Characteristics of Solutions: Solutions are homogeneous mixtures containing two or more substances called the solute and solvent.

The solute is the substance that dissolves.

The solvent is the dissolving medium. When looking at a solution it is impossible to distinguish the solute from the solvent.

A solution can exist as a solid, liquid or gas depending on the state of the solvent.

### Types of Solutions and Examples

<table>
<thead>
<tr>
<th>Type of Solution</th>
<th>Example</th>
<th>Solvent</th>
<th>Solute</th>
</tr>
</thead>
<tbody>
<tr>
<td>GAS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas in gas</td>
<td>Air</td>
<td>Nitrogen(gas)</td>
<td>Oxygen (gas)</td>
</tr>
<tr>
<td>LIQUID</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas in liquid</td>
<td>Carbonated water</td>
<td>Water(liquid)</td>
<td>Carbon dioxide(gas)</td>
</tr>
<tr>
<td>Liquid in liquid</td>
<td>Vinegar</td>
<td>Water (liquid)</td>
<td>Acetic acid (liquid)</td>
</tr>
<tr>
<td>Solid in liquid</td>
<td>Ocean water</td>
<td>Water(liquid)</td>
<td>NaCl(solid)</td>
</tr>
<tr>
<td>SOLID</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid in solid</td>
<td>Dental amalgam</td>
<td>Silver(solid)</td>
<td>Mercury(liquid)</td>
</tr>
<tr>
<td>Solid in solid</td>
<td>Steel</td>
<td>Iron(solid)</td>
<td>Carbon(solid)</td>
</tr>
</tbody>
</table>

Remember that a substance that dissolves in a solvent is said to be soluble in that solvent.

A substance that does not dissolve in a solvent is insoluble.

Two liquids that are soluble in each other are said to be miscible such as water and vinegar, coffee and cream.

Liquids that are not soluble in each other are immiscible such as vegetable oil and vinegar, gasoline and water.

**Process of Dissolving:** Solvent particles surround solute particles to form a solution in a process called solvation.

(This dissolving process in water is called hydration.) This process often results in a change in energy – usually observed by an increase or decrease in temperature.

Remember the phrase Like dissolves like – this means that polar dissolves polar & nonpolar dissolves nonpolar. List examples in the table.
A soluble substance is able to **dissolve** in a solvent because attractive forces between the solvent and solute particles are strong enough to overcome the attractive forces holding the *solute* together.

Some solutions conduct electricity because the solute is an *electrolyte*. NOTE: an electrolyte is an *ionic compound* that *dissociates* (breaks apart) in water to form a solution that *conducts*, an electric *current*.

Solutions that only produce a few ions in solution would be considered a *weak* electrolyte and a solution that contains lots of ions would be a *strong* electrolyte.

**Solubility** refers to the maximum amount of solute that will dissolve in a given amount of solvent at a given temperature and pressure.

Solubility Rules **determine** which compounds are soluble or insoluble.
- We used solubility rules when learning about precipitation reactions in unit 7
- The solubility rules are on the back of the periodic table.

**Factors that affect solubility**
1. **Temperature**
   a. *Solid* solutes in water: if you increase temperature, the solubility generally increases
   b. *Gas* solutes in water: if you increase temperature, the solubility decreases

2. **Amount of solute:** All tables and figures showing solubility MUST indicate the mount of solvent involved

3. **Agitation:** Stirring or agitating any solution will generally increase dissolving by bringing fresh solvent into contact with more solute

4. **Surface Area** (particle size of solute): since dissolving occurs at the surface of a solid, by increasing the surface area we can increase the rate of dissolving. NOTE! Smaller particles **increase** surface area!!

<table>
<thead>
<tr>
<th>Polar Solvent/Solute</th>
<th>Nonpolar Solvent/Solute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water and salt</td>
<td>Paint thinner and paint</td>
</tr>
<tr>
<td>Tea and sugar</td>
<td>Makeup remover and waterproof makeup</td>
</tr>
<tr>
<td>Coke and cherry flavoring</td>
<td>Hairspray and ink</td>
</tr>
</tbody>
</table>
Types of Solutions
1. When a solvent has dissolved all the solute it can at a particular temperature, the solution is said to be saturated.

2. Unsaturated solutions have dissolved some solute but can dissolve more.

3. When a solution is heated and saturated, then if it is allowed to cool gently, it can become supersaturated. Supersaturated solutions contain more solute than normal for that temperature, are unstable. If disturbed, the excess solute will form crystals.

Solubility Curves
As we begin to think about amounts of solute which will dissolve in a given amount of solvent at a particular temperature, it is usually easier to read these solubility values off of a graph.

The Solubility Curve is a graph showing the solubility of several different compounds at temperatures varying from 0°C to 100°C. Notice that MOST substances become more soluble as the temperature goes up, but not necessarily linearly and not necessarily the same increase in solubility with increase in temperature. The solubility is expressed as grams of solute dissolved in 100 grams of water.

Things to Remember:
• If a point is on the line, it is saturated
• If a point is below the line, the solution is unsaturated
• If a point is above the line, the solution is supersaturated

How many grams of potassium nitrate will saturate 100 g of water at 10°C?

How many grams of potassium nitrate will saturate 200 g of water at 10°C?

How many grams of potassium nitrate will be in the bottom of the beaker if you put 40 grams of potassium nitrate in 100 g of water at 10°C?

Solubility of Gases
Gases are usually more soluble at lower temperatures and under pressure. (opposite of solids)

**Solution Concentration**
The concentration of a solution is a measure of how much solute is dissolved in a specific amount of solvent or solutions. Concentration can be described qualitatively using the words concentrated or dilute.

- A concentrated solution contains a large amount of solute
- A dilute solution contains a small amount of solute

We also can express concentration quantitatively. We can do this by using molarity.

- **Molarity (M)** is one of the most common units used to describe the concentration of a solution. The unit (M) is read as molar. The larger the number, the more concentrated the solution.

To calculate the molarity of a solution, you must know the volume of the solution and the amount (in moles) of dissolved solute. See the equation below.

\[
Molarity (M) = \frac{\text{moles of solute}}{\text{Liters of solution}}
\]

Sample Problem: Calculate the molarity of 1.60 L of a solution containing 1.55 g of dissolved KBr. Remember to convert grams to moles!

**Calculating Dilution of Solutions**
Sometimes we have to dilute solutions to make them the right concentration. The equation is: 
\[
M_1V_1 = M_2V_2
\]

Example Problem: When we do labs, we often use a diluted solution of hydrochloric acid. We buy concentrated HCl; it is 12M! How much 12M HCl do I need to make a 0.5 L of 0.1M solution?