# Chapter 12

Solutions

## Key Ideas

- Distinguish between heterogeneous and homogeneous mixtures
- List 3 different solute-solvent combinations
- Compare the properties of suspensions, colloids, and solutions
- Distinguish between electrolytes and nonelectrolytes

Section 12.1

## TYPES OF MIXTURES

## Solutions are homogeneous mixtures

- When something is **soluble**, it means it can dissolve
- A **solution** is a homogeneous mixture of 2 or more uniformly mixed substances
  - Examples?

## Homogeneous vs Heterogeneous

- Homogeneous mixtures are mixed evenly like…

- Heterogeneous mixtures are mixed **un**evenly like…

## Solutions

- A solution contains a solvent and a solute
- The **solvent** is the substance that is doing the dissolving
- The **solute** is the substance being dissolved
  - Usually the substance that has a smaller quantity in the solution

## Solution Examples

- Identify the solvent and the solute in the following examples of solutions
  - A glass of sea water
  - Kool-aid
  - 22 karat gold ring
  - A mixture of 30% acetic acid and water
  - 7 salt cubes placed in a gallon of water
  - Carbon dioxide in your soda
  - Brass is made of 70% Cu and 30% Zn

## Solute-solvent combos

| Solute State | Solvent State | Example |
|---|---|---|
| Gas | Gas | Air |
| Gas | Liquid | Carbon dioxide in water |
| Liquid | Liquid | Alcohol in water |
| Liquid | Solid | Hg in Ag (fillings) |
| Solid | Liquid | Sugar in water |
| Solid | solid | Cu in Ni |

You should be able to identify the Solute-Solvents in the solution

## ID the solute-solvent combo

- OHHHHHHH YEAHHHHHH

## ID the solute-solvent combo

- Identify the solute-solvent combos
  - A glass of sea water
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## Suspensions

- A **suspension** contains solute particles that are so large they settle out of solution
  - Examples

## Colloids

- **Colloids** contain particles larger than solutions but smaller than suspensions
  - These particles are light/small enough to stay afloat but they will reflect light
  - They stay afloat because the particle movement is enough to keep the colloid "stirred"
  - The *dispersed phase* is the substance that is "floating" in the *dispersing medium*
  - These typically look cloudy
    - River water

# Colloid Types

| Class of Colloid | Phases | |
|---|---|---|
| Sol | S in L | Paint, mud |
| Gel | Solid throughout (matrix) | Gelatin, JELLO |
| Liquid emulsion | L in L | Milk, mayonnaise |
| Foam | G in L | Shaving cream |
| Solid aerosol | S in G | Smoke, dusty air |
| Liquid aerosol | L in G | Fog, clouds |
| Solid emulsion | L in S | Cheese, butter |

You should be able to identify the colloid types

# Tyndall Effect

- Colloids can undergo the Tyndall Effect
  - The particles in the colloid will reflect light

http://www.silver-lightning.com/tyndall/

# Properties

| Solutions | Colloids | Suspension |
|---|---|---|
| Homogeneous | Heterogeneous | Heterogeneous |
| 0.01-1 nm | 1-1000 nm | > 1000 nm |
| Particle will not settle out | Particle will not settle out | Particle WILL settle out |
| Cannot be physically separated (filter, etc.) | Cannot be physically separated | Can be physically separated |
| Does NOT scatter light | Does scatter light | Does scatter light |

Know this!

## Electrolytes

- When a substance dissolves in water, they can be classified as ionic or molecular
- When ionic substances dissolve, they separate into their cations and anions
- These ions are available to move around making it possible for the solution to conduct electricity
  - **Electrolytes** are the substances that are dissolved in water to allow it to conduct electricity
  - **Nonelectrolytes** do not conduct electricity when dissolved in water

## Examples

- Electrolytes:

- Nonelectrolytes:

## Assignment

- 12.1 Worksheet

Section 12.2

## THE SOLUTION PROCESS

### Key Ideas

- List and explain 3 factors that affect the rate at which a solid solute dissolves in a liquid solvent
- Explain solution equilibrium, and distinguish among saturated, unsaturated, and supersaturated
- Explain the meaning of “likes dissolve likes” in the terms of polar and nonpolar substances

### Key Ideas

- List 3 interactions that contribute to enthalpy of solution and explain how they combine to cause dissolution to be exothermic or endothermic
- Compare the effect of temperature and pressure on solubility

## Factors that impact dissolving

1. Increase the surface area of the solute
    1. Why?
        1. Crush sugar vs sugar cube
2. Agitate the solution
    1. Why?
        1. Stir
3. Heat the solution
    1. Why
        1. Heat

## Solubility

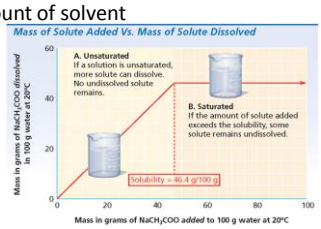
- Solubility is a measure of how well one substance dissolves in another
  - High solubility = dissolves well
    - Sugar water
  - Something can be insoluble
    - Rock and water, oil and water
- There is a limit to solubility
  - i.e. the solute will not dissolve anymore
  - For example, adding sugar to water

## Solubility

- When the solute dissolves in the solvent…
  - Solute particles break apart and float around
  - Some of these solute particles may run into each other and recrystallize (i.e. make a solid)
  - Eventually, the number or molecules returning to solid state and the number dissolving is equal
  - **Solution Equilibrium** is the physical state when this happens

## Saturation Point

- The saturation point is the point where you have dissolved the max amount of solute
  - This can change depending on the temp and amount of solvent




## Solution types

- **Saturated solution** contains the max amount of dissolved solute
- **Unsaturated solution** contains the <u>less than the</u> max amount of dissolved solute
- **Supersaturated solution** contains <u>more than</u> max amount of dissolved solute
  - This is usually done by adding/removing heat

## Sat, Unsat, Supersat, or None?

- 1 grain of sugar in 1 cup of water
- 1 tsp of salt in 1 cup of water
- 4 lbs of sugar in 1 gallon of water
- You place a crystal of X into the solution and it floats to the bottom
- You place a crystal of Z into the solution and the rest of the crystals come out of solution

## Solubility Values

- The **solubility** of a substance is the amount of substance required to form a saturate solution with a specific amount of solvent at a specific temperature.
  - WHAT!!!???
- Re word…

| Substance | 0°C | 40°C | 60°C | 100°C |
|---|---|---|---|---|
| NaCl | 35.7 | 36.4 | 37.1 | 39.2 |
| $AgNO_3$ | 122 | 311 | 440 | 733 |

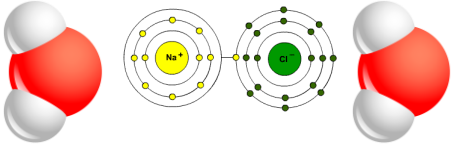
## Dissolving Ionic Cmps in Aq Solutions

- Likes dissolve likes
- Polar molecules (water) will dissolve polar molecules (ionic cmps)
  - They do NOT dissolve nonpolar molecules
- Nonpolar molecules will dissolve nonpolar molecules
  - They do NOT dissolve polar molecules
  - Example of nonpolar???

## Hydration

- **Hydration** is the process when water is the solvent
- Water is polar and this polarity is what helps dissolve ionic cmps

The NaCl is being hydrated



## Nonpolar dissolving

- Oils and fats are nonpolar so they do not dissolve in water
  - Examples:
- We need a nonpolar solvent for them to dissolve (carbon tetrachloride)

## Liquid Solutes and Solvents

- **Immiscible** liquids do NOT mix (not soluble)
  - Example: water and gasoline
- **Miscible** liquids DO mix (they dissolve freely in each other)
  - Example: Ethanol and water

## Effect of Pressure on Solubility

- Pressure increases have very little effect on solids and liquids
- Gas are impacted by pressure differences
  - You can "force" more gas molecules into the solutions if you increase the pressure
  - Example: soda

Equilibrium

$$\text{Gas} + \text{Solvent} \rightleftharpoons \text{Solution}$$

$$\text{Gas} + \text{Solvent} \underset{\text{Increase P}}{\rightleftharpoons} \text{Solution} \qquad \text{Gas} + \text{Solvent} \underset{\text{Decrease P}}{\rightleftharpoons} \text{Solution}$$

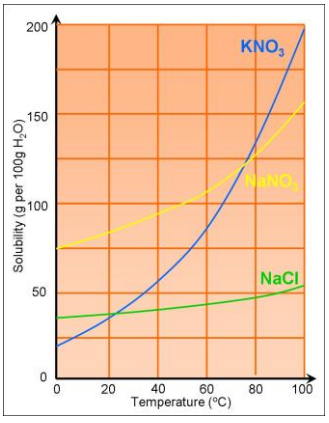
Video

## Henry's Law

- **Henry's Law** states the solubility of a gas in a liquid is directly proportional to the partial pressure of that gas on the surface of the liquid.
- This is why carbon dioxide stays in the soda when the top is closed
- When you open it effervesces
- **Effervescence** is the rapid escape of a gas from a liquid in which is dissolved

## Effects of Temp on Solubility

- Temperature usually increases solubility
  - Why?



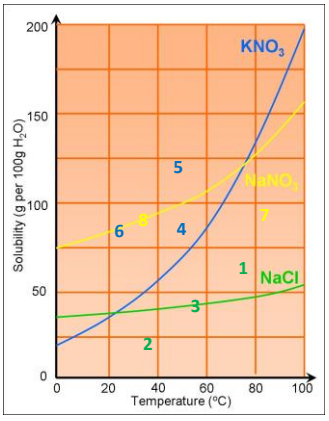

## Solubility Curve

Unsaturated

Saturated

Supersaturated

How do you use this?

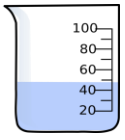



Are the following "numbers" Unsaturated, Saturated, or Supersaturated?

1 _____
2 _____
3 _____
4 _____
5 _____
6 _____
7 _____
8 _____

## A Change in NRG Accompanies Solution Formation

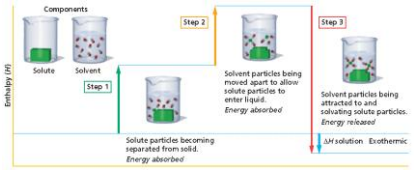
- Quick Demo
  - Dissolve NaOH in water
    - What do you notice about the outside of the beaker?




## A Change in NRG Accompanies Solution Formation

- NRG is required to break the bonds holding each substance together (i.e. the Na to the Cl)
- The solute particle that is surrounded by solvent molecules is said to me **solvated**.
- The net NRG absorbed as hear by the solution when a specific amount of solute dissolves in solvent is the **enthalpy of solution**.
- Figure 2.12 on page 393

## A Change in NRG Accompanies Solution Formation




## Assignment

- 12.2 Worksheet
- POGIL – Saturated and Unsaturated (In Class)
- POGIL – Solubility (In Class)

12.3

## CONCENTRATIONS OF SOLUTIONS

## Key Ideas

- Molarity is moles of solute per liter of solution
- Molarity is moles of solute per kg of solvent

## Concentration

- Think of something "concentrated". How would you describe it to someone without using the concentrated?
- **Concentration** of a solution is the measure of the amount of solute in a given amount of solvent/solution.

## Molarity is Moles of Solute per Liter of Solution

- **Molarity** is the number of moles of solute in 1 liter of solution
  - Example: a 1 molar solution of NaOH has
    - 1 Mole of NaOH dissolved in 1 Liter of water
  - Example: a 2 molar solution of NaOH has
    - 2 Mole of NaOH dissolved in 1 Liter of water
  - What if you don't have 1 liter of solution???

## Molarity is Moles of Solute per Liter of Solution

$$Molarity\ (M) = \frac{amount\ of\ solute\ (mol)}{volume\ of\ solution\ (L)}$$

1. Determine the molarity of a solution that has dissolved 2.3 moles of X in a 4 L solution?
2. How many moles of NaOH where dissolved to make 2.5 liters of 6 M solution?
3. You dissolve 150 grams of NaCl into 3 liters of water, what is the molarity of the solution?

## Preparation of 1 liter of an "X" M Solution

1. Determine the amount of solute needed
2. Pour 500 mL (1/2) into your container
3. Pour your "X" into the container
4. Fill the container to the 1 L mark

## You want to create 1 L of a 2.5 M solution of NaCl

- Determine the amount of NaCl you need

$$Molarity\ (M) = \frac{amount\ of\ solute\ (mol)}{volume\ of\ soluiton\ (L)} \leftarrow \text{Solve}$$

- Convert the moles into grams

$$\frac{2.5\ \text{mole NaCl}}{1\ \text{mole NaCl}} \times 58.45\ \text{g NaCl} = 146.13\ \text{g NaCl}$$

- This is how much NaCl you need for this solution

## You want to create 1 L of a 2.5 M solution of NaCl

- Fill the container with ½ of the final volume of your solution (i.e. 500 mL)
- Put your 146.13 grams of NaCl into the water
- Shake/Stir
- Fill to the 1 L mark

**Why can't you just put 146.13 grams of NaCl into 1 L of water?**

$$Molarity\ (M) = \frac{amount\ of\ A\ (mol)}{volume\ of\ solution\ (L)}$$

## Practice

You have 3.50 L of solution that contains 90.0 g of sodium chloride, NaCl. What is the molarity of that solution?

$$Molarity\ (M) = \frac{amount\ of\ A\ (mol)}{volume\ of\ solution\ (L)}$$

## Practice

You have 0.8 L of a 0.5 M HCl solution. How many moles of HCl does this solution contain

$$Molarity\ (M) = \frac{amount\ of\ A\ (mol)}{volume\ of\ solution\ (L)}$$

## Practice

To produce 40.0 g of silver chromate, you will need at least 23.4 g of potassium chromate in solution as a reactant. All you have on hand is 5 L of a 6.0 M $K_2CrO_4$ solution. What volume of the solution is needed to give you the 23.4 g $K_2CrO_4$ needed for the reaction?

Help: Find moles of $K_2CrO_4$ needed then convert that to volume using the Molarity formula.

## Molality

- **Molality** (m) is the concertation of a solution expressed in moles of solute per kg of solvent

$$Molality\ (m) = \frac{moles\ of\ solute\ (mol)}{mass\ of\ solvent\ (kg)}$$

- MolaRity and MolaLity are similar because they both give you a concentration, the difference is molaLity does NOT depend on temperature
  - Why?

## Comparison

$$Molarity\ (M) = \frac{amount\ of\ A\ (mol)}{volume\ of\ solution\ (L)}$$

$$Molality\ (m) = \frac{amount\ of\ A\ (mol)}{mass\ of\ solvent\ (kg)}$$

## Preparation of m solution

- Same as molaRity but you use the mass of each of the substance and mix them
  - i.e. you do not add the NaCl to 500 mL of water and then fill to 1 L
- You just measure and mix

## Example

- You want a 0.5 m solution of copper (II) sulfate pentahydrate
- Add EXACTY 1 kg (or 1 L) to the container
- Add 124.8 g of copper (II) sulfate pentahydrate
- Mix

$$Molality\ (m) = \frac{amount\ of\ A\ (mol)}{mass\ of\ solvent\ (kg)}$$

## Practice

A solution was prepared by dissolving 17.1 g of sucrose (table sugar, $C_{12}H_{22}O_{11}$) in 125 g of water. Find the molality concentration of this solution.

$$Molality\ (m) = \frac{amount\ of\ A\ (mol)}{mass\ of\ solvent\ (kg)}$$

## Practice

A solution of iodine, $I_2$, in carbon tetrachloride, $CCl_4$, is used when iodine is needed for certain chemical tests. How much iodine must be added to prepare a 0.480 *m* solution of iodine in $CCl_4$ if 100.0 g of $CCl_4$ is used?

## Assignment

- 12.3 Worksheet
- POGIL – Molarity (In Class)