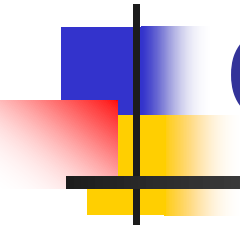
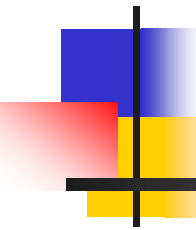


Chapter 3

Substances, Mixtures, and Solubility



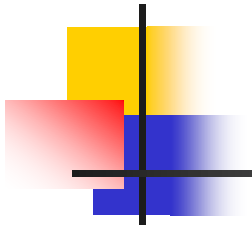
3 – 1 What is a Solution ?

Substances vs. Mixtures

- Substances
  - Compounds
  - Atoms
- Mixtures
  - Heterogeneous
  - Homogeneous

Substances

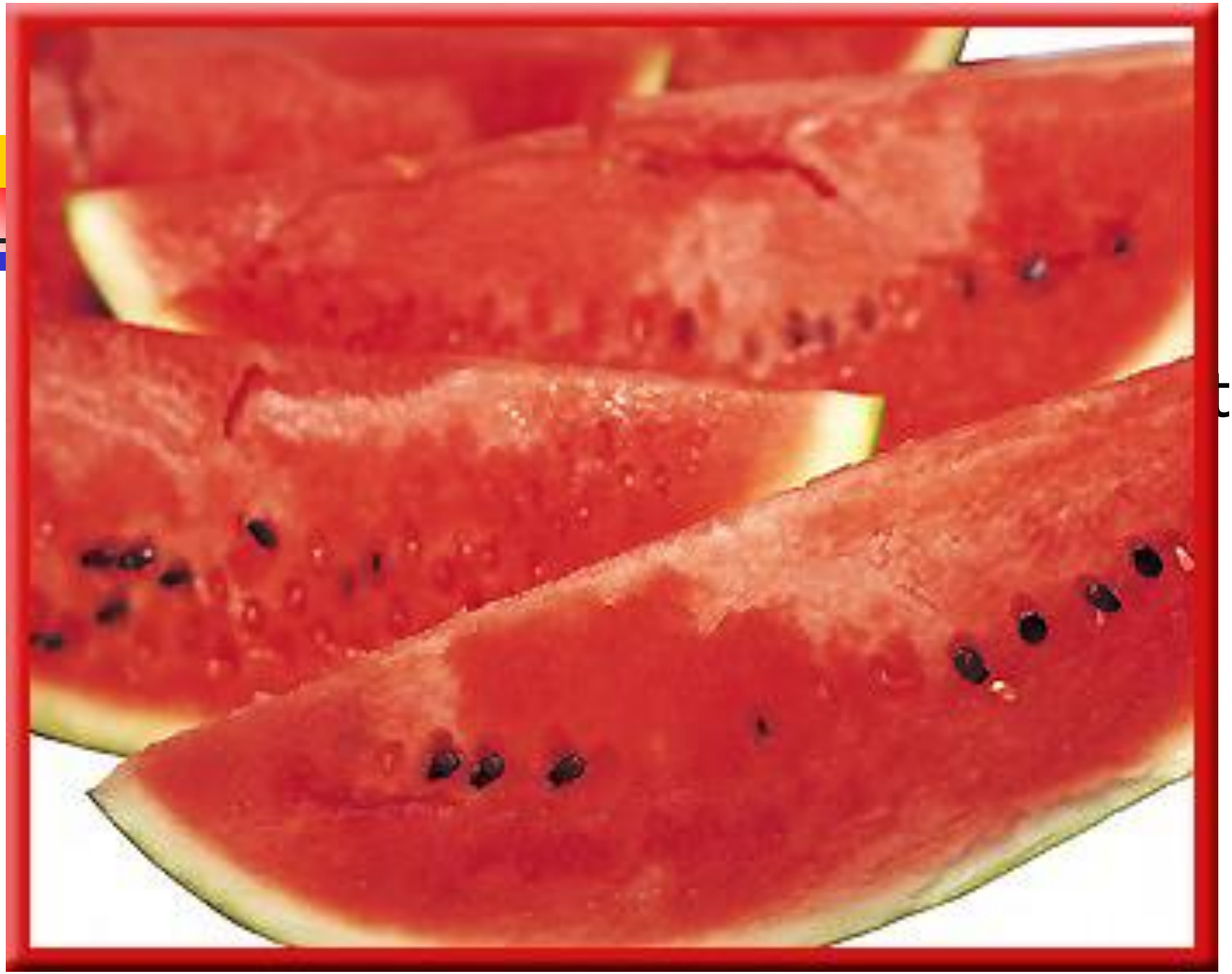
- Substances – matter with a fixed composition whose identity can be changed by chemical processes but not by physical processes.
  - It cannot be broken down into simpler parts by physical processes.
  - Always contains the exact same proportion of elements.



- Example : Nitrogen
  - Nitrogen is an element. It cannot be broken down.
- Example : Water
  - Water is made of Hydrogen and Oxygen. The water molecule cannot be broken down without a chemical reaction.

Mixtures

- Mixture – A combination of substances that are not bonded together and can be separated by physical processes.
  - Does not always contain the same proportion of elements.
    - Example : Adding more sugar to Kool-Aid does not change it into something else, just gives a greater sugar concentration.



Heterogeneous Mixtures

- Different areas of a heterogeneous mixture have different compositions
  - Example : Watermelons do not have seeds evenly distributed throughout.
  - Example : Cereal does not give you the same proportion of cereal to milk each spoon full.
  - Example : Kool-Aid has a lot more sugar settle to the bottom of the pitcher.

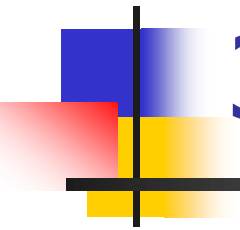
Homogeneous Mixture

- Also known as a "Solution"
  - Solutions are formed by a Solute and a Solvent
  - Solute dissolves in the Solvent
    - Example : sugar (solute) dissolves in water (solvent)
  - Crystallization – occurs when a solute comes back out of its solution and forms a solid.
    - The result of a physical change.

Types of Solutions

- Liquid–Gas Solution
  - Gas is dissolved into a liquid
    - Example : Soda
- Liquid-Liquid Solution
  - Liquid is dissolved into a liquid
    - Example : Vinegar
- Gas-Gas Solution
  - Gas is dissolved into a gas
    - Example : Our atmosphere (oxygen dissolved into Nitrogen)

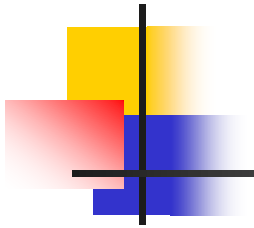
- Solid Solutions
  - The solute may be a solid, liquid, or a gas.
  - Solid-solid solutions are the most common.
    - Most of our metals are not pure substances, they are a mixture of metals.
    - Alloy – a solution of two or more metals.



3 – 2 Solubility

Like Dissolves Like

- Why is it that when a spoon full of sugar is stirred into Kool-Aid, the sugar dissolves but the spoon does not dissolve ?



- Polar solvents dissolve polar solutes.
- Nonpolar solvents dissolve nonpolar solutes.
- Ionic solvents dissolve ionic solutes.

- Oil and water do not mix
  - Oil is nonpolar, water is polar

Water

- "The Universal Solvent"
  - Water will dissolve most solutes.
- Aqueous – Any solution in which water is the solvent.
- Water is polar, and dissolve both polar molecules and ionic compounds.

Solubility

- Solubility – measure of how much solute can be dissolved in a certain amount of solvent.
  - The amount of material that will dissolve into 100g of solvent at a given temperature.
  - If the solubility is 0, or is extremely low, the substance is considered "Insoluble".

The Effect of Temperature on Solubility

- Liquid-Solid Solution
  - Increasing the temperature increases the solubility and speeds the rate at which the solute dissolves.
- Liquid-Gas Solution
  - Increasing the temperature decreases the solubility of the solution.

Saturated Solutions

- Saturated – a solution that holds the total amount of solute that it can hold under given conditions.
- Unsaturated – solution that does not hold the total amount of solute under given conditions.
- Supersaturated – solution that holds more solute than the total amount of solute under the given conditions.

Rate of Dissolving

1. Stir/Shake up -- increases rate
2. Raise temperature -- increases rate
3. Breaking the solute into smaller pieces -- increases rate

Concentration

- Concentration – how much solute is present in a solution compared to the amount of solvent present.
  - Concentrated solution has more solute present than a Dilute solution.

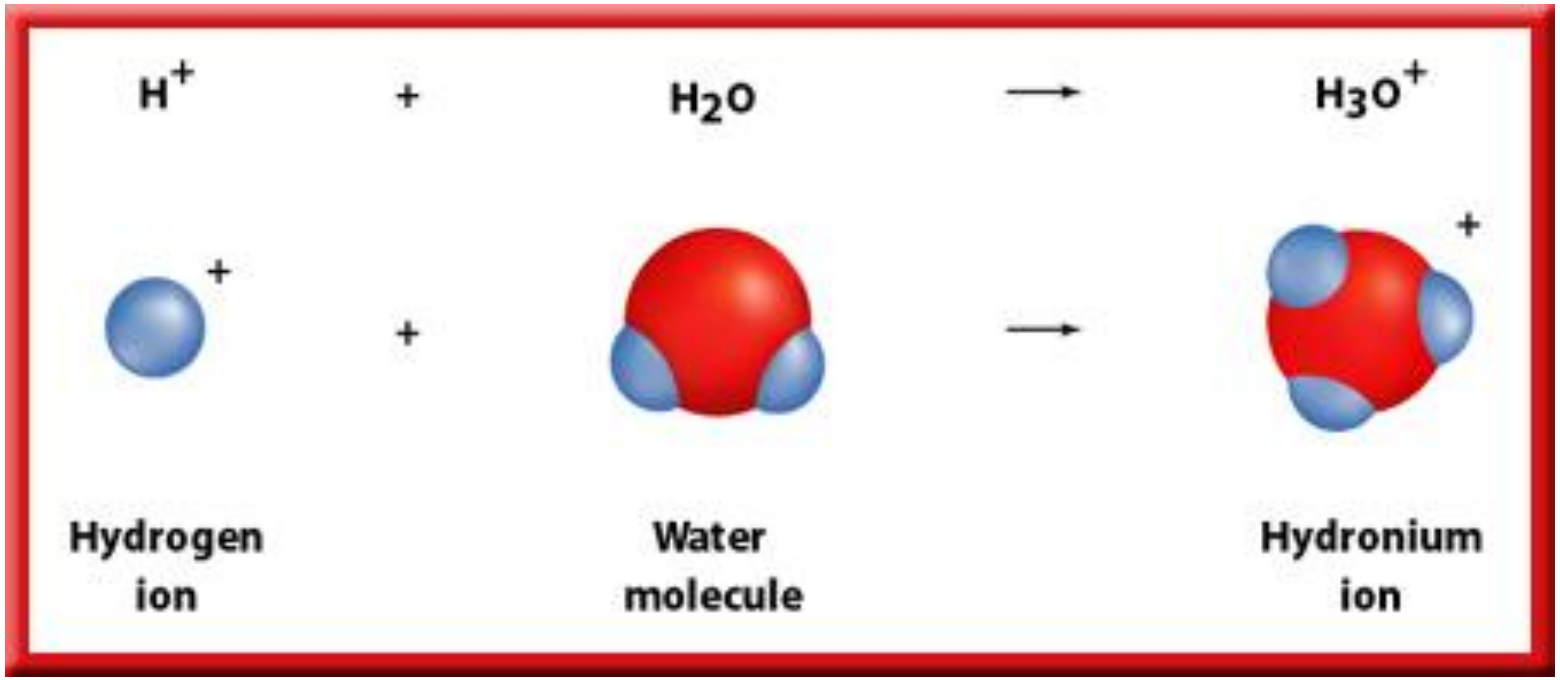
Effects of Solute Particles

- Solute particles prevent the molecules of the solvent from aligning in the proper arrangement in order to freeze.
  - Salt prevents water molecules from forming their crystalline structure when trying to freeze.
  - Salt prevents water molecules from escaping the liquid when boiling.

3 – 3 Acidic and Basic Solutions

Acids

- Acids are substances that release positively charged hydrogen ions, H^+, in the water.
- When an acid mixes with water, the acid dissolves, releasing a hydrogen ion.
- The hydrogen ion then combines with a water molecule to form a hydronium ion.
- **Hydronium ions** are positively charged and have the formula H_3O^+.

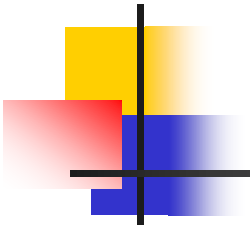

H+ + H2O → H3O+
Hydrogen ion
Water molecule
Hydronium ion

Properties of Acidic Solutions

- Sour taste.
- They can conduct electricity.
- Corrosive - They break down certain substances.
  - Many acids can corrode fabric, skin, and paper.
  - The solutions of some acids also react strongly with certain metals.

Uses of Acids

- Vinegar, which is used in salad dressing, contains acetic acid.
- Lemons, limes, and oranges have a sour taste because they contain citric acid.
- Your body needs ascorbic acid, which is vitamin C.
- Sulfuric acid is used in the production of fertilizers, steel, paints, and plastics.



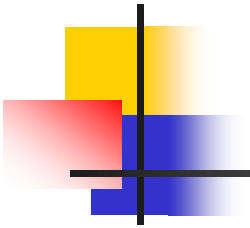
- Acids often are used in batteries because their solutions conduct electricity.
- Hydrochloric acid, which is known commercially as muriatic acid, is used in a process called pickling.
  - Pickling is a process that removes impurities from the surfaces of metals.

Acid in the Environment

- Carbonic acid plays a key role in the formation of caves and of stalactites and stalagmites.
- Carbonic acid is formed when carbon dioxide in soil is dissolved in water.
- When this acidic solution comes in contact with calcium carbonate—or limestone rock—it can dissolve it, eventually carving out a cave in the rock.

Bases

- **Bases** are substances that can accept hydrogen ions.
- When bases dissolve in water, some hydrogen atoms from the water molecules are attracted to the base.
- When bases dissolve in water, some hydrogen atoms from the water molecules are attracted to the base.



- This pair of atoms is a negatively charged ion called a hydroxide ion.
- A hydroxide ion has the formula OH^-.
- Most bases contain a hydroxide ion, which is released when the base dissolves in water.

Properties of Basic Solutions

- Basic solutions feel slippery.
- Bases also taste bitter.
- Like acids, bases are corrosive.
- Basic solutions contain ions and can conduct electricity. Basic solutions are not as reactive with metals as acidic solutions are.

Uses of Bases

- Bases give soaps, ammonia, and many other cleaning products some of their useful properties.
- The hydroxide ions produced by bases can interact strongly with certain substances, such as dirt and grease.

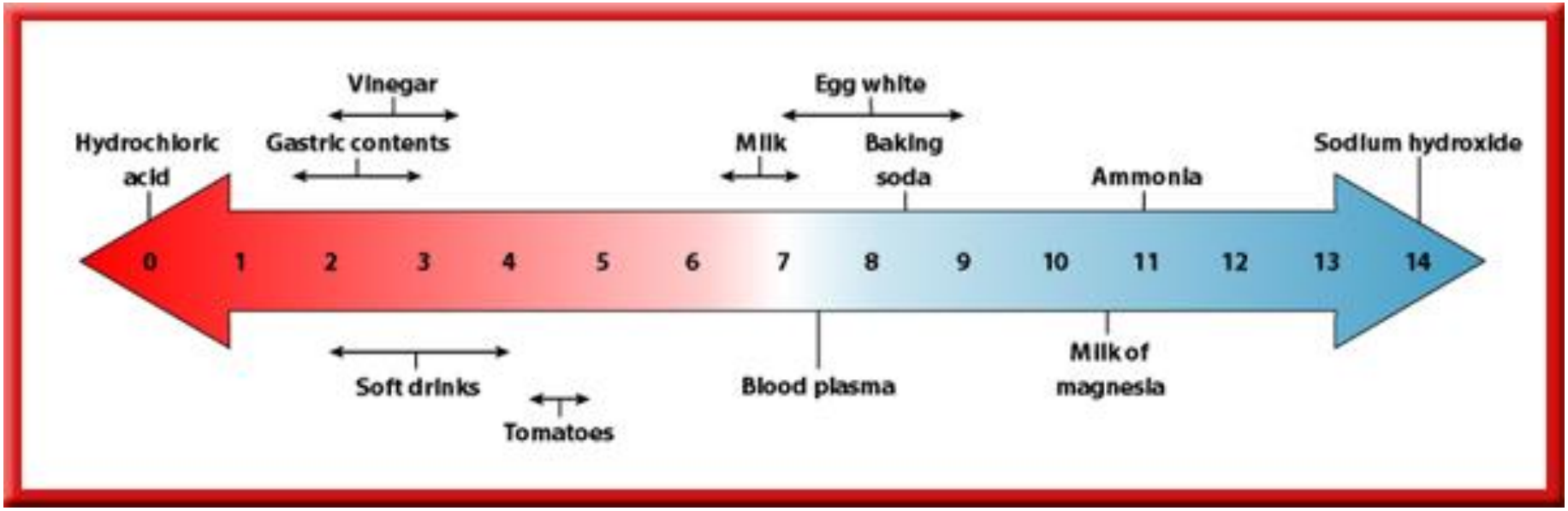
- Chalk and oven cleaner are examples of familiar products that contain bases.
- Your blood is a basic solution.

What is pH?

- **pH** is a measure of how acidic or basic a solution is.
- The pH scale ranges from 0 to 14.
- Acidic solutions have pH values below 7.
- A solution with a pH of 0 is very acidic.
- A solution with a pH of 7 is neutral.
- Basic solutions have pH values above 7.

pH Scale

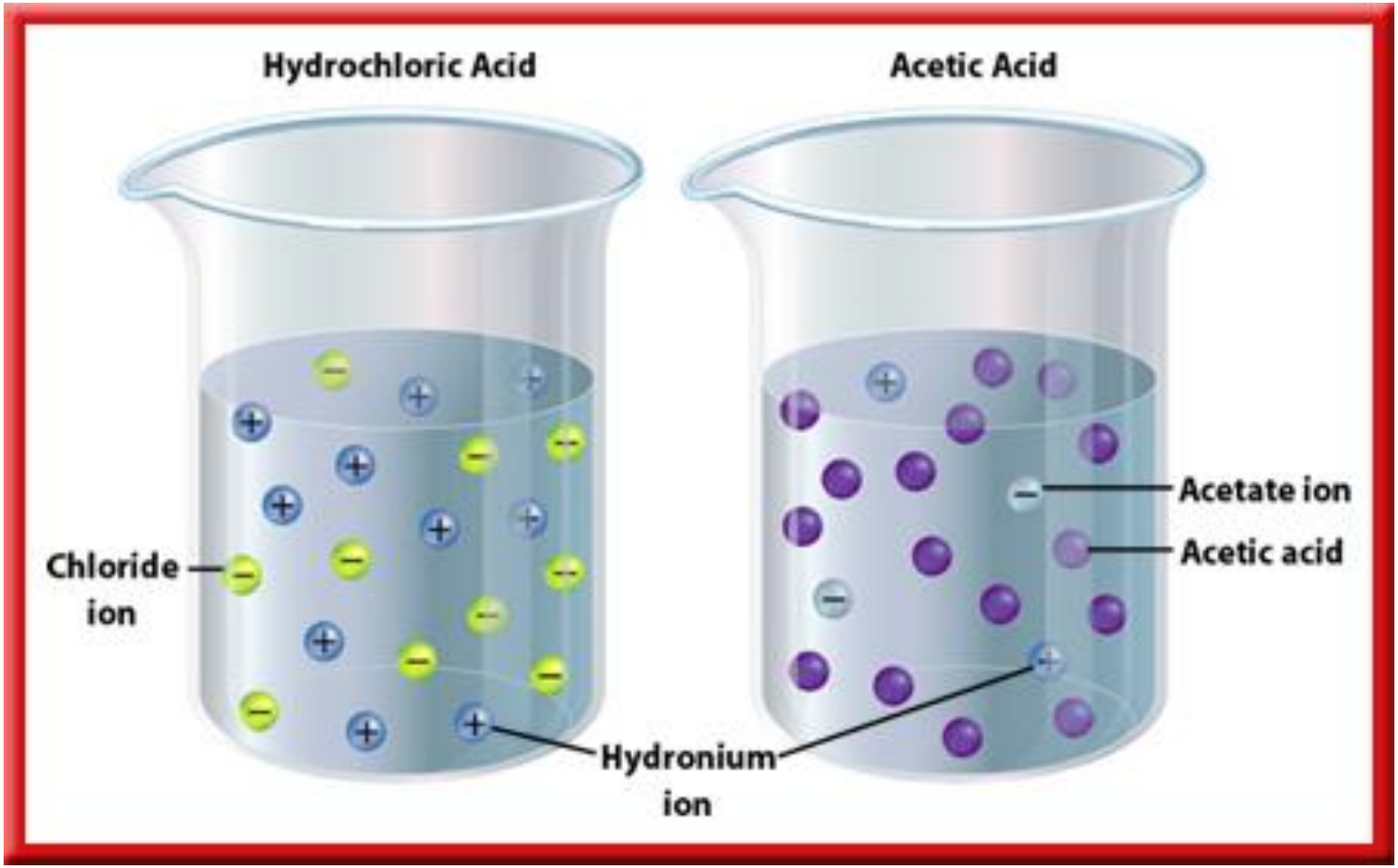
- A change of 1 pH unit represents a tenfold change in the acidity of the solution.
- For example, if one solution has a pH of 1 and a second solution has a pH of 2, the first solution is not twice as acidic as the second—it is ten times more acidic.


Vinegar
Egg white
Hydrochloric acid
Gastric contents
Milk
Baking soda
Ammonia
Sodium hydroxide
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Soft drinks
Tomatoes
Blood plasma
Milk of magnesia

Strengths of Acids and Bases

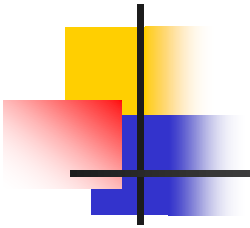
- The difference between food acids and the acids that can burn you is that they have different strengths.
- The strength of an acid is related to how easily the acid separates into ions, or how easily a hydrogen ion is released, when the acid dissolves in water.

- In the same concentration, a strong acid—like hydrochloric acid—forms more hydronium ions in solution than a weak acid does—like acetic acid.



- More hydronium ions means the strong-acid solutions has a lower pH than the weak-acid solution.

Strengths of Some Acids and Bases		
	Acid	**Base**
Strong	hydrochloric (HCl) sulfuric (H_2SO_4) nitric (HNO_3)	sodium hydroxide ($NaOH$) potassium hydroxide (KOH)
Weak	acetic (CH_3COOH) carbonic (H_2CO_3) ascorbic ($H_2C_6H_6O_6$)	ammonia (NH_3) aluminum hydroxide ($Al(OH)_3$) iron (III) hydroxide ($Fe(OH)_3$)



- The strength of a base is related to how easily the base separates into ions, or how easily a hydroxide ion is released, when the base dissolves in water.

Indicators

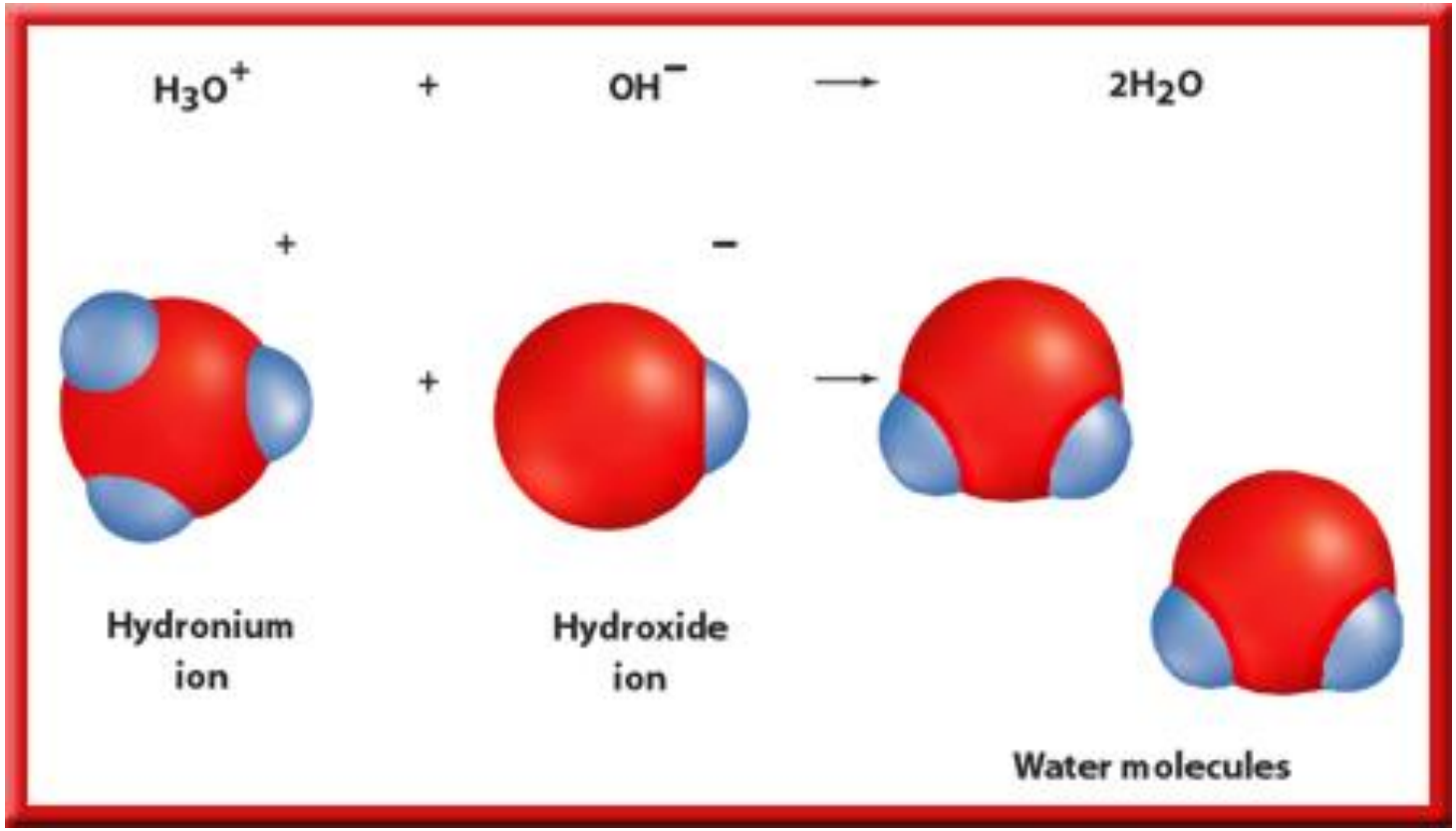
- **Indicators** are compounds that react with acidic and basic solutions and produce certain colors, depending on the solution's pH.
- Because they are different colors at different pHs, indicators can help you determine the pH of a solution.
- When litmus paper is placed in an acidic solution, it turns red. When placed in a basic solution, litmus paper turns blue.

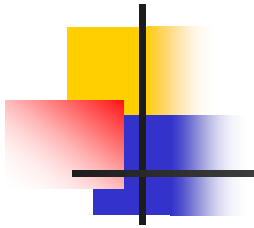
Neutralization

- Heartburn or stomach discomfort is caused by excess hydrochloric acid in the stomach.
- An antacid product, often made from the base magnesium hydroxide, $Mg(OH)_2$, neutralizes the excess acid.
- **Neutralization** (new truh luh ZAY shun) is the reaction of an acid with a base. It is called this because the properties of both the acid and base are diminished, or neutralized.

How does neutralization occur?

- Recall that every water molecule contains two hydrogen atoms and one oxygen atom.
- When one hydronium ion reacts with one hydroxide ion, the product is two water molecules. This reaction occurs during acid-base neutralization.


H_3O^+ + OH^- → $2H_2O$
+
−
+
Hydronium ion
Hydroxide ion
Water molecules



- Equal numbers of hydronium ions from the acidic solution and hydroxide ions from the basic solution react to produce water.
- Pure water has a pH of 7, which means that it’s neutral.