Solution Definitions
solution: a homogeneous mixture

--

-- e.g.,
alloy: a solid solution of metals

-- e.g.,
solvent: the substance that dissolves the solute

soluble: “will dissolve in”
miscible: refers to two liquids that mix evenly in all proportions

-- e.g., food coloring and water

Factors Affecting the Rate of Dissolution

1. temperature

2. particle size

3. mixing

4. nature of solvent or solute

Classes of Solutions

aqueous solution: solvent =

amalgam: solvent =
e.g., dental amalgam

tincture: solvent =
e.g., tincture of iodine (for cuts)

organic solution: solvent contains ___________
e.g., gasoline, benzene, toluene, hexane
Non-Solution Definitions

**insoluble**: “will NOT dissolve in”

  e.g.,

**immiscible**: refers to two liquids that will NOT form a solution

  e.g.,

**suspension**: appears uniform while being stirred, but settles over time

Molecular Polarity

**nonpolar** molecules:  
-- e⁻ are shared equally
-- tend to be symmetric

  e.g.,

**polar** molecules:  
-- e⁻ NOT shared equally

  e.g.,

“Like dissolves like.”

Using Solubility Principles

Chemicals used by body obey solubility principles.

  -- **water-soluble vitamins**:  
  
  e.g.,

  -- **fat-soluble vitamins**:  
  
  e.g.,

Dry cleaning employs nonpolar liquids.

  -- polar liquids damage wool, silk
  
  also, dry clean for stubborn stains (ink, rust, grease)

  -- **tetrachloroethylene** is in common use

\[
\text{Cl}_2 \text{C} = \text{C} \text{Cl}_2
\]
emulsifying agent (emulsifier): --

--

e.g., soap detergent lecithin eggs

MODEL OF A SOAP MOLECULE

\[ \text{Na}^{+} \]

NONPOLAR

POLAR

HYDROCARBON

TAIL

soap vs. detergent

-- --

Hard water contains minerals ~w/ions like Ca\(^{2+}\), Mg\(^{2+}\), and Fe\(^{3+}\) that replace Na\(^{1+}\) at polar end of soap molecule. Soap is changed into an insoluble precipitate (i.e., soap scum).

micelle: a liquid droplet covered ~w/soap or detergent molecules

**Solubility →**

unsaturated: sol’n could hold more solute;
saturated: sol’n has “just right” amt. of solute;
supersaturated: sol’n has “too much” solute dissolved in it;

Solids dissolved in liquids

Gases dissolved in liquids

\[ \text{Sol} \]

\[ \text{Sol.} \]

As \( T^\circ \) ↑, solubility ___

As \( T^\circ \) ↑, solubility ___

**SOLUBILITY CURVE**

\[ \text{KNO}_3 (s) \]

\[ \text{KCl (s)} \]

\[ \text{HCl (g)} \]

Temp. (\(^\circ\)C)
Using an available solubility curve, classify as unsaturated, saturated, or supersaturated.

\[
\begin{align*}
\text{per} & \quad \text{100 g H}_2\text{O} \\
80 \text{ g NaNO}_3 & @ 30^\circ\text{C} \\
45 \text{ g KCl} & @ 60^\circ\text{C} \\
50 \text{ g NH}_3 & @ 10^\circ\text{C} \\
70 \text{ g NH}_4\text{Cl} & @ 70^\circ\text{C} \\
\text{Per 500 g H}_2\text{O, 120 g KNO}_3 & @ 40^\circ\text{C}
\end{align*}
\]

Describe each situation below.

(A) Per 100 g H\text{2}O, 100 g NaNO\text{3} @ 50^\circ\text{C}.

(B) Cool sol’n (A) very slowly to 10^\circ\text{C}.

(C) Quench sol’n (A) in an ice bath to 10^\circ\text{C}.

**Glassware – Precision and Cost**

\[
\begin{align*}
\text{beaker} & \quad \text{vs.} \quad \text{volumetric flask} \\
1000 \text{ mL } \pm 5\% & \quad 1000 \text{ mL } \pm 0.30 \text{ mL}
\end{align*}
\]

When filled to 1000 mL line, how much liquid is present?

- **beaker**
- **volumetric flask**
**Concentration**...a measure of solute-to-solvent ratio

- **Concentrated**
- **Dilute**

Add water to dilute a sol'n; boil water off to concentrate it.

<table>
<thead>
<tr>
<th>Selected units</th>
<th>A. mass % = ( \frac{\text{mass of solute}}{\text{mass of sol'n}} \times 100 )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B. parts per million (ppm) = ( \frac{\text{mass of solute}}{\text{mass of sol'n}} \times 10^6 )</td>
</tr>
<tr>
<td></td>
<td>→ also, ppb and ppt</td>
</tr>
<tr>
<td></td>
<td>-- commonly used for minerals or contaminants in water supplies</td>
</tr>
<tr>
<td></td>
<td>C. molarity (M) = ( \frac{\text{moles of solute}}{\text{L of sol'n}} )</td>
</tr>
<tr>
<td></td>
<td>-- used most often in this class</td>
</tr>
</tbody>
</table>

1: How many mol solute are req'd to make 1.35 L of 2.50 M sol'n?

A. What mass sodium hydroxide is this?

B. What mass magnesium phosphate is this?

2: Find molarity if 58.6 g barium hydroxide are in 5.65 L sol'n.

3: You have 10.8 g potassium nitrate. How many mL of sol'n will make this a 0.14 M sol'n?
**Molarity and Stoichiometry**

EX.  \[ \text{__Pb(NO}_3\text{)}_2(aq) + \text{__KI (aq)} \rightarrow \text{__PbI}_2(s) + \text{__KNO}_3(aq) \]

What volume of 4.0 M KI sol’n is req’d to yield 89 g PbI\(_2\)?

Strategy:

(1)

(2)

---

How many mL of a 0.500 M CuSO\(_4\) sol’n will react w/ excess Al to produce 11.0 g Cu?
**Dilutions of Solutions** → Acids (and sometimes bases) are purchased in concentrated form ("concentrate") and are easily diluted to any desired concentration.

**Safety Tip:**

Dilution Equation:

EX. Conc. $\text{H}_3\text{PO}_4$ is 14.8 M. What volume of concentrate is req’d to make 25.00 L of 0.500 M $\text{H}_3\text{PO}_4$?

How would you mix the above sol’n?

1. Measure out ________ L of conc. $\text{H}_3\text{PO}_4$.
2. In separate container, obtain ~20 L of cold $\text{H}_2\text{O}$.
3. In fume hood, slowly pour $\text{H}_3\text{PO}_4$ into cold $\text{H}_2\text{O}$.
4. Add enough $\text{H}_2\text{O}$ until 25.00 L of sol’n is obtained.

EX. You have 75 mL of conc. HF (28.9 M); you need 15.0 L of 0.100 M HF. Do you have enough to do the experiment?

**Dissociation** occurs when neutral combinations of particles separate into ions while in aqueous solution.

- sodium chloride → $\text{NaCl}$
- sodium hydroxide → $\text{NaOH}$
- hydrochloric acid → $\text{HCl}$
- sulfuric acid → $\text{H}_2\text{SO}_4$
- acetic acid → $\text{CH}_3\text{COOH}$

In general, ________ yield hydrogen ($\text{H}^+$) ions in aqueous solution; ________ yield hydroxide ($\text{OH}^-$) ions.
Strong electrolytes exhibit nearly 100% dissociation.

\[
\text{NaCl} \rightarrow \text{Na}^+ + \text{Cl}^- \\
\text{NOT in water:} \\
\text{in aq. sol'n:}
\]

Weak electrolytes exhibit little dissociation.

\[
\text{CH}_3\text{COOH} \rightarrow \text{CH}_3\text{COO}^- + \text{H}^+ \\
\text{NOT in water:} \\
\text{in aq. sol'n:}
\]

electrolytes: solutes that dissociate in sol'n
-- conduct elec. current because of free-moving ions
-- e.g.,
-- are crucial for many cellular processes
-- obtained in a healthy diet
--

nonelectrolytes: solutes that DO NOT dissociate
--
-- e.g., any type of sugar
**Colligative Properties**

Compared to solvent's…

- …normal freezing point (NFP)
- …normal boiling point (NBP)

Applications (NOTE: Data are fictitious.)

1. salting roads in winter

<table>
<thead>
<tr>
<th></th>
<th>FP</th>
<th>BP</th>
</tr>
</thead>
<tbody>
<tr>
<td>water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>water + a little salt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>water + more salt</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. antifreeze (AF) / coolant

<table>
<thead>
<tr>
<th></th>
<th>FP</th>
<th>BP</th>
</tr>
</thead>
<tbody>
<tr>
<td>water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>water + a little AF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50% water + 50% AF</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. law enforcement

<table>
<thead>
<tr>
<th>white powder</th>
<th>starts melting at…</th>
<th>finishes melting at…</th>
<th>penalty, if convicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>