Solutions

Solution = homogeneous mixture
= uniform composition

Reactions faster (better molecular interactions)
Volume measurements convenient

Solutions Characteristics:

Uniform distribution of components (homogeneous)
Components cannot be seen

Variable compositions

May exist in any of three states:
solid, liquid, or gas

Particles do not settle upon standing

Terms

Solvent
single substance that does the dissolving
substance present in the largest amount

Solute
1 or more substance that is dissolved
substance present in the lower amount

Solubility
quantity of a solute that will dissolve at a fixed temperature
typically expressed a grams solute/per 100 mL

Conventions
when solid or gas dissolved in liquid,
solvent = liquid
solute = solid or gas

Water as solvent = aqueous solution (aq)
“universal solvent”
### Solvent Examples

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Solute</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>gas</td>
<td>gas</td>
<td>O₂ in N₂</td>
</tr>
<tr>
<td>liquid</td>
<td>gas</td>
<td>CO₂ in H₂O</td>
</tr>
<tr>
<td>solid</td>
<td>gas</td>
<td>H₂ in Pd</td>
</tr>
<tr>
<td>gas</td>
<td>liquid</td>
<td>Clouds</td>
</tr>
<tr>
<td>liquid</td>
<td>liquid</td>
<td>Alcohol in water</td>
</tr>
<tr>
<td>solid</td>
<td>liquid</td>
<td>H₂O (from air) &amp; NaOH</td>
</tr>
<tr>
<td>solid</td>
<td>gas</td>
<td>S in Air</td>
</tr>
<tr>
<td>liquid</td>
<td>solid</td>
<td>Ag in Hg</td>
</tr>
<tr>
<td>solid</td>
<td>solid</td>
<td>Cu in Zn (brass)</td>
</tr>
</tbody>
</table>

### The Water Molecule

The Water molecule is dipolar because of the unequal distribution of charge (like a magnet). This is created by electron repulsion between oxygen’s 2 unshared pairs.

**Unshared Electrons**

Dipole = unequal distribution of charge (like a magnet) created by electron repulsion between oxygen’s 2 unshared pairs.

**Solution:**

NH₃ in H₂O

Allows networks of attraction between polar molecules.
Dissolving Salts

At the molecular level: Ions separated from solid surface

(-) charged ions at surface attracted by (+) (H) regions of water
(+) charged ions at surface attracted by (-) (O) regions of water

Ions become “Hydrated”

Na = Blue
Cl = Cyan
H = White
O = Red

Individual ions surrounded by water molecules

Dissociation (Dissolving)

Process of using water to separate ions of a substance sodium chloride dissociates when dissolved in water

\[ \text{NaCl (s)} \rightarrow \text{Na}^{+} (\text{aq}) + \text{Cl}^{-} (\text{aq}) \]
A physical change
Results in a uniform mixture of water & Na\(^+\) & Cl\(^-\)

Solution Process is Reversible

Dissolved particles move randomly as they leave salt crystal
Solution becomes homogeneous (stirring helps)
Dissolved particles may return to solid state (crystallize)

Equilibrium

In a saturated (maximum solute possible) solution:
\[ \text{NaCl}_\text{(s)} \rightarrow \text{Na}^+ \text{(aq)} + \text{Cl}^- \text{(aq)} \]
forward rate = reverse rate
overall concentrations remain constant

Solubility Terms

Saturated
solution contains the maximum amount of solute
A dynamic equilibrium exists

Unsaturated
solution contains less than the maximum amount of solute

Supersaturated
solution contains more than the maximum amount of solute carefully prepared
unstable
Solubility Curves
Plot of amount of solute vs. temperature

Supersaturation

Solubility is a function of temperature
In general, increase in temperature increases solubility

Assume:
solubility of $X = 15 \text{ g/100 g H}_2\text{O}$ at $25^\circ\text{C}$
solubility of $X = 28 \text{ g/100 g H}_2\text{O}$ at $80^\circ\text{C}$

So:
Place 18 g $X$ in a beaker of water
heat to $80^\circ\text{C}$  … all 18 g of $X$ dissolves
   Unsaturated since 18 g < 28 g solubility limit
Slowly cool back to $25^\circ\text{C}$
If left undisturbed, 18 g remain in solution
   Supersaturated since 18 g > 15 g solubility limit
If disturbed, 3 grams immediately falls to the bottom.
   Saturated since 15 g is solubility limit
Supersaturation Examples

Carbonated beverages
gas (CO2) in liquid (water)

Rock Candy
solid (sugar) in liquid (water)

Decompression Sickness (Bends)
gas (N2) in liquid (tissues)

Reef Growth
solid (CaCO3) in water

Cumulus Clouds
liquid (water) in gas

Relative (Qualitative) Solution Concentration Terms

Concentrated
Contains a relatively large amount of solute

Dilute
Contains a relatively small amount of solute

For Solution #1: 15.20 g NaNO₃ in 84.8 g water
For Solution #2: 3.29 g NaNO₃ in 96.7 g water

Solution #1 more concentrated than #2
Solution #1 less dilute than #2
Solution #2 more dilute than #1
Solution #2 less concentrated than #1

Solution Compatibility (Miscibility)

Miscible
Liquids that dissolve in each other in all proportions
Alcohol & water
Vinegar & water

Immiscible
Liquids that do not dissolve in each other
Separate into separate layers
Hydrocarbons & water

Assignment

Start Taking Unit 9 Practice Test

The Practice Quiz is very similar to the Unit Exam
Success on Unit exam is directly related to practice exam experience