text{ mol NaOH}}{40.00 \text{ g NaOH}} = 0.375 \text{ mol NaOH}
\]

\[
250 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} = 0.25 \text{ L}
\]

\[
M = \frac{0.375 \text{ mol NaOH}}{0.25 \text{ L solution}} = 1.5 \text{ M}
\]

Answer

8.18 Use the molarity as a conversion factor to determine the number of milliliters as in Sample Problem 8.9.

a. \[V(\text{L}) = \frac{\text{moles of solute (mol)}}{M} = \frac{0.15 \text{ mol glucose}}{1.5 \text{ mol/L}} = 0.10 \text{ L solution}\]

\[
V(\text{L}) = \frac{\text{moles of solute (mol)}}{M} = \frac{0.15 \text{ mol glucose}}{1.5 \text{ mol/L}} = 0.10 \text{ L solution}
\]

\[
0.10 \text{ solution} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 1.0 \times 10^2 \text{ mL glucose solution}
\]

Answer

b. \[V(\text{L}) = \frac{\text{moles of solute (mol)}}{M} = \frac{0.020 \text{ mol glucose}}{1.5 \text{ mol/L}} = 0.013 \text{ L solution}
\]

\[
V(\text{L}) = \frac{\text{moles of solute (mol)}}{M} = \frac{0.020 \text{ mol glucose}}{1.5 \text{ mol/L}} = 0.013 \text{ L solution}
\]

\[
0.013 \text{ solution} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 13 \text{ mL glucose solution}
\]

Answer

c. \[V(\text{L}) = \frac{\text{moles of solute (mol)}}{M} = \frac{0.0030 \text{ mol glucose}}{1.5 \text{ mol/L}} = 0.0020 \text{ L solution}
\]

\[
V(\text{L}) = \frac{\text{moles of solute (mol)}}{M} = \frac{0.0030 \text{ mol glucose}}{1.5 \text{ mol/L}} = 0.0020 \text{ L solution}
\]

\[
0.0020 \text{ solution} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 2.0 \text{ mL glucose solution}
\]

Answer

d. \[V(\text{L}) = \frac{\text{moles of solute (mol)}}{M} = \frac{3.0 \text{ mol glucose}}{1.5 \text{ mol/L}} = 2.0 \text{ L solution}
\]

\[
V(\text{L}) = \frac{\text{moles of solute (mol)}}{M} = \frac{3.0 \text{ mol glucose}}{1.5 \text{ mol/L}} = 2.0 \text{ L solution}
\]

\[
2.0 \text{ L solution} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 2.0 \times 10^3 \text{ mL glucose solution}
\]

Answer

8.19 Use the molarity as a conversion factor to determine the number of moles.

a. \[\text{mol} = V(\text{L}) \times M = (2.0 \text{ L})(2.0 \text{ mol/L}) = 4.0 \text{ mol NaCl}
\]

b. \[\text{mol} = V(\text{L}) \times M = (2.5 \text{ L})(0.25 \text{ mol/L}) = 0.63 \text{ mol NaCl}
\]
c. mol = V \, (L) \cdot M = (0.025 \, \text{L})(2.0 \, \text{mol/L}) = 0.050 \, \text{mol NaCl} \\

d. mol = V \, (L) \cdot M = (0.25 \, \text{L})(0.25 \, \text{mol/L}) = 0.063 \, \text{mol NaCl}

8.20 Use the molarity to convert the volume of the solution to moles of solute. Then use the molar mass to convert moles to grams as in Example 8.8.

<table>
<thead>
<tr>
<th>Volume</th>
<th>Molarity</th>
<th>Molar Mass Conversion Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 0.10 , \text{L solution}</td>
<td>\frac{1.25 , \text{mol NaCl}}{1 , \text{L}}</td>
<td>\frac{58.44 , \text{g NaCl}}{1 , \text{mol NaCl}}</td>
</tr>
<tr>
<td>b. 2.0 , \text{L solution}</td>
<td>\frac{1.25 , \text{mol NaCl}}{1 , \text{L}}</td>
<td>\frac{58.44 , \text{g NaCl}}{1 , \text{mol NaCl}}</td>
</tr>
<tr>
<td>c. 0.55 , \text{L solution}</td>
<td>\frac{1.25 , \text{mol NaCl}}{1 , \text{L}}</td>
<td>\frac{58.44 , \text{g NaCl}}{1 , \text{mol NaCl}}</td>
</tr>
<tr>
<td>d. 50. , \text{mL solution}</td>
<td>\frac{1 , \text{mol NaCl}}{1000 , \text{mL}} \cdot \frac{1.25 , \text{mol NaCl}}{1 , \text{L}}</td>
<td>\frac{58.44 , \text{g NaCl}}{1 , \text{mol NaCl}}</td>
</tr>
</tbody>
</table>

\begin{align*}
\text{a.} & \quad 0.125 \, \text{mol NaCl} \times \frac{58.44 \, \text{g NaCl}}{1 \, \text{mol NaCl}} = 7.3 \, \text{g NaCl} \\
\text{Answer} & \\
\text{b.} & \quad 2.5 \, \text{mol NaCl} \times \frac{58.44 \, \text{g NaCl}}{1 \, \text{mol NaCl}} = 150 \, \text{g NaCl} \\
\text{Answer} & \\
\text{c.} & \quad 0.69 \, \text{mol NaCl} \times \frac{58.44 \, \text{g NaCl}}{1 \, \text{mol NaCl}} = 40. \, \text{g NaCl} \\
\text{Answer} & \\
\text{d.} & \quad 0.125 \, \text{mol NaCl} \times \frac{58.44 \, \text{g NaCl}}{1 \, \text{mol NaCl}} = 7.3 \, \text{g NaCl} \\
\text{Answer} & \\
\end{align*}

8.21 Use the molar mass to convert grams to moles. Then use the molarity to convert moles of solute to volume of solution. Sample Problem 8.10 is similar, but the order of steps is different.

<table>
<thead>
<tr>
<th>Molar Mass Conversion Factor</th>
<th>Molarity Conversion Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 0.500 , \text{g sucrose} \times \frac{1 , \text{mol sucrose}}{342.3 , \text{g sucrose}} \times \frac{1 , \text{L}}{0.25 , \text{mol sucrose}} \times \frac{1000 , \text{mL}}{1 , \text{L}} = 5.8 , \text{mL solution}</td>
<td></td>
</tr>
<tr>
<td>b. 2.0 , \text{g sucrose} \times \frac{1 , \text{mol sucrose}}{342.3 , \text{g sucrose}} \times \frac{1 , \text{L}}{0.25 , \text{mol sucrose}} \times \frac{1000 , \text{mL}}{1 , \text{L}} = 23 , \text{mL solution}</td>
<td></td>
</tr>
<tr>
<td>c. 1.25 , \text{g sucrose} \times \frac{1 , \text{mol sucrose}}{342.3 , \text{g sucrose}} \times \frac{1 , \text{L}}{0.25 , \text{mol sucrose}} \times \frac{1000 , \text{mL}}{1 , \text{L}} = 15 , \text{mL solution}</td>
<td></td>
</tr>
<tr>
<td>d. 50.0 , \text{mg sucrose} \times \frac{1 , \text{mol sucrose}}{1000 , \text{mg}} \times \frac{1 , \text{mol sucrose}}{342.3 , \text{g sucrose}} \times \frac{1 , \text{L}}{0.25 , \text{mol sucrose}} \times \frac{1000 , \text{mL}}{1 , \text{L}} = 0.58 , \text{mL solution}</td>
<td></td>
</tr>
</tbody>
</table>

\begin{align*}
\text{a.} & \quad 5.8 \, \text{mL solution} \\
\text{Answer} & \\
\text{b.} & \quad 23 \, \text{mL solution} \\
\text{Answer} & \\
\text{c.} & \quad 15 \, \text{mL solution} \\
\text{Answer} & \\
\text{d.} & \quad 0.58 \, \text{mL solution} \\
\text{Answer} & \\
\end{align*}
8.22 Calculate a new molarity \( (M_2) \) using the equation, \( M_1V_1 = M_2V_2 \).

\[
M_2 = \frac{M_1V_1}{V_2} = \frac{(3.8 \text{ M})(25.0 \text{ mL})}{(275 \text{ mL})} = 0.35 \text{ M glucose solution}
\]

Answer

8.23 Calculate the volume needed \( (V_1) \) using the equation, \( M_1V_1 = M_2V_2 \).

\[
a. \quad V_1 = \frac{M_2V_2}{M_1} = \frac{(2.5 \text{ M})(525 \text{ mL})}{6.0 \text{ M}} = 220 \text{ mL}
\]

Answer

\[
b. \quad V_1 = \frac{M_2V_2}{M_1} = \frac{(4.0 \text{ M})(750 \text{ mL})}{6.0 \text{ M}} = 5.0 \times 10^2 \text{ mL}
\]

Answer

\[
c. \quad V_1 = \frac{M_2V_2}{M_1} = \frac{(0.10 \text{ M})(450 \text{ mL})}{6.0 \text{ M}} = 7.5 \text{ mL}
\]

Answer

\[
d. \quad V_1 = \frac{M_2V_2}{M_1} = \frac{(3.5 \text{ M})(25 \text{ mL})}{6.0 \text{ M}} = 15 \text{ mL}
\]

Answer

8.24 Calculate the new concentration of ketamine, and determine the volume needed to supply 75 mg.

\[
C_2 = \frac{C_1V_1}{V_2} = \frac{(100. \text{ mg/mL})(2.0 \text{ mL})}{10.0 \text{ mL}} = 20. \text{ mg/mL}
\]

75 \text{ mg} \times \frac{1 \text{ mL}}{20. \text{ mg}} = 3.8 \text{ mL}

Answer

8.25 Determine the number of “particles” contained in the solute. Use 0.51 °C/mol as a conversion factor to relate the temperature change to the number of moles of solute particles, as in Example 8.10.

a. 2.0 mol of sucrose molecules

\[
\frac{0.51 \text{ °C}}{\text{mol particles}} \times 2.0 \text{ mol} = 1.0 \text{ °C} \quad \text{Boiling point} = 100.0 \text{ °C} + 1.0 \text{ °C} = 101.0 \text{ °C}
\]

b. 2.0 mol of KNO₃

\[
\frac{0.51 \text{ °C}}{\text{mol particles}} \times 2.0 \text{ mol KNO₃} \times \frac{2 \text{ mol particles}}{\text{mol KNO₃}} = 2.0 \text{ °C}
\]

Boiling point = 100.0 °C + 2.0 °C = 102.0 °C
c. 2.0 mol of CaCl₂

\[
\frac{0.51 \, ^\circ \text{C}}{\text{mol particles}} \times 2.0 \, \text{mol CaCl}_2 \times \frac{3 \, \text{mol particles}}{\text{mol CaCl}_2} = 3.1 \, ^\circ \text{C}
\]

Boiling point = 100.0 °C + 3.1 °C = 103.1 °C

d. 20.0 g of NaCl

\[
20.0 \, \text{g NaCl} \times \frac{1 \, \text{mol NaCl}}{58.44 \, \text{g NaCl}} = 0.342 \, \text{mol NaCl}
\]

\[
\frac{0.51 \, ^\circ \text{C}}{\text{mol particles}} \times 0.342 \, \text{mol NaCl} \times \frac{2 \, \text{mol particles}}{\text{mol NaCl}} = 0.35 \, ^\circ \text{C}
\]

Boiling point = 100.0 °C + 0.35 °C = 100.35 °C rounded to 100.4 °C

8.26 Determine the number of “particles” contained in the solute. Use 1.86 °C/mol as a conversion factor to relate temperature change to the number of moles of solute particles, as in Sample Problem 8.14.

a. 2.0 mol of sucrose molecules

\[
\frac{1.86 \, ^\circ \text{C}}{\text{mol particles}} \times 2.0 \, \text{mol} = 3.7 \, ^\circ \text{C} \quad \text{Melting point} = -3.7 \, ^\circ \text{C}
\]

b. 2.0 mol of KNO₃

\[
\frac{1.86 \, ^\circ \text{C}}{\text{mol particles}} \times 2.0 \, \text{mol KNO}_3 \times \frac{2 \, \text{mol particles}}{\text{mol KNO}_3} = 7.4 \, ^\circ \text{C} \quad \text{Melting point} = -7.4 \, ^\circ \text{C}
\]

c. 2.0 mol of CaCl₂

\[
\frac{1.86 \, ^\circ \text{C}}{\text{mol particles}} \times 2.0 \, \text{mol CaCl}_2 \times \frac{3 \, \text{mol particles}}{\text{mol CaCl}_2} = 11 \, ^\circ \text{C} \quad \text{Melting point} = -11 \, ^\circ \text{C}
\]

d. 20.0 g of NaCl

\[
20.0 \, \text{g NaCl} \times \frac{1 \, \text{mol NaCl}}{58.44 \, \text{g NaCl}} = 0.342 \, \text{mol NaCl}
\]

\[
\frac{1.86 \, ^\circ \text{C}}{\text{mol particles}} \times 0.342 \, \text{mol NaCl} \times \frac{2 \, \text{mol particles}}{\text{mol NaCl}} = 1.27 \, ^\circ \text{C} \quad \text{Melting point} = -1.27 \, ^\circ \text{C}
\]

8.27 Determine the number of moles of ethylene glycol. Use 1.86 °C/mol as a conversion factor to relate temperature change to the number of moles of solute particles, as in Sample Problem 8.14.

\[
250 \, \text{g ethylene glycol} \times \frac{1 \, \text{mol}}{62.07 \, \text{g}} = 4.0 \, \text{mol ethylene glycol}
\]

\[
\text{temperature decrease} = \frac{1.86 \, ^\circ \text{C}}{\text{mol particles}} \times 4.0 \, \text{mol C}_2\text{H}_6\text{O}_2 = -7.4 \, ^\circ \text{C}
\]
8.28 The solvent (water) flows from the less concentrated solution to the more concentrated solution.
   a. A 5.0% sugar solution has greater osmotic pressure than a 1.0% sugar solution.
   b. 4.0 M NaCl has greater osmotic pressure than 3.0 M NaCl.
   c. 0.75 M NaCl has greater osmotic pressure than 1.0 M glucose solution because NaCl has two particles for each NaCl, whereas glucose has only one.

8.29
   a. Water flows across the membrane.
   b. More water initially flows from the 1.0 M side to the more concentrated 1.5 M side. When equilibrium is reached there is equal flow of water in both directions.
   c. The height of the 1.5 M side will be higher and the height of the 1.0 M NaCl will be lower.

8.30 A hypotonic solution has a lower osmotic pressure than body fluids.
   A hypertonic solution has a higher osmotic pressure than body fluids.
   a. A 3% (w/v) glucose solution is hypotonic, so it will cause hemolysis.
   b. A 0.15 M KCl solution is isotonic, so no change results.
   c. A 0.15 M Na₂CO₃ solution is hypertonic, so it will cause crenation.

### Solutions to End-of-Chapter Problems

8.31 A shows KI dissolved in water, since the K⁺ and I⁻ ions are separated when KI is dissolved. The solution contains ions, so it conducts an electric current. B shows KI as a molecule, without being separated into ions, a situation that does not occur.

8.32 B shows NaF dissolved in water, since the Na⁺ and F⁻ ions are separated when NaF is dissolved. The solution contains ions, so it conducts an electric current. A shows NaF as a molecule, without being separated into ions, a situation that does not occur.

8.33 Use the definitions from Answer 8.1 to classify each substance as a heterogeneous mixture, a solution, or a colloid.
   a. bronze (alloy of Sn and Cu): solution
d. household ammonia: solution
   b. diet soda: solution
e. gasoline: solution
   c. orange juice with pulp: heterogeneous mixture
   f. fog: colloid

8.34 Use the definitions from Answer 8.1 to classify each substance as a heterogeneous mixture, a solution, or a colloid.
   a. soft drink: solution
d. lava rock: heterogeneous mixture
   b. cream: colloid
e. bleach: solution
   c. wine: solution
   f. apple juice: solution

8.35 A solution that has less than the maximum number of grams of solute is said to be **unsaturated**.
   A solution that has the maximum number of grams of solute that can dissolve is said to be **saturated**.
   A solution that has more than the maximum number of grams of solute is said to be **supersaturated**.
a. Adding 30 g to 100 mL of H₂O at 20 °C: unsaturated
b. Adding 65 g to 100 mL of H₂O at 50 °C: saturated
c. Adding 20 g to 50 mL of H₂O at 20 °C: saturated
d. Adding 42 g to 100 mL of H₂O at 50 °C and slowly cooling to 20 °C to give a clear solution with no precipitate: supersaturated

8.36 A solution that has less than the maximum number of grams of solute is said to be unsaturated. A solution that has the maximum number of grams of solute that can dissolve is said to be saturated. A solution that has more than the maximum number of grams of solute is said to be supersaturated.

a. Adding 200 g to 100 mL of H₂O at 20 °C: unsaturated
b. Adding 245 g to 100 mL of H₂O at 50 °C: unsaturated
c. Adding 110 to 50 mL of H₂O at 20 °C: saturated
d. Adding 220 g to 100 mL of H₂O at 50 °C and slowly cooling to 20 °C to give a clear solution with no precipitate: supersaturated

8.37 Use the general solubility rule: “Like dissolves like.” Generally, ionic and polar compounds are soluble in water. Nonpolar compounds are soluble in nonpolar solvents.

\[
\begin{array}{c}
\text{a. LiCl} & \text{b. H-C=C-C-CH₃} \\
\text{ionic} & \text{nonpolar} \\
\text{water soluble} & \text{NOT water soluble}
\end{array}
\]
\[
\begin{array}{c}
\text{c. H-C-C-} & \text{d. Na₃PO₄} \\
\text{H} & \text{ionic} \\
\text{H} & \text{polar} \\
\text{H} & \text{water soluble}
\end{array}
\]

8.38 Use the general solubility rule: “Like dissolves like.” Generally, ionic and polar compounds are soluble in water, whereas nonpolar compounds are soluble in nonpolar solvents.

\[
\begin{array}{c}
\text{a. C₅H₁₂} & \text{b. CaCl₂} & \text{c. H-C=N-H} & \text{d. CH₃Br} \\
\text{nonpolar} & \text{ionic} & \text{polar} & \text{polar} \\
\text{NOT water soluble} & \text{water soluble} & \text{water soluble}
\end{array}
\]

8.39 Methanol will hydrogen bond to water.

\[
\text{hydrogen bond}
\]
8.40 Dimethyl ether can hydrogen bond with water.

8.41 Water-soluble compounds are ionic or are small polar molecules that can hydrogen bond with the water solvent, but nonpolar compounds, such as oil, are soluble in nonpolar solvents.

8.42 A bottle of salad dressing that contains oil and vinegar has two layers because the oil is nonpolar and the vinegar is polar. A heterogenous mixture is formed because the oil and vinegar are insoluble in each other.

8.43 Iodine would not be soluble in water but is soluble in CCl₄ since I₂ is nonpolar and CCl₄ is a nonpolar solvent.

8.44 Glycine is soluble in water because the nitrogen and oxygen atoms can form hydrogen bonds to water.

8.45 Cholesterol is not water soluble because it is a large nonpolar molecule with a single OH group.

8.46 a. KCl and CCl₄ do not form a solution.
   b. 1-Propanol (C₃H₈O) and H₂O do form a solution.
   c. Cyclohexanone (C₁₀H₁₈O) and H₂O do not form a solution.
   d. Pentane (C₅H₁₂) and hexane (C₆H₁₄) do form a solution.

8.47 The solubility of gases decreases with increasing temperature. The H₂O molecules are omitted in each representation.

a. Less O₂ is dissolved at 50 °C.

b. More O₂ is dissolved at 10 °C.
8.48 The solubility of most ionic solids increases with increasing temperature and decreases with decreasing temperature. The H₂O molecules are omitted in each representation.

\[ = \text{Na}^+ \quad = \text{Cl}^- \]

a. More NaCl is dissolved at 50 °C
b. Less NaCl is dissolved at 10 °C

8.49 For most ionic and molecular solids, solubility generally increases as temperature increases. The solubility of gases decreases as temperature increases.

Pressure changes do not affect the solubility of liquids and solids.

The higher the pressure, the higher the solubility of a gas in a solvent.

<table>
<thead>
<tr>
<th>NaCl(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. increasing temperature</td>
</tr>
<tr>
<td>b. decreasing temperature</td>
</tr>
<tr>
<td>c. increasing pressure</td>
</tr>
<tr>
<td>d. decreasing pressure</td>
</tr>
</tbody>
</table>

8.50 For most ionic and molecular solids, solubility generally increases as temperature increases. The solubility of gases decreases as temperature increases.

Pressure changes do not affect the solubility of liquids and solids.

The higher the pressure, the higher the solubility of a gas in a solvent.

<table>
<thead>
<tr>
<th>He(g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. increasing temperature</td>
</tr>
<tr>
<td>b. decreasing temperature</td>
</tr>
<tr>
<td>c. increasing pressure</td>
</tr>
<tr>
<td>d. decreasing pressure</td>
</tr>
</tbody>
</table>

8.51 A decrease in temperature (a) increases the solubility of a gas and (b) decreases the solubility of a solid.

8.52 A decrease in pressure (a) decreases the solubility of a gas and (b) has no affect on the solubility of a solid.

8.53 Many ionic compounds are soluble in water because the ion–dipole interactions between ions and water provide the energy needed to break apart the ions from the crystal lattice. The water molecules form a loose shell of solvent around each ion.

8.54 Some ionic compounds are insoluble in water because the attractions between the ions in the crystalline solid are stronger than the forces of attraction between the ions and water.
8.55 Identify the cation and anion and use the solubility rules to predict if the ionic compound is water soluble.

b. $MgSO_4$: cation $Mg^{2+}$ with anion $SO_4^{2-}$—water soluble.
c. $ZnCO_3$: cation $Zn^{2+}$ with anion $CO_3^{2-}$—not water soluble.
d. $KI$: cation $K^+$ with anion $I^-$—water soluble.
e. $Fe(NO_3)_3$: cation $Fe^{3+}$ with anion $NO_3^-$—water soluble.
f. $PbCl_2$: cation $Pb^{2+}$ with anion $Cl^-$—not water soluble.
g. $CsCl$: cation $Cs^+$ with anion $Cl^-$—water soluble.
h. $Ni(HCO_3)_2$: cation $Ni^{2+}$ with anion $HCO_3^-$—not water soluble.

8.56 Identify the cation and anion and use the solubility rules to predict if the ionic compound is water soluble.

a. $Al(NO_3)_3$: cation $Al^{3+}$ with anion $NO_3^-$—water soluble.
c. $Cr(OH)_2$: cation $Cr^{3+}$ with anion $OH^-$—not water soluble.
d. $LiOH$: cation $Li^+$ with anion $OH^-$—water soluble.
e. $CuCO_3$: cation $Cu^{2+}$ with anion $CO_3^{2-}$—not water soluble.
f. $(NH_4)_2SO_4$: cation $NH_4^+$ with anion $SO_4^{2-}$—water soluble.
g. $Fe(OH)_3$: cation $Fe^{3+}$ with anion $OH^-$—not water soluble.
h. $(NH_4)_3PO_4$: cation $NH_4^+$ with anion $PO_4^{3-}$—water soluble.

8.57 Write two conversion factors for each concentration.

a. $5\% (w/v)$
   \[
   \frac{5\ g}{100\ mL} \quad \frac{100\ mL}{5\ g}
   \]

b. $6.0\ M$
   \[
   \frac{6.0\ mol}{1.0\ L} \quad \frac{1.0\ L}{6.0\ mol}
   \]

c. $10\ ppm$
   \[
   \frac{10\ g}{10^6\ g} \quad \frac{10^6\ g}{10\ g}
   \]

8.58 Write two conversion factors for each concentration.

a. $15\% (w/v)$
   \[
   \frac{15\ mL}{100\ mL} \quad \frac{100\ mL}{15\ mL}
   \]

b. $12.0\ M$
   \[
   \frac{12.0\ mol}{1.0\ L} \quad \frac{1.0\ L}{12.0\ mol}
   \]

c. $15\ ppm$
   \[
   \frac{15\ g}{10^6\ g} \quad \frac{10^6\ g}{15\ g}
   \]

8.59 Use the formula in Example 8.2 to solve the problems.

a. \[
   (w/v)\% = \frac{10.0\ g\ LiCl}{750\ mL\ solution} \times 100\% = 1.3\% (w/v)\ LiCl
   \]
   Answer

b. \[
   (w/v)\% = \frac{25\ g\ NaNO_3}{150\ mL\ solution} \times 100\% = 17\% (w/v)\ NaNO_3
   \]
   Answer

c. \[
   (w/v)\% = \frac{40.0\ g\ NaOH}{500.\ mL\ solution} \times 100\% = 8.00\% (w/v)\ NaOH
   \]
   Answer
8.60  Use the formula in Example 8.2 to solve the problems.

a. \( (w/v)\% = \frac{5.5 \text{ g LiCl}}{550 \text{ mL solution}} \times 100\% = 1.0\%(w/v) \text{ LiCl} \)  
   \( \text{Answer} \)

b. \( (w/v)\% = \frac{12.5 \text{ g NaNO}_3}{250 \text{ mL solution}} \times 100\% = 5.0\%(w/v) \text{ NaNO}_3 \)  
   \( \text{Answer} \)

c. \( (w/v)\% = \frac{20.0 \text{ g NaOH}}{400. \text{ mL solution}} \times 100\% = 5.00\%(w/v) \text{ NaOH} \)  
   \( \text{Answer} \)

8.61  Use the formula in Example 8.3 to solve the problem.

\( (v/v)\% = \frac{25 \text{ mL ethyl acetate}}{150 \text{ mL solution}} \times 100\% = 17\%(v/v) \text{ ethyl acetate} \)  
   \( \text{Answer} \)

8.62  Use the formula in Example 8.3 to solve the problem.

\( (v/v)\% = \frac{75 \text{ mL acetone}}{250 \text{ mL solution}} \times 100\% = 30\% (v/v) \text{ acetone} \)  
   \( \text{Answer} \)

8.63  Calculate the molarity of each aqueous solution as in Example 8.7.

a. \( M = \frac{\text{moles of solute (mol)}}{V (L)} = \frac{3.5 \text{ mol KCl}}{1.50 \text{ L solution}} = 2.3 \text{ M} \)  
   \( \text{Answer} \)

b. \( 855 \text{ mL solution} \times \frac{1 \text{ L}}{1000 \text{ mL}} = 0.855 \text{ L solution} \)  
   \( M = \frac{\text{moles of solute (mol)}}{V (L)} = \frac{0.44 \text{ mol NaNO}_3}{0.855 \text{ L solution}} = 0.51 \text{ M} \)  
   \( \text{Answer} \)

c. \( 25.0 \text{ g NaCl} \times \frac{1 \text{ mol NaCl}}{58.44 \text{ g}} = 0.428 \text{ mol NaCl} \)  
   \( 650 \text{ mL solution} \times \frac{1 \text{ L}}{1000 \text{ mL}} = 0.65 \text{ L solution} \)  
   \( M = \frac{\text{moles of solute (mol)}}{V (L)} = \frac{0.428 \text{ mol NaCl}}{0.65 \text{ L solution}} = 0.66 \text{ M} \)  
   \( \text{Answer} \)

d. \( 10.0 \text{ g NaHCO}_3 \times \frac{1 \text{ mol NaHCO}_3}{84.01 \text{ g}} = 0.119 \text{ mol NaHCO}_3 \)  
   \( 3.3 \text{ L solution} \times \frac{1 \text{ mol NaHCO}_3}{3.3 \text{ L solution}} = 0.036 \text{ M} \)  
   \( \text{Answer} \)
8.64 Calculate the molarity of each aqueous solution as in Example 8.7.

a. \[ M = \frac{\text{moles of solute (mol)}}{V \text{ (L)}} = \frac{2.4 \text{ mol NaOH}}{1.50 \text{ L solution}} = 1.6 \text{ M} \]

b. \[ M = \frac{\text{moles of solute (mol)}}{V \text{ (L)}} = \frac{0.48 \text{ mol KNO}_3}{0.75 \text{ L solution}} = 0.64 \text{ M} \]

c. \[ M = \frac{\text{moles of solute (mol)}}{V \text{ (L)}} = \frac{0.335 \text{ mol KCl}}{0.65 \text{ L solution}} = 0.52 \text{ M} \]

d. \[ M = \frac{\text{moles of solute (mol)}}{V \text{ (L)}} = \frac{0.0943 \text{ mol Na}_2\text{CO}_3}{3.8 \text{ L solution}} = 0.025 \text{ M} \]

8.65

a. Add 12 g of acetic acid to the flask and then water to bring the volume to 250 mL.

\[(\text{w/v})\% = \frac{x \text{ g acetic acid}}{250 \text{ mL solution}} \times 100\% = 4.8\% \text{ (w/v) acetic acid} \quad x = 12 \text{ g acetic acid} \]

b. Add 55 mL of ethyl acetate to the flask and then water to bring the volume to 250 mL.

\[(\text{v/v})\% = \frac{x \text{ mL ethyl acetate}}{250 \text{ mL solution}} \times 100\% = 22\% \text{ (v/v) ethyl acetate} \quad x = 55 \text{ mL ethyl acetate} \]

c. Add 37 g of NaCl to the flask and then water to bring the volume to 250 mL.

\[ M = \frac{\text{moles of solute (mol)}}{V \text{ (L)}} = \frac{(0.25 \text{ L solution})}{(2.5 \text{ M})} = 0.63 \text{ mol NaCl} \]

\[ 0.63 \text{ molar NaCl} \times \frac{58.44 \text{ g}}{1 \text{ molar NaCl}} = 37 \text{ g NaCl} \]
8.66

a. Add 5.0 g of KCl to the flask and then water to bring the volume to 250 mL.

\[
\text{(w/v)}\% = \frac{x \text{ g KCl}}{250 \text{ mL solution}} \times 100\% = 2.0\% \text{ (w/v) KCl} \quad x = 5.0 \text{ g KCl}
\]

\text{Answer}\]

b. Add 85 mL of ethanol to the flask and then water to bring the volume to 250 mL.

\[
\text{(v/v)}\% = \frac{x \text{ mL ethanol}}{250 \text{ mL solution}} \times 100\% = 34\% \text{ (v/v) ethanol} \quad x = 85 \text{ mL ethanol}
\]

\text{Answer}\]

c. Add 58 g of NaCl to the flask and then water to bring the volume to 250 mL.

\[
M = \frac{\text{moles of solute (mol)}}{V \text{ (L)}}
\]

\[
\text{moles of solute (mol)} = (M)(V) = (4.0 \text{ M})(0.25 \text{ L solution}) = 1.0 \text{ mol NaCl}
\]

\[
1.0 \text{ mol NaCl} \times \frac{58.44 \text{ g}}{1 \text{ mol NaCl}} = 58 \text{ g NaCl}
\]

\text{Answer}\]

8.67 Calculate the moles of solute in each solution.

a. \[\text{moles of solute (mol)} = (M)(V) = (0.25 \text{ M})(0.15 \text{ L solution}) = 0.038 \text{ mol NaNO}_3\]

\text{Answer}\]

b. \[\text{moles of solute (mol)} = (M)(V) = (2.0 \text{ M})(0.045 \text{ L solution}) = 0.090 \text{ mol HNO}_3\]

\text{Answer}\]

c. \[\text{moles of solute (mol)} = (M)(V) = (1.5 \text{ M})(2.5 \text{ L solution}) = 3.8 \text{ mol HCl}\]

\text{Answer}\]

8.68 Calculate the moles of solute in each solution.

a. \[\text{moles of solute (mol)} = (M)(V) = (0.55 \text{ M})(0.25 \text{ L solution}) = 0.14 \text{ mol NaNO}_3\]

\text{Answer}\]

b. \[\text{moles of solute (mol)} = (M)(V) = (4.0 \text{ M})(0.145 \text{ L solution}) = 0.58 \text{ mol HNO}_3\]

\text{Answer}\]

c. \[\text{moles of solute (mol)} = (M)(V) = (2.5 \text{ M})(6.5 \text{ L solution}) = 16 \text{ mol HCl}\]

\text{Answer}\]

8.69 Calculate the number of grams of each solute.

a. \[0.038 \text{ mol NaNO}_3 \times \frac{85.00 \text{ g NaNO}_3}{1 \text{ mol NaNO}_3} = 3.2 \text{ g NaNO}_3\]

\text{Answer}\]
b. $0.090 \text{ mol HNO}_3 \times \frac{63.02 \text{ g HNO}_3}{1 \text{ mol HNO}_3} = 5.7 \text{ g HNO}_3$

Answer

c. $3.8 \text{ mol HCl} \times \frac{36.46 \text{ g HCl}}{1 \text{ mol HCl}} = 140 \text{ g HCl}$

Answer

8.70 Calculate the number of grams of each solute.

a. $0.14 \text{ mol NaNO}_3 \times \frac{85.00 \text{ g NaNO}_3}{1 \text{ mol NaNO}_3} = 12 \text{ g NaNO}_3$

Answer

b. $0.58 \text{ mol HNO}_3 \times \frac{63.02 \text{ g HNO}_3}{1 \text{ mol HNO}_3} = 37 \text{ g HNO}_3$

Answer

c. $16 \text{ mol HCl} \times \frac{36.46 \text{ g HCl}}{1 \text{ mol HCl}} = 580 \text{ g HCl}$

Answer

8.71 Calculate the number of milliliters of ethanol in the bottle of wine.

$$\frac{(v/v)\%}{100\%} = \frac{x \text{ mL ethanol}}{750 \text{ mL solution}} \times 100\% = 11.0\% \text{ (v/v) ethanol} \quad x = 83 \text{ mL ethanol}$$

Answer

8.72 Use the density and molar mass to calculate the molarity.

$$\frac{20.0 \text{ g ethanol}}{100 \text{ mL}} \times \frac{0.790 \text{ g ethanol}}{1 \text{ mL ethanol}} \times \frac{\text{mol ethanol}}{46.07 \text{ g ethanol}} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 3.43 \text{ M}$$

Answer

8.73 Calculate the amount of acetic acid (number of grams and number of moles) in the solution and convert to molarity.

a. $(w/v)\% = \frac{x \text{ g acetic acid}}{1890 \text{ mL solution}} \times 100\% = 5.0\% \text{ (w/v) acetic acid} \quad x = 95 \text{ g acetic acid}$

Answer

b. $95 \text{ g acetic acid} \times \frac{1 \text{ mol acetic acid}}{60.05 \text{ g acetic acid}} = 1.6 \text{ mol acetic acid}$

Answer

c. $M = \frac{\text{moles of solute (mol)}}{\text{V (L)}} = \frac{1.6 \text{ mol acetic acid}}{1.89 \text{ L solution}} = 0.85 \text{ M}$

Answer

8.74 Calculate the amount of glucose and convert to molarity.

$$\frac{15.4 \text{ g glucose}}{100 \text{ mL}} \times \frac{1000 \text{ mL}}{1 \text{ L}} \times \frac{\text{mol glucose}}{180.18 \text{ g glucose}} = 0.83 \text{ M}$$

Answer
8.75 Use the formula, ppm = \( \frac{\text{g of solute}}{\text{g of solution}} \times 10^6 \), to calculate parts per million as in Example 8.6.

a. \( 80 \, \mu g \text{ CHCl}_3 \times \frac{1 \text{ g}}{1,000,000 \, \mu g} = 0.00008 \, \text{g CHCl}_3 \) \( \frac{0.00008 \, \text{g CHCl}_3}{1,000 \, \text{g}} \times 10^6 = 0.08 \, \text{ppm CHCl}_3 \) Answer

b. \( 700 \, \mu g \text{ glyphosate} \times \frac{1 \text{ g}}{1,000,000 \, \mu g} = 0.0007 \, \text{g glyphosate} \) \( \frac{0.0007 \, \text{g glyphosate}}{1,000 \, \text{g}} \times 10^6 = 0.7 \, \text{ppm glyphosate} \) Answer

8.76 Use the formula ppm = \( \frac{\text{g of solute}}{\text{g of solution}} \times 10^6 \), to calculate parts per million as in Example 8.6.

a. \( 1,300 \, \mu g \text{ Cu} \times \frac{1 \text{ g}}{1,000,000 \, \mu g} = 0.0013 \, \text{g Cu} \) \( \frac{0.0013 \, \text{g Cu}}{1,000 \, \text{g}} \times 10^6 = 1.3 \, \text{ppm Cu} \) Answer

b. \( 10 \, \mu g \text{ As} \times \frac{1 \text{ g}}{1,000,000 \, \mu g} = 0.00001 \, \text{g As} \) \( \frac{0.00001 \, \text{g As}}{1,000 \, \text{g}} \times 10^6 = 0.01 \, \text{ppm As} \) Answer

c. \( 100 \, \mu g \text{ Cr} \times \frac{1 \text{ g}}{1,000,000 \, \mu g} = 0.0001 \, \text{g Cr} \) \( \frac{0.0001 \, \text{g Cr}}{1,000 \, \text{g}} \times 10^6 = 0.1 \, \text{ppm Cr} \) Answer

8.77 When solution X is diluted, the volume will increase, but the amount of solute will stay the same (B).

8.78 C is the most concentrated and A is the least concentrated.
8.79

a. Add H₂O.

b. \[ M_1 V_1 = M_2 V_2 = (0.1 \text{ M})(50.0 \text{ mL}) = (0.05 \text{ M})(x \text{ mL}) \]

\[ x = 100 \text{ mL} \]

Since the original volume was 50 mL, **50 mL** of water is added.

8.80

a. Add H₂O.

b. \[ M_1 V_1 = M_2 V_2 = (2.0 \text{ M})(100. \text{ mL}) = (1.2 \text{ M})(x \text{ mL}) \]

\[ x = 1.7 \times 10^2 \text{ mL} \]

Since the original volume was 100 mL, **70 mL** of water is added.

8.81 Concentration is the amount of solute per unit volume in a solution. Dilution is the addition of solvent to decrease the concentration of solute.

8.82 Dilution is the addition of solvent to decrease the concentration of solute. The amount of solute is a constant. The addition of solvent would decrease the molar concentration of the 2.5 M NaOH solution, not increase it, so it is impossible to prepare 200 mL of a 5.0 M NaOH solution by diluting a 2.5 M NaOH solution.

8.83 Use the equation, \((C_1)(V_1) = (C_2)(V_2)\), to calculate the new concentration after dilution.

a. \[ C_2 = \frac{C_1 V_1}{V_2} = \frac{(30.0\%)(100. \text{ mL})}{200. \text{ mL}} = 15.0\% (\text{w/v}) \]

b. \[ C_2 = \frac{C_1 V_1}{V_2} = \frac{(30.0\%)(100. \text{ mL})}{500. \text{ mL}} = 6.00\% (\text{w/v}) \]

c. \[ C_2 = \frac{C_1 V_1}{V_2} = \frac{(30.0\%)(250 \text{ mL})}{1500 \text{ mL}} = 5.0\% (\text{w/v}) \]

d. \[ C_2 = \frac{C_1 V_1}{V_2} = \frac{(30.0\%)(350 \text{ mL})}{750 \text{ mL}} = 14\% (\text{w/v}) \]
8.84 Use the equation \((C_1)(V_1) = (C_2)(V_2)\) to calculate the new concentration after dilution.

\[ \text{a.} \quad (\text{w/v})\% = \frac{1.00 \text{ g}}{10.0 \text{ mL solution}} \times 100\% = 10.0\% \text{ (w/v)} \]

\[ \text{b. [1]} \quad C_2 = \frac{C_1 V_1}{V_2} = \frac{(10.0\%)(1.0 \text{ mL})}{10.0 \text{ mL}} = 1.0\% \text{ (w/v)} \]

\[ \text{b. [2]} \quad C_2 = \frac{C_1 V_1}{V_2} = \frac{(10.0\%)(1.0 \text{ mL})}{2.5 \text{ mL}} = 4.0\% \text{ (w/v)} \]

\[ \text{b. [3]} \quad C_2 = \frac{C_1 V_1}{V_2} = \frac{(10.0\%)(1.0 \text{ mL})}{50.0 \text{ mL}} = 0.20\% \text{ (w/v)} \]

\[ \text{b. [4]} \quad C_2 = \frac{C_1 V_1}{V_2} = \frac{(10.0\%)(1.0 \text{ mL})}{120 \text{ mL}} = 0.083\% \text{ (w/v)} \]

8.85 Use the equation, \((M_1)(V_1) = (M_2)(V_2)\), to calculate the new molarity after dilution.

\[ M_2 = \frac{M_1 V_1}{V_2} = \frac{(12.0 \text{ M})(125 \text{ mL})}{850 \text{ mL}} = 1.8 \text{ M} \]

8.86 Use the equation \((M_1)(V_1) = (M_2)(V_2)\) to calculate the new molarity after dilution.

\[ M_2 = \frac{M_1 V_1}{V_2} = \frac{(6.0 \text{ M})(250 \text{ mL})}{450 \text{ mL}} = 3.3 \text{ M} \]

8.87 Use the equation, \((M_1)(V_1) = (M_2)(V_2)\), to calculate the volume needed to prepare each solution.

\[ \text{a.} \quad V_1 = \frac{M_2 V_2}{M_1} = \frac{(1.0 \text{ M})(25 \text{ mL})}{2.5 \text{ M}} = 10. \text{ mL} \]

\[ \text{b.} \quad V_1 = \frac{M_2 V_2}{M_1} = \frac{(0.75 \text{ M})(1500 \text{ mL})}{2.5 \text{ M}} = 450 \text{ mL} \]

\[ \text{c.} \quad V_1 = \frac{M_2 V_2}{M_1} = \frac{(0.25 \text{ M})(15 \text{ mL})}{2.5 \text{ M}} = 1.5 \text{ mL} \]

\[ \text{d.} \quad V_1 = \frac{M_2 V_2}{M_1} = \frac{(0.025 \text{ M})(250 \text{ mL})}{2.5 \text{ M}} = 2.5 \text{ mL} \]

8.88 Use the equation \((M_1)(V_1) = (M_2)(V_2)\) to calculate the volume needed to prepare each solution.

\[ \text{a.} \quad V_1 = \frac{M_2 V_2}{M_1} = \frac{(4.0 \text{ M})(45 \text{ mL})}{5.0 \text{ M}} = 36. \text{ mL} \]
b. $V_1 = \frac{M_2V_2}{M_1} = \frac{(0.5 \text{ M})(150 \text{ mL})}{5.0 \text{ M}} = 20 \text{ mL}$

c. $V_1 = \frac{M_2V_2}{M_1} = \frac{(0.025 \text{ M})(1,200 \text{ mL})}{5.0 \text{ M}} = 6.0 \text{ mL}$

d. $V_1 = \frac{M_2V_2}{M_1} = \frac{(1.0 \text{ M})(750 \text{ mL})}{5.0 \text{ M}} = 150 \text{ mL}$

8.89 Ocean water contains nonvolatile dissolved salts, which increase the boiling point.

8.90 Osmotic pressure is the pressure that prevents the flow of additional solvent into a solution on one side of a semipermeable membrane. Pure water will not have osmotic pressure since water is on both sides of the semipermeable membrane and there will be no pressure difference.

8.91 Determine the number of “particles” contained in the solute. Use 0.51 °C/mol as a conversion factor to relate temperature change to the number of moles of solute particles, as in Example 8.10.

a. 3.0 mol of fructose molecules

\[
\frac{0.51 \text{ °C}}{\text{mol particles}} \times 3.0 \text{ mol} = 1.5 \text{ °C} \\
100.0 \text{ °C} + 1.5 \text{ °C} = 101.5 \text{ °C}
\]

b. 1.2 mol of KI

\[
\frac{0.51 \text{ °C}}{\text{mol particles}} \times 1.2 \text{ mol KI} \times \frac{2 \text{ mol particles}}{\text{mol KI}} = 1.2 \text{ °C} \\
100.0 \text{ °C} + 1.2 \text{ °C} = 101.2 \text{ °C}
\]

c. 1.5 mol Na₃PO₄

\[
\frac{0.51 \text{ °C}}{\text{mol particles}} \times 1.5 \text{ mol Na₃PO₄} \times \frac{4 \text{ mol particles}}{\text{mol Na₃PO₄}} = 3.1 \text{ °C} \\
100.0 \text{ °C} + 3.1 \text{ °C} = 103.1 \text{ °C}
\]

8.92 Determine the number of “particles” contained in the solute. Use 1.86 °C/mol as a conversion factor to relate temperature change to the number of moles of solute particles, as in Example 8.10.

a. 3.0 mol of fructose molecules

\[
\frac{1.86 \text{ °C}}{\text{mol particles}} \times 3.0 \text{ mol} = 5.6 \text{ °C} \\
0.0 \text{ °C} - 5.6 \text{ °C} = -5.6 \text{ °C}
\]

b. 1.2 mol of KI

\[
\frac{1.86 \text{ °C}}{\text{mol particles}} \times 1.2 \text{ mol KI} \times \frac{2 \text{ mol particles}}{\text{mol KI}} = 4.5 \text{ °C} \\
0.0 \text{ °C} - 4.5 \text{ °C} = -4.5 \text{ °C}
\]
c. 1.5 mol Na$_3$PO$_4$

$$\frac{1.86 \degree C}{\text{mol particles}} \times 1.5 \text{ mol Na}_3\text{PO}_4 \times \frac{4 \text{ mol particles}}{\text{mol Na}_3\text{PO}_4} = 11 \degree C$$

0.0 \degree C – 11 \degree C = –11 \degree C

8.93 Determine the number of “particles” contained in the solute. Use 1.86 \degree C/mol as a conversion factor to relate temperature change to the number of moles of solute particles, as in Sample Problem 8.14.

$$150 \text{ g ethylene glycol} \times \frac{1 \text{ mol ethylene glycol}}{62.07 \text{ g ethylene glycol}} = 2.4 \text{ mol ethylene glycol}$$

$$\frac{1.86 \degree C}{\text{mol particles}} \times 2.4 \text{ mol} = 4.5 \degree C \quad \text{Melting point} = –4.5 \degree C$$

8.94 Determine the number of “particles” contained in the solute. Use 1.86 \degree C/mol as a conversion factor to relate temperature change to the number of moles of solute particles, as in Sample Problem 8.14.

$$\Delta T = 0.0 \degree C – 10. \degree C = –10. \degree C$$

$$\frac{1.86 \degree C}{\text{mol particles}} \times x \text{ mol} = 10. \degree C \quad x \text{ mol} = 5.4 \text{ mol}$$

$$5.4 \text{ mol ethylene glycol} \times \frac{62.07 \text{ g ethylene glycol}}{1 \text{ mol ethylene glycol}} = 330 \text{ g ethylene glycol}$$

8.95 a. The NaCl solution has a higher boiling point because it contains two particles per mole, whereas the glucose solution contains one per mole.

b. The glucose solution has the higher melting point because it contains one particle per mole, whereas the NaCl solution contains two particles per mole.

c. The NaCl solution has the higher osmotic pressure because it contains two particles per mole, whereas the glucose solution contains one per mole.

d. The glucose solution has a higher vapor pressure at a given temperature because it contains one particle per mole, whereas the NaCl solution contains two particles per mole.

8.96 a. The CaCl$_2$ solution has a higher boiling point because it contains three particles per mole, whereas the NaCl solution contains two particles per mole.

b. The NaCl solution has the higher melting point because it contains two particles per mole, whereas the CaCl$_2$ solution contains three particles per mole.

c. The CaCl$_2$ solution has the higher osmotic pressure because it contains three particles per mole, whereas the NaCl solution contains two particles per mole.

d. The NaCl solution has a higher vapor pressure at a given temperature because it contains two particles per mole, whereas the CaCl$_2$ solution contains three particles per mole.
8.97 Determine the number of “particles” contained in the solute. If necessary, use 1.86 °C/mol as a conversion factor to relate the temperature change to the number of moles of solute particles.

a. A 0.10 M glucose solution has a higher melting point than 0.10 M NaOH even though the solutions have the same molar concentration, because the NaOH solution contains twice as many particles. Therefore the NaOH solution will have its melting point reduced by twice as much as the glucose solution.

b. A 0.20 M NaCl solution has a higher melting point than a 0.15 M CaCl₂ solution.

\[
\begin{align*}
\frac{1.86 \degree C}{mol \text{ particles}} & \times 0.20 \text{ mol NaCl} \times \frac{2 \text{ mol particles}}{mol \text{ NaCl}} = 0.74 \degree C \quad \text{Melting point} = -0.74 \degree C \\
\text{higher melting point} \\
\frac{1.86 \degree C}{mol \text{ particles}} & \times 0.15 \text{ mol CaCl}_2 \times \frac{3 \text{ mol particles}}{mol \text{ CaCl}_2} = 0.84 \degree C \quad \text{Melting point} = -0.84 \degree C
\end{align*}
\]

c. A 0.10 M Na₂SO₄ solution has a higher melting point than 0.10 M Na₃PO₄ even though the solutions have the same molar concentration, because the Na₂SO₄ solution contains fewer particles (three vs. four).

d. A 0.10 M glucose solution has a higher melting point than a 0.20 M glucose solution since it has a lower molar concentration, which causes less melting point depression.

8.98 Determine the number of “particles” contained in the solute. If necessary, use 0.51 °C/mol as a conversion factor to relate the temperature change to the number of moles of solute particles.

a. A 0.10 M NaOH solution has a higher boiling point than 0.10 M glucose, even though the solutions have the same molar concentration, because the NaOH solution contains twice as many particles. Therefore, the NaOH solution will have its boiling point increased by twice as much as the glucose solution.

b. A 0.15 M CaCl₂ solution has a higher boiling point than a 0.20 M NaCl solution.

\[
\begin{align*}
\frac{0.51 \degree C}{mol \text{ particles}} & \times 0.20 \text{ mol NaCl} \times \frac{2 \text{ mol particles}}{mol \text{ NaCl}} = 0.20 \degree C \quad \text{Boiling point} = 100.20 \degree C \\
\frac{0.51 \degree C}{mol \text{ particles}} & \times 0.15 \text{ mol CaCl}_2 \times \frac{3 \text{ mol particles}}{mol \text{ CaCl}_2} = 0.23 \degree C \quad \text{Boiling point} = 100.23 \degree C \\
\text{higher boiling point}
\end{align*}
\]

c. A 0.10 M Na₃PO₄ solution has a higher boiling point than 0.10 M Na₂SO₄, even though the solutions have the same molar concentration, because the Na₂SO₄ solution contains fewer particles (three vs. four).

d. A 0.20 M glucose solution has a higher boiling point than a 0.10 M glucose solution since it has a higher molar concentration, which causes an increased boiling point elevation.
8.99  
**a. A > B.** Since solution A contains a dissolved solute, water will flow from compartment B to compartment A.

**b. B > A.** Since solution B is more concentrated, water will flow from compartment A to compartment B.

**c. No change** will occur since the solutions have an equal number of dissolved particles.

**d. A > B.** Solution A contains more dissolved particles than solution B. Therefore, water will flow from compartment B to compartment A.

**e. No change** will occur since the solutions have an equal number of dissolved particles (NaCl has two particles per mole, making it equivalent to the glucose solution).

8.100  
**a. Diagram 2** represents the final level of the liquid since solution B is more concentrated. Thus, water will flow from compartment A to compartment B.

**b. Diagram 3** represents the final level of the liquid since solution A contains more dissolved particles than solution B. Therefore, water will flow from compartment B to compartment A.

**c. Diagram 2** represents the final level of the liquid since solution B contains a dissolved solute. Thus, water will flow from compartment A to compartment B.

**d. Diagram 3** represents the final level of the liquid since solution A contains a dissolved solute. Thus, water will flow from compartment B to compartment A.

**e. Diagram 3** represents the final level of the liquid since solution A is more concentrated. Thus, water will flow from compartment B to compartment A.

8.101  
At warmer temperatures, CO₂ is less soluble in water and more is in the gas phase and escapes as the can is opened and pressure is reduced.

8.102  
Sugar is more soluble at higher temperatures, so more sugar dissolves in hot coffee than iced coffee.

8.103  
Calculate the weight/volume percent concentration of glucose, and the molarity.

\[
\text{(w/v)\%} = \frac{0.09 \text{ g glucose}}{100 \text{ mL blood}} \times 100\% = 0.09\% \ (\text{w/v}) \text{ glucose}
\]

\[
0.09 \text{ g glucose} \times \frac{1 \text{ mol glucose}}{180.2 \text{ g glucose}} = 0.0005 \text{ mol glucose}
\]

\[
0.0005 \text{ mol glucose} \div \frac{0.1 \text{ L blood}}{= 0.005 \text{ M}}
\]

8.104  
Convert L to mL and mg to g.

\[
5.0 \text{ L} \times \frac{1000 \text{ mL}}{1 \text{ L}} \times \frac{90. \text{ mg glucose}}{100 \text{ mL blood}} \times \frac{1 \text{ g}}{1000 \text{ mg}} = 4.5 \text{ g glucose}
\]

8.105  
**a. 280 mL of mannitol solution would have to be given.**

\[
\text{(w/v)\%} = \frac{70. \text{ g mannitol}}{x \text{ mL solution}} \times 100\% = 25\% \ (\text{w/v}) \text{ mannitol}
\]

**b. The hypertonic mannitol solution draws water out of swollen brain cells and thus reduces the pressure on the brain.**
8.106 Calculate the mass of glucose and then convert to moles.

\[ \frac{10.0 \text{ g glucose}}{100 \text{ mL solution}} \times 750 \text{ mL solution} = 75 \text{ g glucose} \]

**Answer**

\[ \frac{75 \text{ g glucose}}{180.2 \text{ g glucose}} = 0.42 \text{ mol glucose} \]

**Answer**

8.107 When a cucumber is placed in a concentrated salt solution, water moves out of the cells of the cucumber to the hypertonic salt solution, so the cucumber shrinks and loses its crispness.

8.108 When a raisin is placed in water, water moves into the raisin (hypotonic solution), so the raisin swells.

8.109 NaCl, KCl, and glucose are found in the bloodstream. If they weren’t in the dialyzer fluid, they would move out of the bloodstream into the dialyzer, and their concentrations in the bloodstream would fall.

8.110 Pure water is not used in the solution contained in a dialyzer during hemodialysis because water would move out of the dialyzer and into the bloodstream and dilute the blood.

8.111 Convert ounces to milliliters, and then calculate the weight/volume percent concentration.

\[ 8.0 \text{ oz} \times \frac{29.6 \text{ mL}}{1 \text{ oz}} = 240 \text{ mL} \]

\[ (\text{w/v})\% = \frac{15 \text{ g complex carbohydrates}}{240 \text{ mL solution}} \times 100\% = 6.3\% \text{ (w/v) complex carbohydrates} \]

**Answer**

8.112 Convert ounces to millimeters, and then calculate the ppm concentration.

\[ 8.0 \text{ oz} \times \frac{29.6 \text{ mL}}{1 \text{ oz}} = 240 \text{ mL} \times \frac{1.0 \text{ g}}{1.0 \text{ mL}} = 240 \text{ g solution} \]

\[ 25 \text{ mg Mg} \times \frac{1 \text{ g}}{1000 \text{ mg}} = 0.025 \text{ g Mg} \]

\[ \frac{0.025 \text{ g Mg}}{240 \text{ g solution}} \times 10^6 = 1.0 \times 10^2 \text{ ppm} \]

**Answer**

8.113 Use the molarity to determine the number of moles of HCl, and then convert this to grams.

\[ \text{mol} = M \times V = 0.10 \text{ M HCl} \times 2.0 \text{ L} = 0.20 \text{ mol HCl} \]

\[ 0.20 \text{ mol HCl} \times \frac{36.46 \text{ g HCl}}{1 \text{ mol HCl}} = 7.3 \text{ g HCl} \]

**Answer**
8.114 When a red blood cell is placed in pure water, water will move into the blood cell, causing it to swell and eventually rupture.

8.115

\[ 5.0 \, \text{L} = 5.0 \times 10^3 \, \text{mL blood} \]

\[ \frac{(w/v)\%}{\times \, 100\%} = \frac{x \, \text{g ethanol}}{5.0 \times 10^3 \, \text{mL blood}} \times \frac{4 \, \text{g ethanol}}{1 \, \text{g}} \]

\[ 4 \, \text{g ethanol} \times \frac{1000 \, \text{mg}}{1 \, \text{g}} = 4000 \, \text{mg ethanol} \]

Answer

8.116

\[ \frac{40 \, \text{mL ethanol}}{100 \, \text{mL solution}} \times \frac{250 \, \text{mL solution}}{1.0 \times 10^2 \, \text{mL ethanol}} \]

Answer

8.117

a. \[ \frac{x \, \text{g acetaminophen}}{1 \, \text{mL}} \times 10^6 = 15 \, \text{ppm acetaminophen} \]

\[ 0.000 \, 015 \, \text{g acetaminophen} \times \frac{10^6 \, \mu \text{g}}{1 \, \text{g}} = 15 \, \mu \text{g acetaminophen}, \text{ which is in the therapeutic range} \]

b. \[ \frac{0.000 \, 015 \, \text{g acetaminophen}}{1 \, \text{mL blood}} \times \frac{5000 \, \text{mL blood}}{1 \, \text{mol}} \times \frac{1 \, \text{mol}}{151.2 \, \text{g}} \]

\[ = 0.000 \, 50 \, \text{mol acetaminophen} \]

Answer

8.118 The two values are equivalent because 5.2 \times 10^{-3} \text{ M} is the same as 200. \text{ mg/dL} to 2 significant figures.

\[ \frac{5.2 \times 10^{-3} \, \text{mol}}{\text{L}} \times \frac{386.74 \, \text{g}}{\text{mole}} \times \frac{1000 \, \text{mg}}{1 \, \text{g}} \times \frac{1 \, \text{L}}{10 \, \text{dL}} = 2.0 \times 10^2 \, \text{mg/dL} \]