Heterogeneous Mixtures

〉 What is a heterogeneous mixture?

〉 A heterogeneous mixture does not have a fixed composition.

– The amount of each substance in different samples varies.

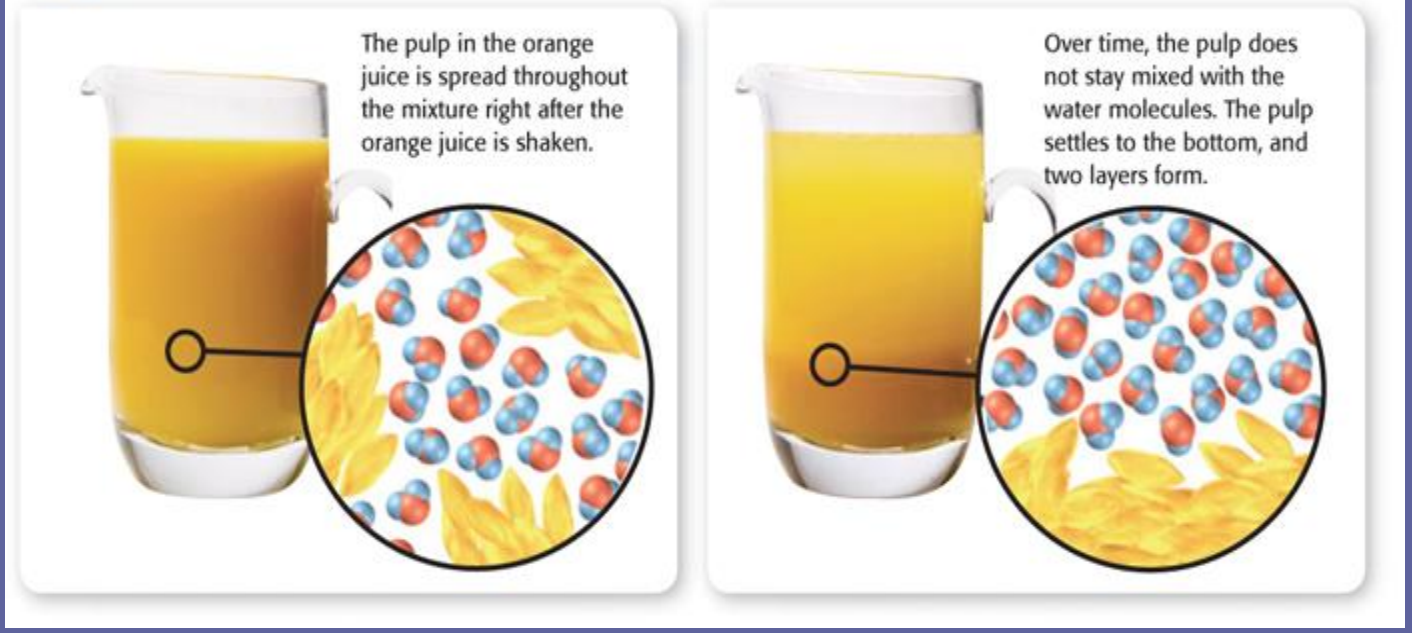
- fruit salad
- dirt
- granite

Heterogeneous Mixtures, *continued*

- Particles in a suspension are large and settle out.
- **Suspension:** a mixture in which particles of a material are more or less evenly dispersed throughout a liquid or gas
  - Natural orange juice contains particles of pulp.
- Particles in a suspension may settle over time.
- Particles in a suspension may be filtered out.

Suspension

Figure 2 **Orange Juice: A Heterogeneous Mixture**



Heterogeneous Mixtures, *continued*

- Some mixtures of two liquids will separate.
  - Oil and vinegar in salad dressing separate into two layers.
- Liquids that do not mix with each other are *immiscible.*
- *decanting:* process of pouring *a* less dense liquid off a denser liquid
  - use to separate two immiscible liquids

Heterogeneous Mixtures, *continued*

- Particles in a colloid are too small to settle out.
- **colloid:** a mixture consisting of tiny particles that are intermediate in size between those in solutions and those in suspensions and that are suspended in a liquid, solid or gas
- Particles in a colloid are large enough to scatter light that passes through.
  - This is called the *Tyndall effect.*

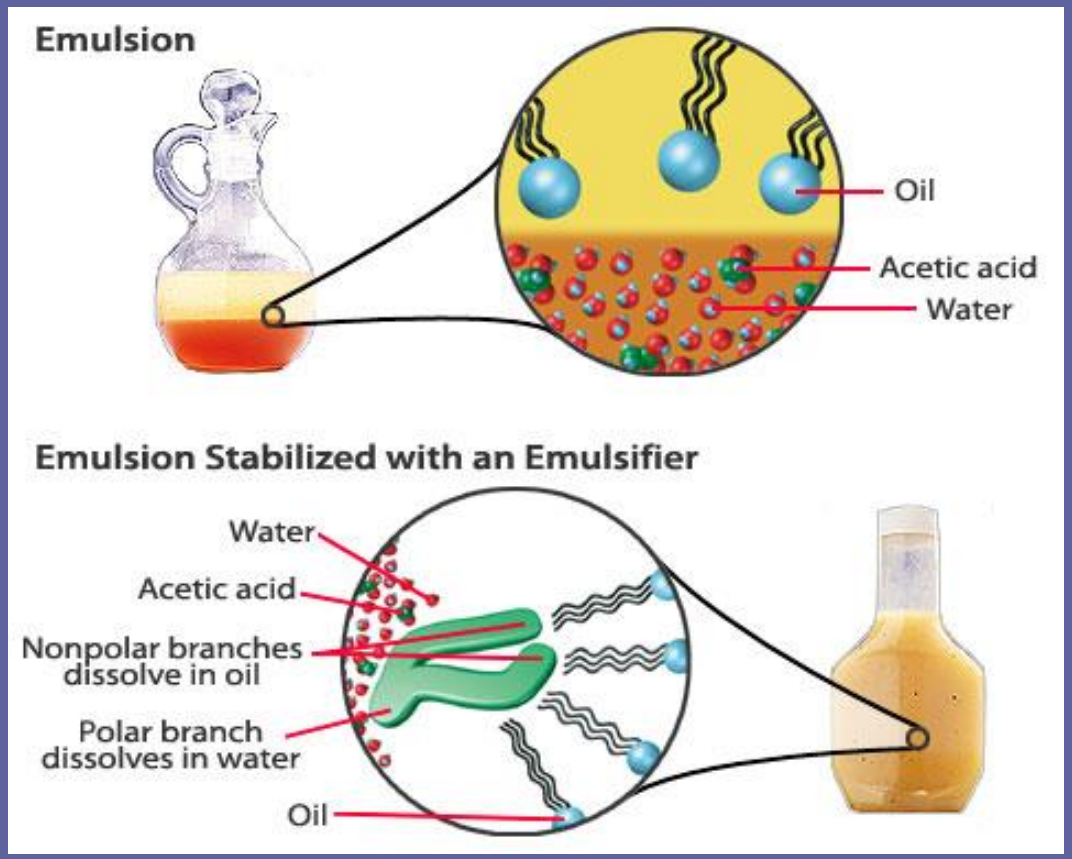
Colloids

Not a colloid Colloid

Heterogeneous Mixtures, *continued*

- Other familiar materials are colloids.
  - gelatin desserts, egg whites, and blood plasma
- Some immiscible liquids can form colloids.
  - **emulsion:** any mixture of two or more immiscible liquids in which one liquid is dispersed in the other

Emulsions



Homogeneous Mixtures

- What is a homogeneous mixture?

- A homogeneous mixture looks uniform even when you examine it under a microscope because the individual components of the mixture are too small to be seen.

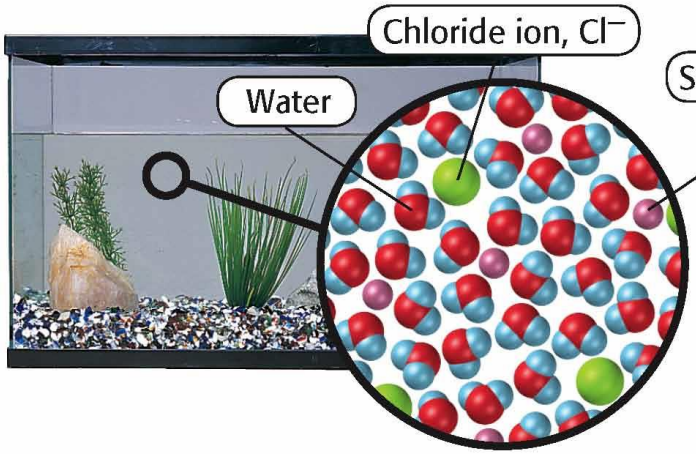
  - In salt water, the number of ions is the same everywhere.

Homogeneous Mixtures, *continued*

- Homogeneous mixtures are solutions.
- **solution:** a homogeneous mixture throughout which two or more substances are uniformly dispersed
- **solute:** in a solution, the substance that dissolves in the solvent
- **solvent:** in a solution, the substance in which the solute dissolves

Homogeneous Mixture

Plain water is homogeneous because it is a single substance.



Salt water is also homogeneous because it is a uniform mixture of water molecules, sodium ions, and chloride ions.

Homogeneous Mixtures, *continued*

- Miscible liquids mix to form solutions.
  - *miscible:* liquids that form a single layer when mixed
  - *distillation:* a method used to separate miscible liquids that have different boiling points
- Liquid solutions sometimes contain no water.
  - *petroleum:* a liquid solution of gasoline, diesel fuel, and kerosene

Homogeneous Mixtures, *continued*

- Other states of matter can also form solutions.
  - The air is a solution of nitrogen, oxygen, argon, and other gases.
  - *amalgam*: a solution of mercury dissolved in silver
- The substance that there is the most amount of is the solvent.
- The substance that there is the least of amount of is the solute.
- Solids can dissolve in other solids.
  - **alloy:** a solid or liquid mixture of two or more metals

Water: A Common Solvent

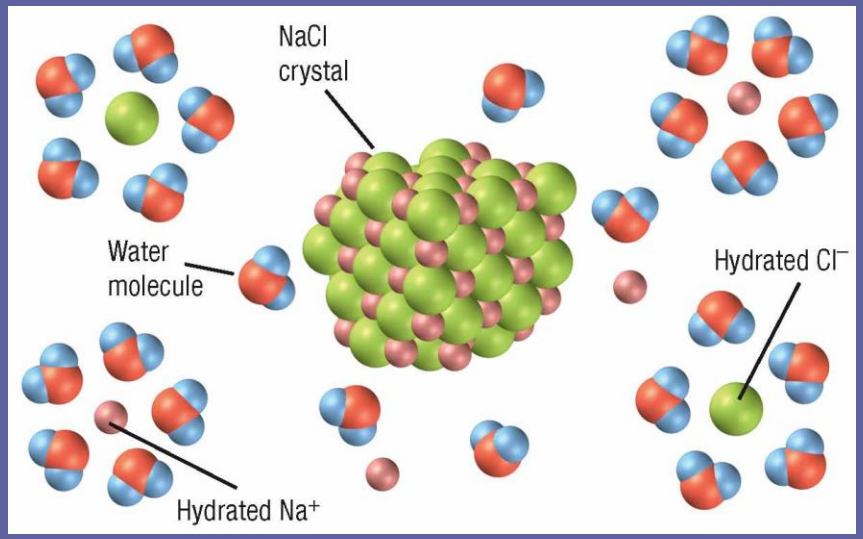
〉 Why is water called the universal solvent?

〉 Water is called the *universal solvent* because many substances can dissolve in water.

- Water can dissolve ionic compounds.
  - Water is a polar compound.
  - **polar:** describes a molecule in which the positive and negative charges are separated
  - Water molecules attract both positive ions and negative ions.

Water: A Common Solvent, *continued*

- Polar water molecules pull ionic crystals apart, as shown below.



- The partially negative oxygen atoms of water molecules attract the positively charged sodium ions.

- The partially positive hydrogen atoms of water molecules attract the negatively charged chloride ions.

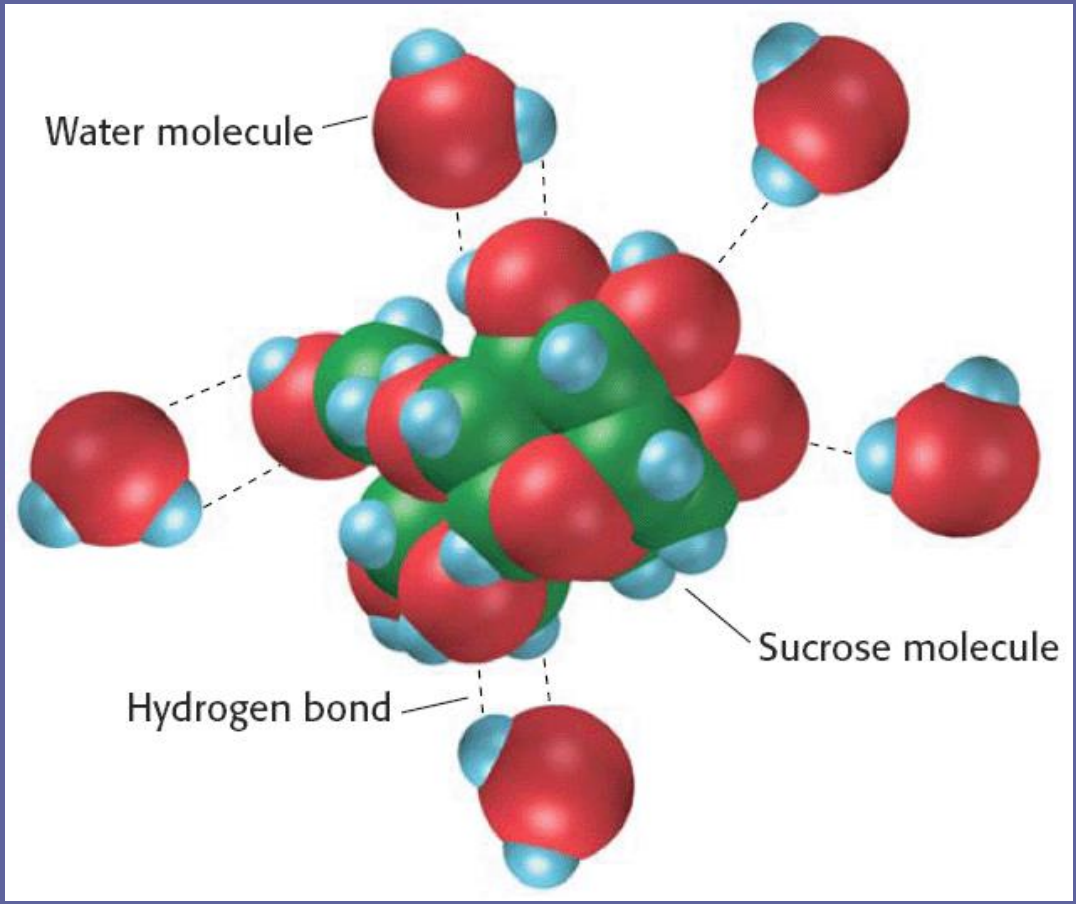
Water: A Common Solvent, *continued*

- Dissolving depends on the forces between particles.
  - The forces between the solvent molecules and the particles of the substances must be greater than the force between the particles in the crystal.

- Water dissolves many molecular compounds.
  - Water forms hydrogen bonds with molecular compounds such as sugar.

- **hydrogen bond:** the intermolecular force occurring when a hydrogen atom that is bonded to a highly electronegative atom of one molecule is attracted to two unshared electrons of another molecule

Hydrogen Bonding



Water: A Common Solvent, *continued*

- Like dissolves like.
  - A solvent will dissolve substances that have molecular structures that are like the solvent's structure.

- Nonpolar compounds usually will not dissolve in water.
  - **nonpolar:** describes a molecule in which the centers of positive and negative charge are not separated

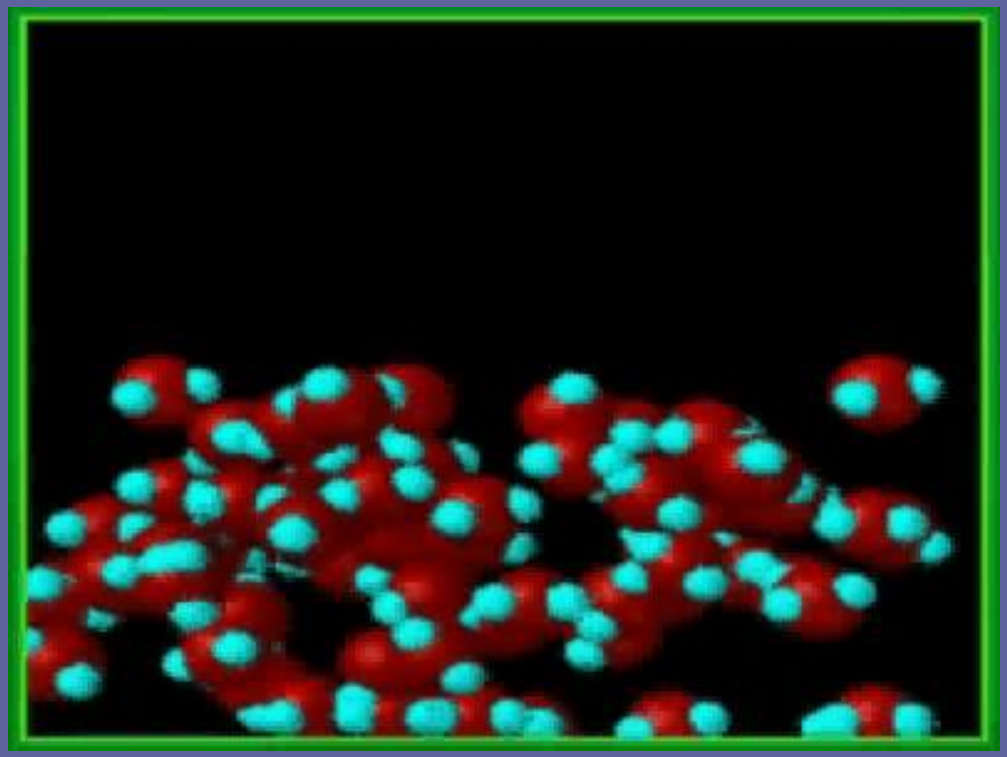
  - Nonpolar solvents are used to dissolve nonpolar materials.

The Dissolving Process

- Why do substances dissolve?

- The energy transferred from the solvent to the solute, as well as the attractive forces between the solvent and solute molecules, causes molecules at the surface of the crystal to dissolve.

Dissolving Process



The Dissolving Process, *continued*

- Solutes with a larger surface area dissolve faster.
  - More solute particles are exposed to the solvent.

- Stirring or shaking a solution helps the solute dissolve faster.
  - Dissolved solute particles diffuse throughout the solution faster.
  - More solute particles can dissolve.

- Solutes dissolve faster when the solvent is hot.
  - Collisions occur between solute and solvent particles more frequently and with more energy.

Surface Area

This salt crystal has a much smaller surface area than its total volume.

The Dissolving Process, *continued*

- Solutes affect the physical properties of a solution.
  - Solutes increase the boiling point of a solution.
    - If you dissolve salt in water, it will boil at a higher temperature.
  - Solutes lower the freezing point of a solution.
    - The coolant mixture of ethylene glycol and water keeps a car's radiator fluid from freezing in winter.

Solubility in Water

〉 What is solubility?

〉 The solubility of a substance is the maximum mass of a solute that can dissolve in 100 g of solvent at a certain temperature and standard atmospheric pressure.

- **solubility:** the ability of one substance to dissolve in another at a given temperature and pressure

Solubility in Water, *continued*

Substance	Formula	Solubility in g/100 g H_2O at 20 °C
Calcium chloride	$CaCl_2$	75
Calcium fluoride	CaF_2	0.0015
Calcium sulfate	$CaSO_4$	0.32
Iron(II) sulfide	FeS	0.0006
Silver chloride	AgCl	0.000 19
Silver nitrate	$AgNO_3$	216
Sodium chloride	NaCl	35.9
Sodium fluoride	NaF	4.06
Sodium iodide	NaI	178
Sodium sulfide	Na_2S	26.3

- Different substances have different solubilities.

Solubility in Water, *continued*

- How much of substance is in a solution?
- To express how much of a substance can dissolve in a solvent, you need to use the *concentration.*
- **Concentration:** the amount of a particular substance in a given volume of a mixture, solution, or ore
  - A *concentrated* solution has a large amount of solute.
  - A *dilute* solution has only a small amount of solute.

Saturated Solutions

〉 What happens when you add more solute to a saturated solution?

〉 In a saturated solution, the dissolved solute is in equilibrium with undissolved solute. So, if you add more solute, it just settles to the bottom of the container.

- **saturated solution:** a solution that cannot dissolve any more solute under the given conditions

Saturated Solutions, *continued*

- Unsaturated solutions can become saturated.
- **unsaturated solution:** a solution that contains less solute than a saturated solution does and that is able to dissolve additional solute
- Heating a saturated solution can dissolve more solid.
  - The solubility of most solutes increases with temperature.

Saturated Solutions, *continued*

- **supersaturated solution:** a solution that holds more dissolved solute than is required to reach equilibrium at a given temperature.
  - To make a supersaturated solution, you raise the temperature of a solution, dissolve more solute, then let the solution cool again.

Saturated Solutions, *continued*

- Temperature and pressure affect the solubility of gases.
- Gaseous solutes are *less* soluble in warmer water.
  - Example: Soda goes flat quickly at room temperature.
- Gases are more soluble under higher pressure.
  - Example: When a can of soda is opened, carbon dioxide gas that had been dissolved in the soda bubbles out of solution.

Concentration of Solutions

〉 How do you describe how much of a solute is in a solution?

One of the most common ways of expressing the concentration of solution is molarity.

- **Molarity:** a concentration unit of a solution expressed in moles of solute dissolved per liter of solution.

$$molarity = \frac{moles\ of\ solute}{liters\ of\ solution}, \text{ or } M = \frac{\text{mol}}{\text{L}}$$

Concentration of Solutions, *continued*

Molarity is moles per liter of *solution,* not per liter of *solvent.*

A 1.0 M solution of NaCl contains 1.0 mol of dissolved NaCl in every 1.0 L of solution.

Math Skills

Molarity

Calculate the molarity of sucrose, $C_{12}H_{22}O_{11}$, in a solution of 124 g of solute in 0.500 L of solution.

1. List the given and unknown values.

Given: *mass of sucrose* = 124 g
volume of solution = 0.500 L

Unknown: *molarity,* amount of sucrose in 1 L of solution

Math Skills, *continued*

2. Write the equation for moles $C_{12}H_{22}O_{11}$ and molarity.

$$\text{moles } C_{12}H_{22}O_{11} = \frac{\text{mass } C_{12}H_{22}O_{11}}{\text{molar mass } C_{12}H_{22}O_{11}}$$

$$\text{molarity} = \frac{\text{moles } C_{12}H_{22}O_{11}}{\text{liters of solution}}$$

Math Skills, *continued*

3. Find the number of moles of $C_{12}H_{22}O_{11}$ and calculate molarity.

molar mass $C_{12}H_{22}O_{11} = 342\ g$

$$\textit{moles}\ C_{12}H_{22}O_{11} = \frac{124\ g}{342\ g} = 0.362\ mol\ C_{12}H_{22}O_{11}$$

$$\textit{molarity of solution} = \frac{0.362\ mol\ C_{12}H_{22}O_{11}}{0.500\ L\ solution} = \boxed{0.724\ M}$$