Chapter 8  Solutions

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8.1  Solutions
Solutions: Solute and Solvent

Solutions

- are homogeneous mixtures of two or more substances
- consist of a solvent and one or more solutes
Nature of Solutes in Solutions

Solutes

- spread evenly throughout the solution
- cannot be separated by filtration
- can be separated by evaporation
- are not visible but can give a color to the solution
Examples of Solutions

- The solute and solvent in a solution can be a solid, liquid, and/or a gas.

**TABLE 8.1 Some Examples of Solutions**

<table>
<thead>
<tr>
<th>Type</th>
<th>Example</th>
<th>Primary Solute</th>
<th>Solvent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gas Solutions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas in a gas</td>
<td>Air</td>
<td>Oxygen (gas)</td>
<td>Nitrogen (gas)</td>
</tr>
<tr>
<td><strong>Liquid Solutions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas in a liquid</td>
<td>Soda water</td>
<td>Carbon dioxide (gas)</td>
<td>Water (liquid)</td>
</tr>
<tr>
<td></td>
<td>Household ammonia</td>
<td>Ammonia (gas)</td>
<td>Water (liquid)</td>
</tr>
<tr>
<td>Liquid in a liquid</td>
<td>Vinegar</td>
<td>Acetic acid (liquid)</td>
<td>Water (liquid)</td>
</tr>
<tr>
<td>Solid in a liquid</td>
<td>Seawater</td>
<td>Sodium chloride (solid)</td>
<td>Water (liquid)</td>
</tr>
<tr>
<td></td>
<td>Tincture of iodine</td>
<td>Iodine (solid)</td>
<td>Ethanol (liquid)</td>
</tr>
<tr>
<td><strong>Solid Solutions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid in a solid</td>
<td>Dental amalgam</td>
<td>Mercury (liquid)</td>
<td>Silver (solid)</td>
</tr>
<tr>
<td>Solid in a solid</td>
<td>Brass</td>
<td>Zinc (solid)</td>
<td>Copper (solid)</td>
</tr>
<tr>
<td></td>
<td>Steel</td>
<td>Carbon (solid)</td>
<td>Iron (solid)</td>
</tr>
</tbody>
</table>
Learning Check

Identify the solute in each of the following solutions:

A. 2 g sugar (1) and 100 mL water (2)
B. 60.0 mL of ethyl alcohol (1) and 30.0 mL of methyl alcohol (2)
C. 55.0 mL water (1) and 1.50 g NaCl (2)
D. Air: 200 mL O$_2$ (1) and 800 mL N$_2$ (2)
Solution

Identify the solute in each of the following solutions:

A. sugar (1)
B. methyl alcohol (2)
C. NaCl (2)
D. O₂ (1)
Water

- is the most common solvent
- is a polar molecule
- forms hydrogen bonds between the hydrogen atom in one molecule and the oxygen atom in a different water molecule
# Combinations of Solutes and Solvents in Solutions

<table>
<thead>
<tr>
<th>Solute</th>
<th>Solvent</th>
<th>Solute</th>
<th>Solvent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polar</td>
<td>Polar</td>
<td>Polar</td>
<td>Nonpolar</td>
</tr>
<tr>
<td>Nonpolar</td>
<td>Nonpolar</td>
<td>Nonpolar</td>
<td>Polar</td>
</tr>
</tbody>
</table>

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Formation of a Solution

Na\(^+\) and Cl\(^-\) ions

- on the surface of a NaCl crystal are attracted to polar water molecules
- are hydrated in solution by many H\(_2\)O molecules surrounding each ion
When NaCl(s) dissolves in water, the reaction can be written as

\[ \text{H}_2\text{O} \quad \text{NaCl(s)} \rightarrow \text{Na}^+(aq) + \text{Cl}^-(aq) \]

solid \hspace{2cm} \text{separation of ions}
Learning Check

Solid LiCl is added to water. It dissolves because:
A. The Li$^+$ ions are attracted to the
   1) oxygen atom ($\delta^-$) of water.
   2) hydrogen atom ($\delta^+$) of water.

B. The Cl$^-$ ions are attracted to the
   1) oxygen atom ($\delta^-$) of water.
   2) hydrogen atom ($\delta^+$) of water.
Solid LiCl is added to water. It dissolves because:

A. The Li$^+$ ions are attracted to the
   1) oxygen atom ($\delta^-$) of water.

B. The Cl$^-$ ions are attracted to the
   2) hydrogen atom ($\delta^+$) of water.
Two substances form a solution

- when there is an attraction between the particles of the solute and solvent
- when a polar solvent (such as water) dissolves polar solutes (such as sugar) and/or ionic solutes (such as NaCl)
- when a nonpolar solvent such as hexane \( (C_6H_{14}) \) dissolves nonpolar solutes such as oil or grease

Like Dissolves Like
Water and a Polar Solute

Methanol (CH$_3$OH) solute

Water solvent

Methanol-water solution with hydrogen bonding

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Like Dissolves Like

Solvents
- Water (polar)
- CH\(_2\)Cl\(_2\) (nonpolar)

Solutes
- Ni(NO\(_3\))\(_2\) (polar)
- I\(_2\) (nonpolar)
Learning Check

Will each of the following solutes dissolve in water? Why or why not?
1) \( \text{Na}_2\text{SO}_4 \)
2) gasoline (nonpolar)
3) \( \text{I}_2 \)
4) \( \text{HCl} \)
Will each of the following solutes dissolve in water? Why or why not?

1) Na$_2$SO$_4$  Yes. The solute is ionic.
2) gasoline      No. The solute is nonpolar.
3) I$_2$         No. The solute is nonpolar.
4) HCl           Yes. The solute is polar.

Most polar and ionic solutes dissolve in water because water is a polar solvent.