Acids and Bases

- They are all around us!
- Cabbage indicator lab for bonus points! ASK!

Properties of Acids

- Acids taste sour
- Acids effect indicators
  - Blue litmus turns red
  - Methyl orange turns red
- Acids have a pH lower than 7
- Acids are proton (hydrogen ion, H^+) donors
- Acids react with active metals, produce H_2
- Acids react with carbonates to release carbon dioxide and water
- Acids neutralize bases to form salt and water
- Acids are sticky
- Acids are electrolytes

Nomenclature of Acids

- Two types:

1. Binary Acids H___ Prefix Hydro______ ending ic Acid

- HBr Hydrobromic Acid
- HCl ?
- ? Hydrofluoric Acid

2. Oxy Acids

- Hydrogen ______Oxygen   H___O_x
- **Prefix and ending indicate number of oxygens present:**
- + 2 oxygens   Hyper ___ic acid $HClO_5$ Hyperchloric Acid
- +1 oxygen   per____ic acid $HClO_4$ PerChloric Acid
- Normal Poly # (ate ending) ____ic acid $HClO_3$ Chloric Acid
- -1 oxygen   ____ous acid $HClO_2$ Chlorous Acid
- -2 oxygens   Hypo ____ous acid   HClO   Hypochlorous Acid

Acids you SHOULD know:

Strong Acids

Sulfuric acid, H_2SO_4

Hydrochloric acid, HCl

Nitric acid, HNO_3

Weak Acids

Phosphoric acid, H_3PO_4

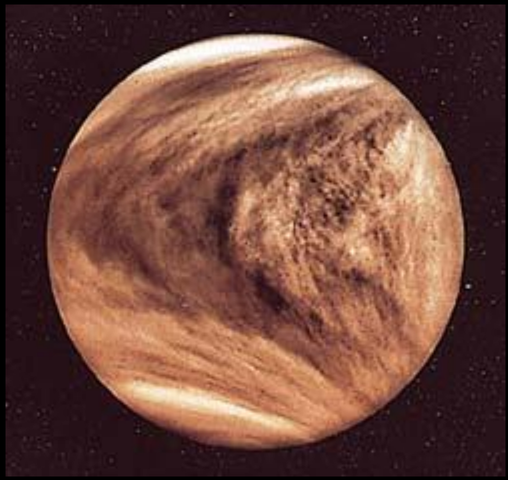
Acetic acid, $HC_2H_3O_2$

Sulfuric Acid H_2SO_4

- Highest volume production of any chemical in the U.S. *(can judge the industrialization by consumption)*
- Used in the production of paper
- Used in production of fertilizers
- Used in petroleum refining

Thick clouds of sulfuric acid are a feature of the atmosphere of Venus.

(image provided by NASA)

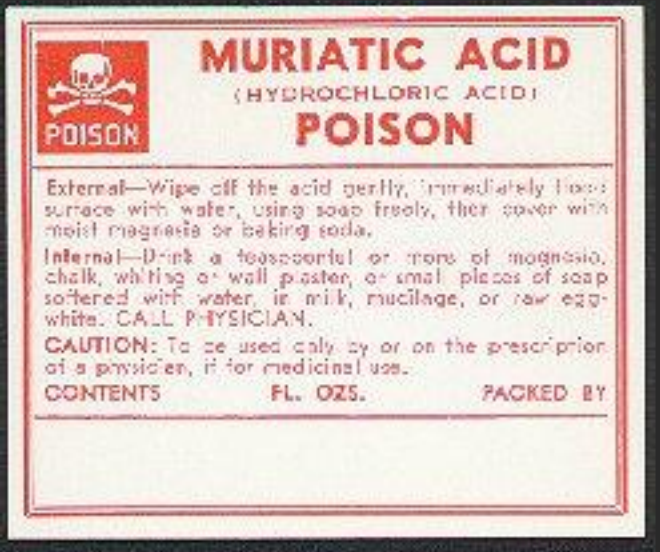


Nitric Acid
HNO_3

- Used in the production of fertilizers
- Used in the production of explosives
- Nitric acid is a volatile acid – its reactive components evaporate easily
- Stains proteins (including skin! Horrible yellow color)

Hydrochloric Acid HCl

- Used in the pickling of steel
- Used to purify magnesium from sea water
- Part of gastric juice, it aids in the digestion of protein
- Sold commercially as "Muriatic acid"



Phosphoric Acid H_3PO_4

- A flavoring agent in sodas
- Used in the manufacture of detergents
- Used in the manufacture of fertilizers
- *Not* a common laboratory reagent

Acetic Acid $HC_2H_3O_2$

- Used in the manufacture of plastics
- Used in making pharmaceuticals
- Acetic acid is the acid present in vinegar
- Pungent SMELL!

Acids are Proton Donors-

More hydrogens doesn't mean stronger!!!!

Monoprotic acids	Diprotic acids	Triprotic acids
HCl	H_2SO_4	H_3PO_4
$HC_2H_3O_2$	H_2CO_3	
HNO_3		

Concentration in Terms of NORMALITY

- **Normality = M x # of equivalences**

- ***Equivalences are the number of hydrogens (for acids) or hydroxides (for bases)***

- What is the normality of a 3.0 M H_2SO_4 solution?

Strong Acids vs. Weak Acids

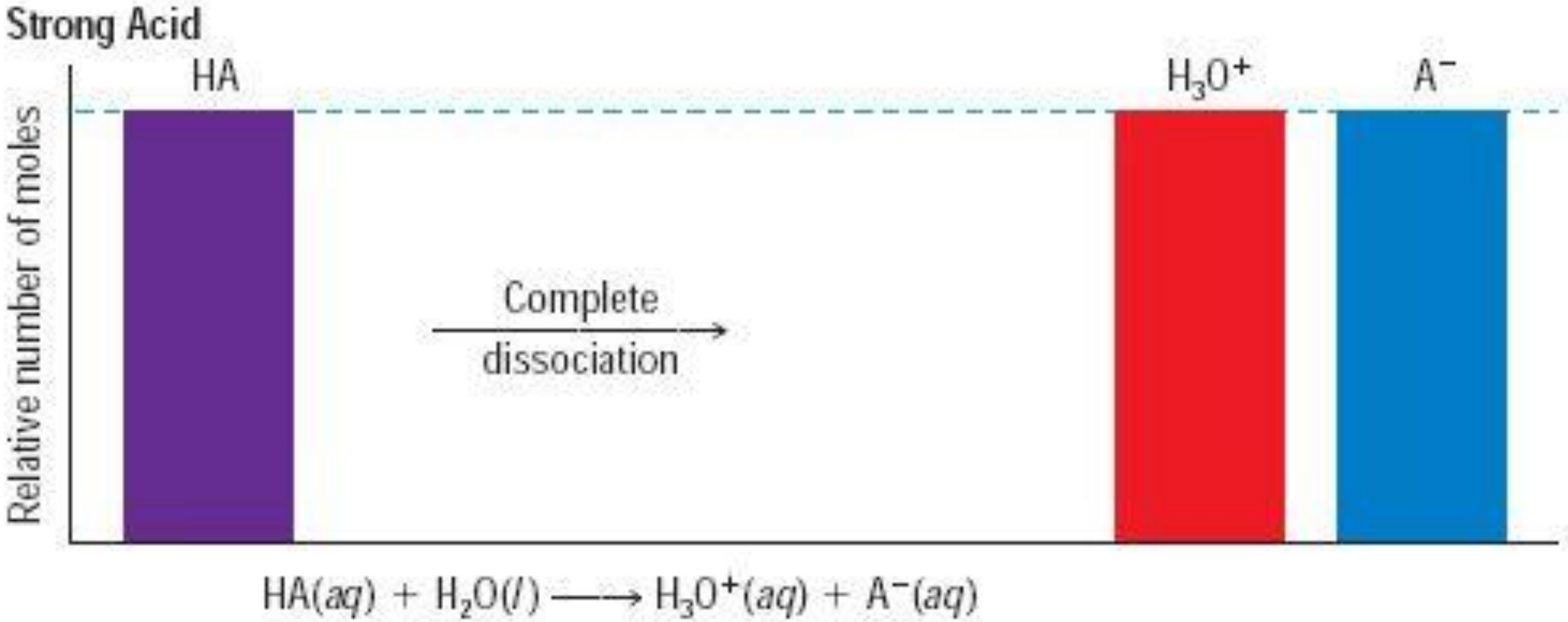
Strong acids are assumed to be 100% ionized in solution (good proton donors).

HCl H_2SO_4 HNO_3

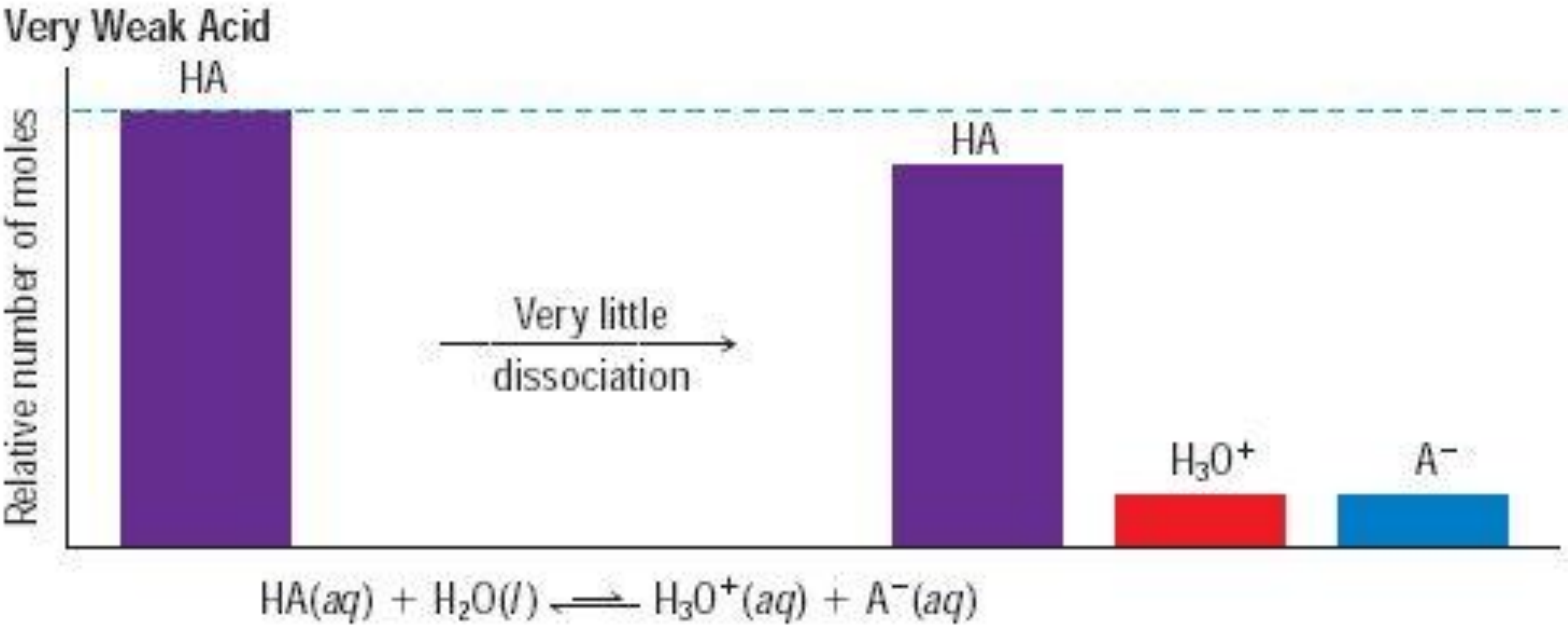
Weak acids are usually less than 5% ionized in solution (poor proton donors).

H_3PO_4 $HC_2H_3O_2$ Organic acids

Strong Acid Dissociation

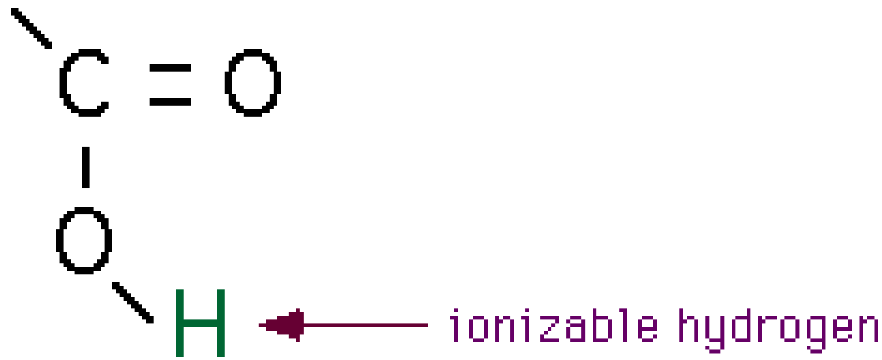


Weak Acid Dissociation



Organic Acids

Organic acids all contain the "carboxyl" group, sometimes several of them.



The carboxyl group is a poor proton donor, so ALL organic acids are weak acids.

Examples of Organic Acids

- Citric acid in citrus fruit
- Malic acid in sour apples
- Deoxyribonucleic acid, DNA
- Amino acids, the building blocks of protein
- Lactic acid in sour milk and sore muscles
- Butyric acid in rancid butter

Common Acids

Citrus fruits contain citric acid.

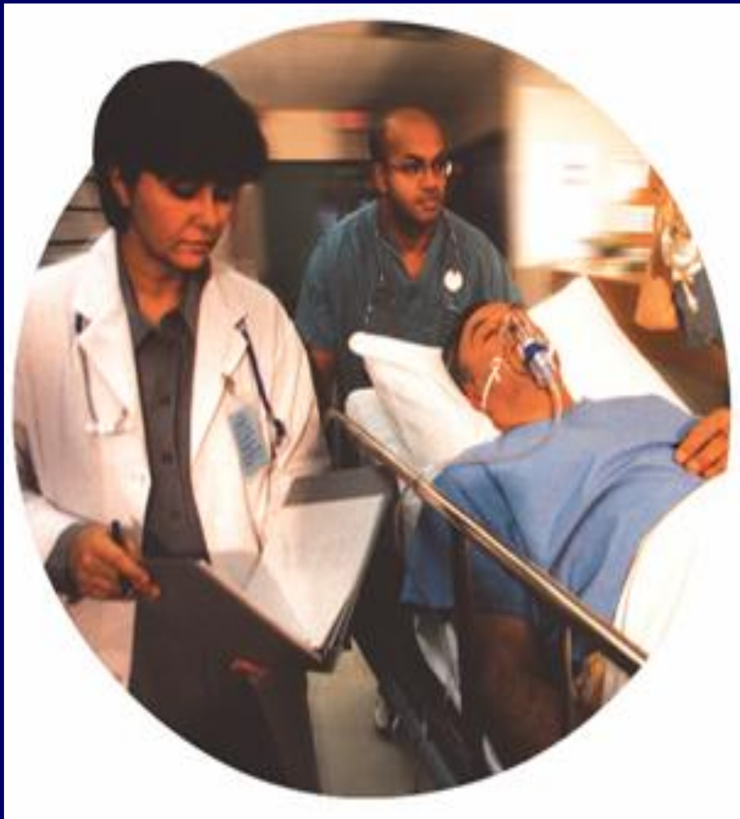
•Tea contains tannic acid.

Acids Effect Indicators

Blue litmus paper turns red in contact with an acid.

Hydrogen Ions and Acidity

- To test a diagnosis of diabetic coma, a doctor orders several tests, including the acidity of the patient's blood.
- Results from this test will be expressed in units of pH.
- You will learn how the pH scale is used to indicate the acidity of a solution and why the pH scale is used.

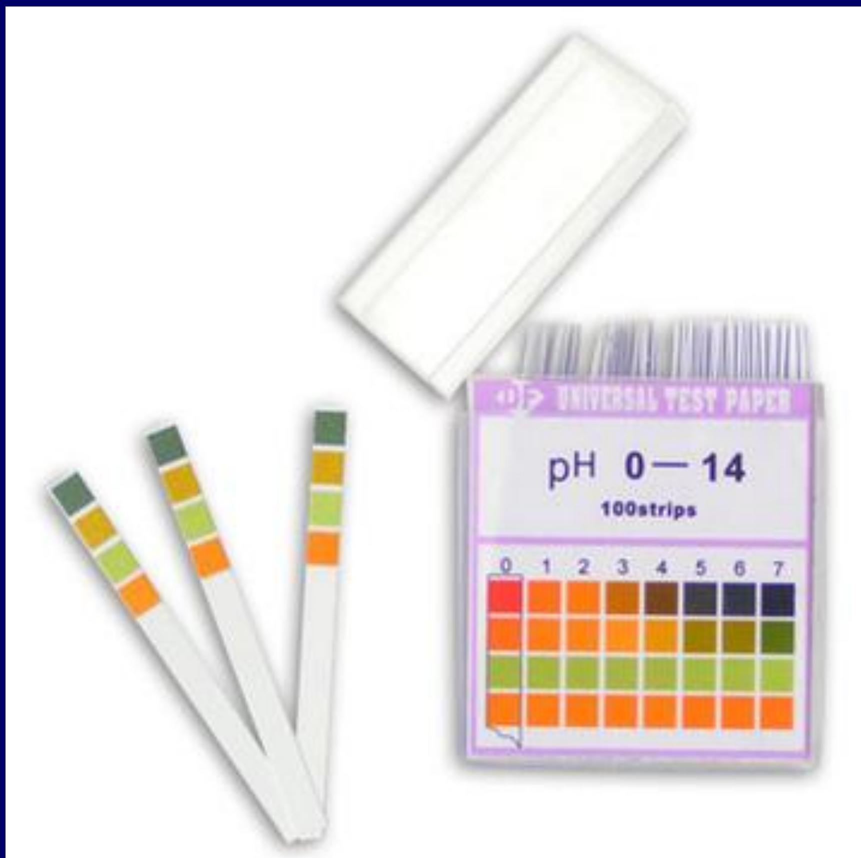


The pH Concept

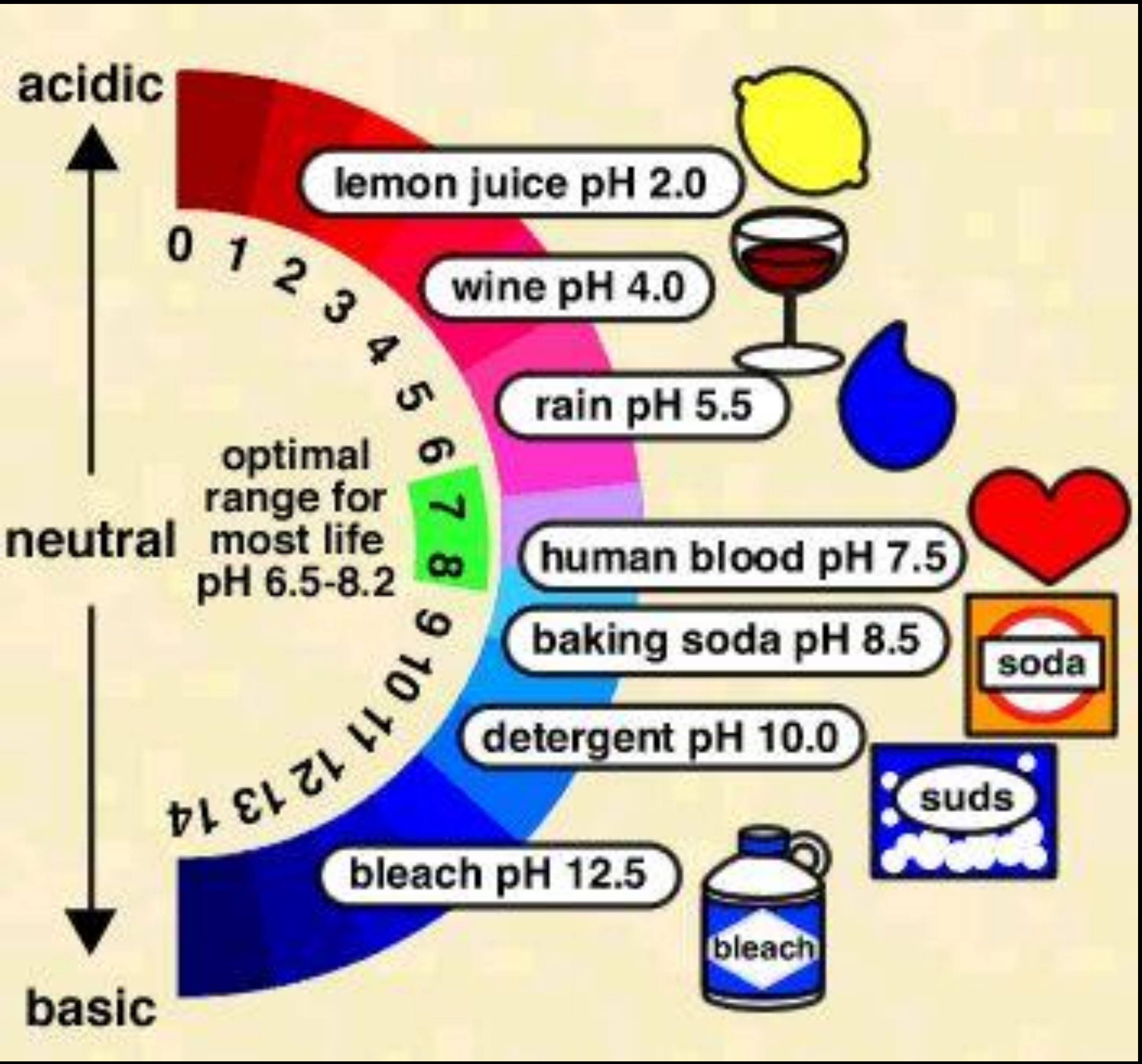
- The pH of a solution is the negative logarithm of the hydrogen-ion concentration.

$$pH = -\log[H^+]$$

Indicator- an organic molecule that changes color with pH



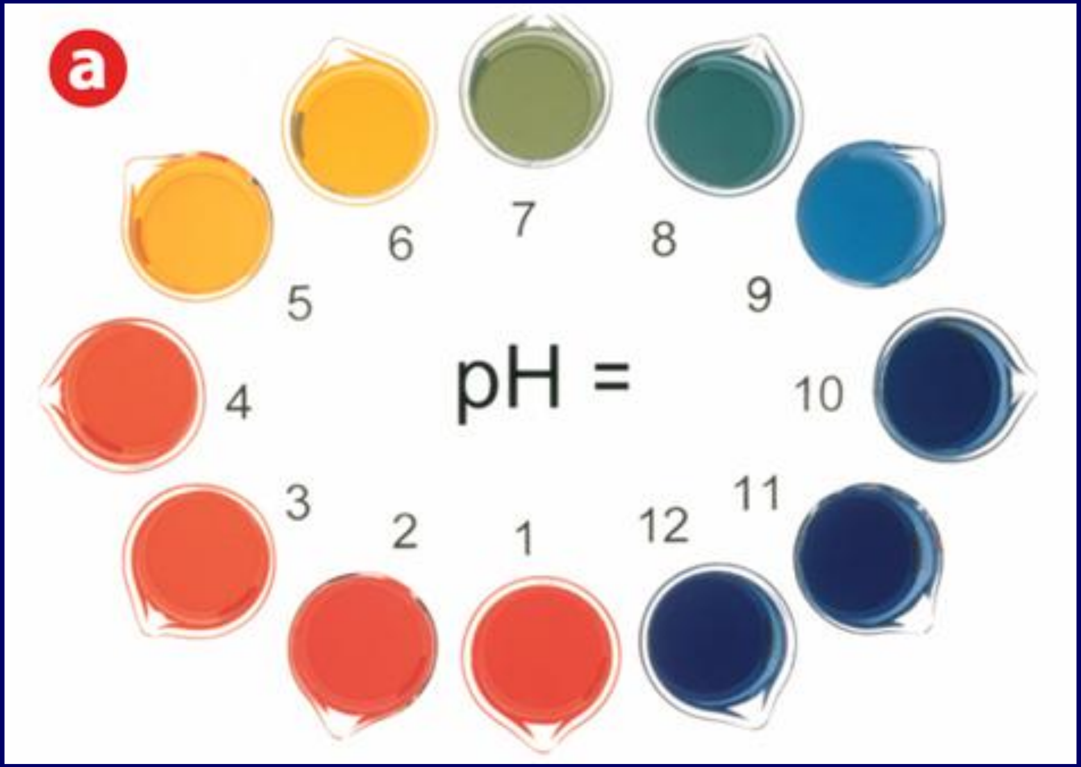
Hydrangeas will change color based on soil pH- My Fav!



Acids Have a pH less than 7

Measuring pH

- Universal Indicators change color over the entire pH scale.



Hydrogen Ions from Water

- **The reaction in which water molecules produce ions is called the** self-ionization **of water.**
- **The self-ionization of water occurs to a VERY small extent.**
- ***Note the hydrogen ion will pick up a water molecule forming hydronium ion H_3O^+***

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$$

Hydrogen ion   Hydroxide ion

The pH Concept

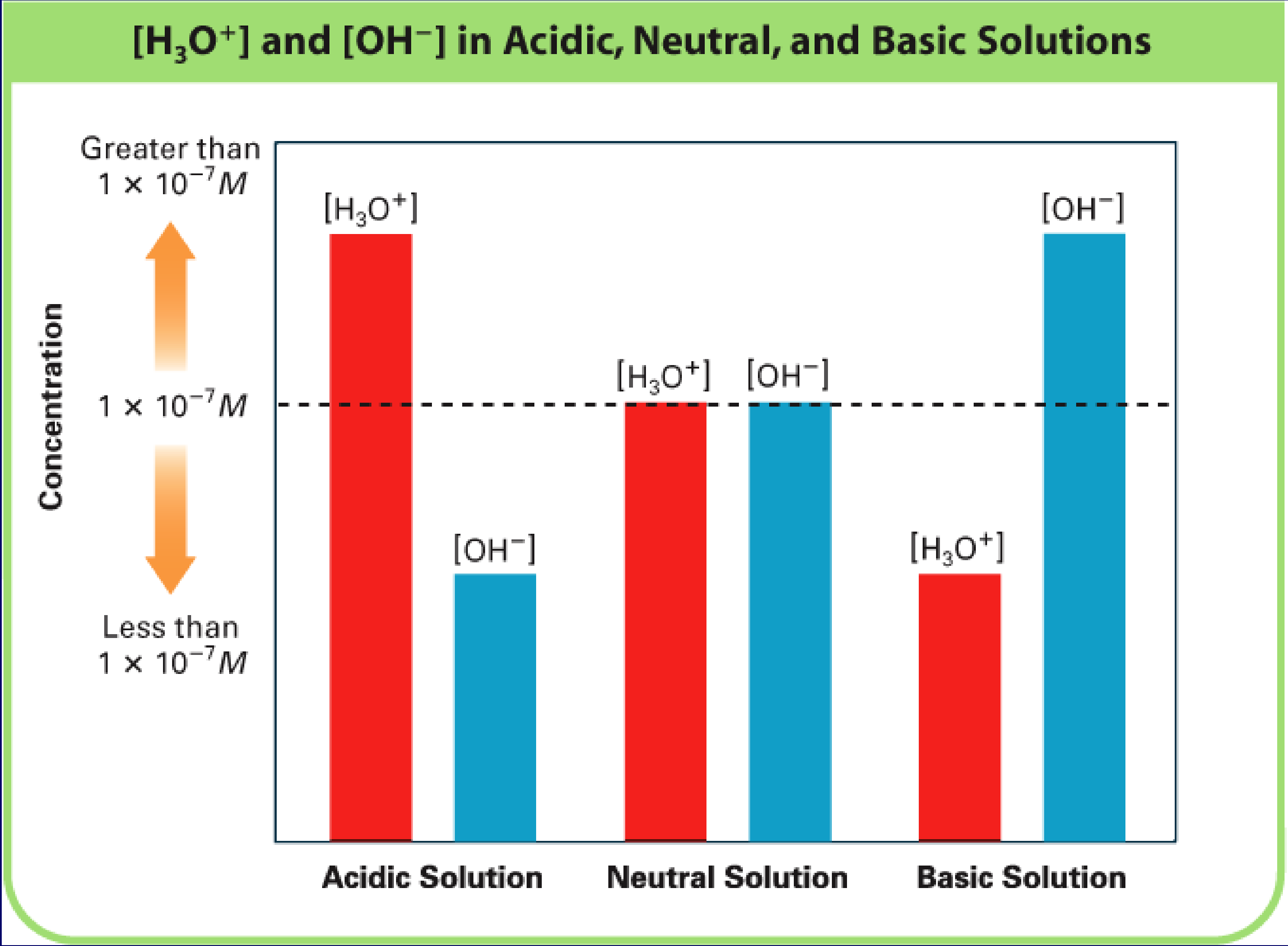
- A solution in which $[H^+]$ is greater than 1×10^{-7} *M* has a pH less than 7.0 and is acidic.

- The pH of pure water or a neutral aqueous solution is 7.0 and has a $[H^+]$ equal to 1×10^{-7} *M*.

- A solution with a pH greater than 7 is basic and has a $[H^+]$ of less than 1×10^{-7} *M*.

19.2

The pH Concept

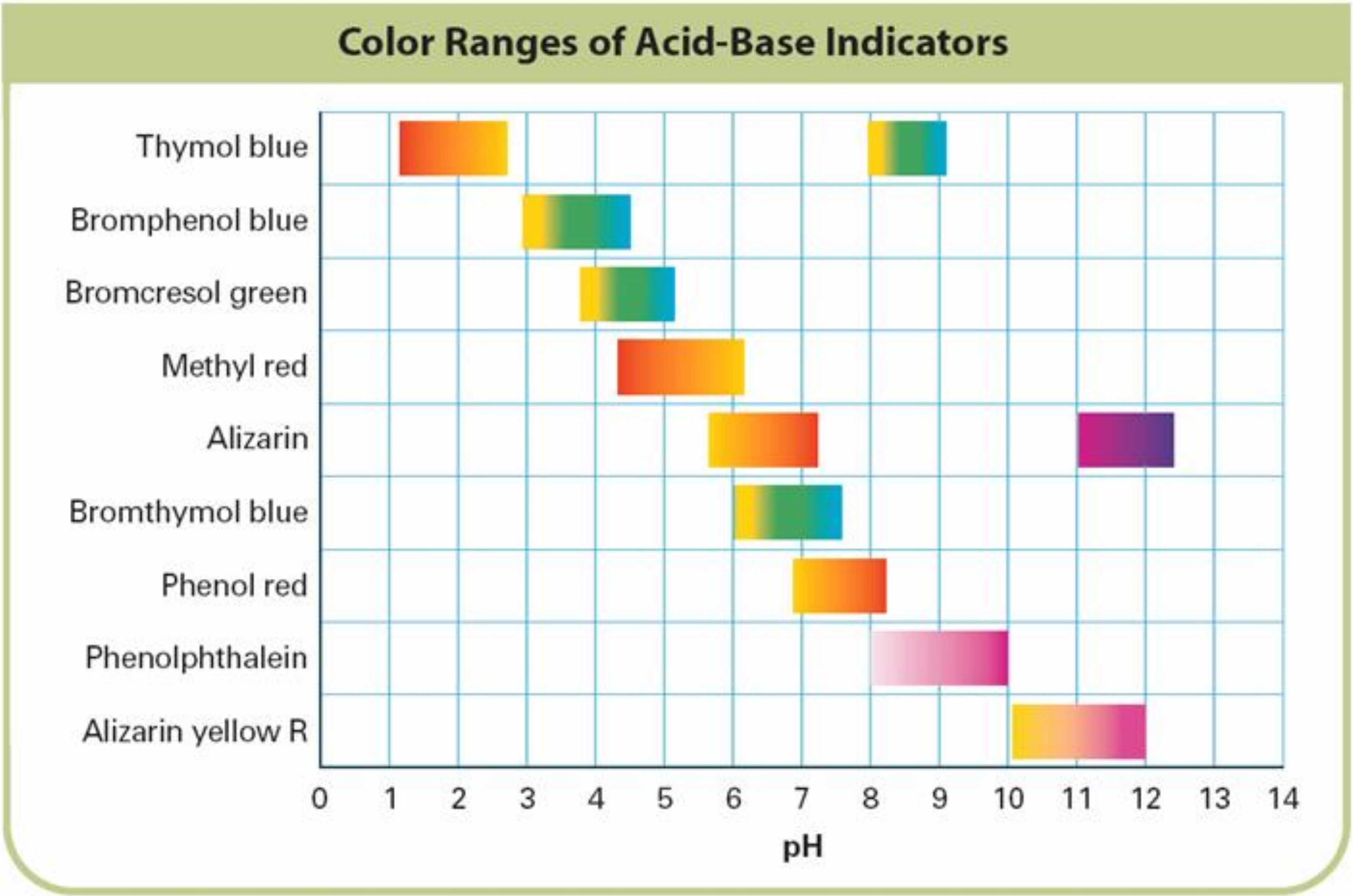


19.2

The pH Concept

Relationship among $[H^+]$, $[OH^-]$, and pH

	$[H^+]$ (mol/L)	$[OH^-]$ (mol/L)	pH	Aqueous system
	1×10^{0}	1×10^{-14}	0.0	1*M* HCl
Increasing acidity ↑	1×10^{-1}	1×10^{-13}	1.0	0.1*M* HCl; Gastric juice
	1×10^{-2}	1×10^{-12}	2.0	Lemon juice
	1×10^{-3}	1×10^{-11}	3.0	
	1×10^{-4}	1×10^{-10}	4.0	Tomato juice
	1×10^{-5}	1×10^{-9}	5.0	Black coffee
	1×10^{-6}	1×10^{-8}	6.0	Milk
Neutral	1×10^{-7}	1×10^{-7}	7.0	Pure water
	1×10^{-8}	1×10^{-6}	8.0	Blood
Increasing basicity ↓	1×10^{-9}	1×10^{-5}	9.0	Sodium bicarbonate, sea water
	1×10^{-10}	1×10^{-4}	10.0	
	1×10^{-11}	1×10^{-3}	11.0	Milk of magnesia; Household ammonia
	1×10^{-12}	1×10^{-2}	12.0	Washing soda
	1×10^{-13}	1×10^{-1}	13.0	0.1*M* NaOH
	1×10^{-14}	1×10^{0}	14.0	1*M* NaOH


Color Ranges of Acid-Base Indicators
Thymol blue
Bromphenol blue
Bromcresol green
Methyl red
Alizarin
Bromthymol blue
Phenol red
Phenolphthalein
Alizarin yellow R
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
pH

Acids React with Active Metals

Acids react with active metals to form salts and hydrogen gas.

$Mg + 2HCl \rightarrow MgCl_2 + H_2(g)$

$Zn + 2HCl \rightarrow ZnCl_2 + H_2(g)$

$Mg + H_2SO_4 \rightarrow MgSO4 + H_2(g)$

Acids React with Carbonates

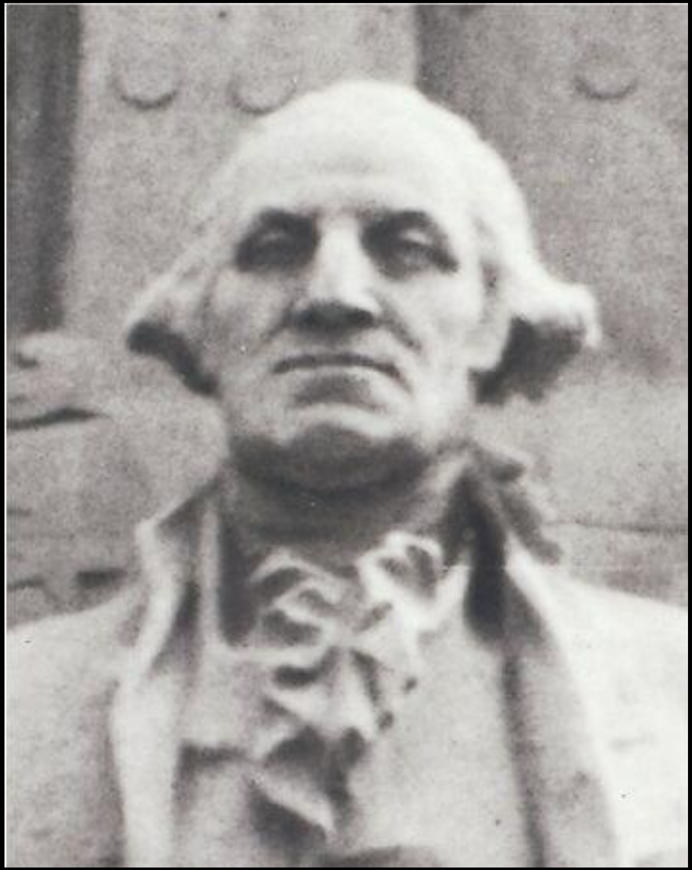
$2HC_2H_3O_{2\,(aq)}$ + $Na_2CO_{3\,(s)}$

↓

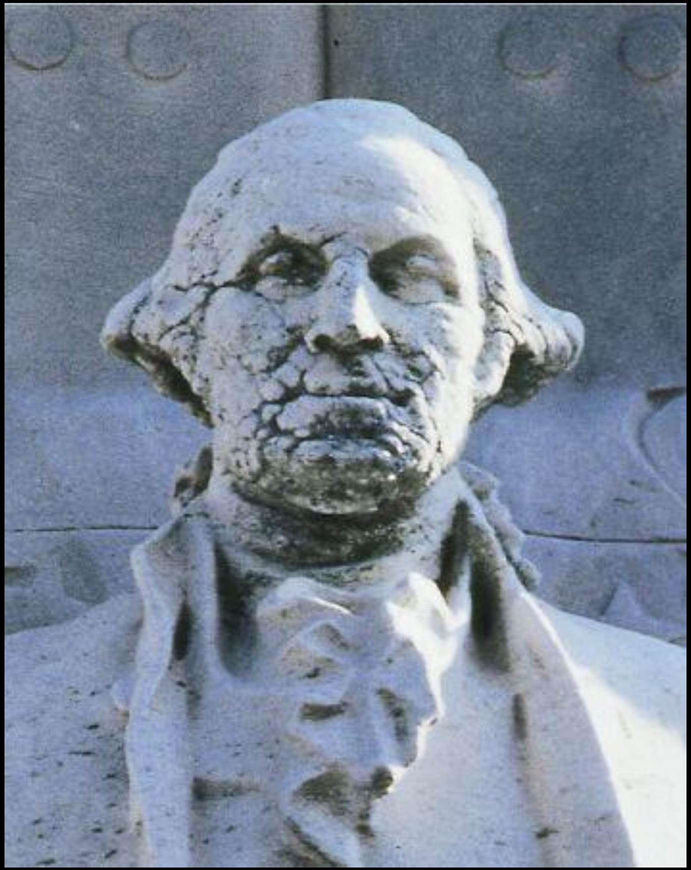
$2\ NaC_2H_3O_{2\,(aq)} + H_2O\ (l) + CO_{2\,(g)}$

Effects of Acid Rain on Marble (calcium carbonate)

George Washington: BEFORE



George Washington: AFTER



Acids Neutralize Bases

Neutralization reactions ALWAYS produce a salt and water.

$HCl + NaOH \rightarrow NaCl + H_2O$

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

$2HNO_3 + Mg(OH)_2 \rightarrow Mg(NO_3)_2 + 2H_2O$

BASES

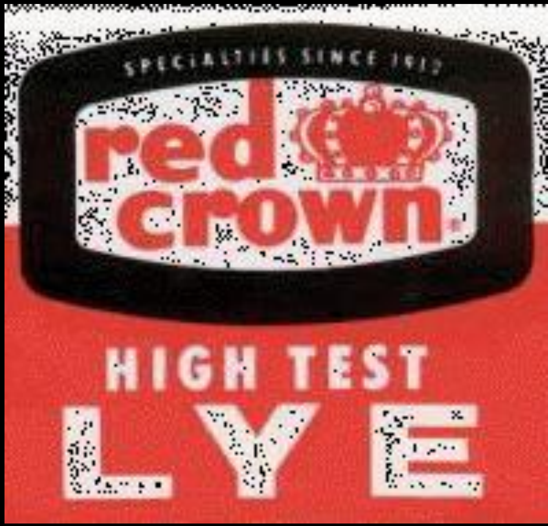
- Bracken Cave, near San Antonio, Texas, is home to twenty to forty million bats.
- Visitors to the cave must protect themselves from the dangerous levels of ammonia in the cave.
- Ammonia is a byproduct of the bats' urine.
- You will learn why ammonia is considered a base.

Properties of Bases

- Bases taste bitter
- Bases effect indicators
  - Red litmus turns blue
  - Phenolphthalein turns magenta
  - Bases have a pH greater than 7
- Bases are proton (hydrogen ion, H^+) acceptors
- Hydroxide donors (OH^{-1})
- Solutions of bases feel slippery
- Bases are electrolytes
- Bases neutralize acids
- Bases emulsify fats and oils- SOAP

Examples of Bases

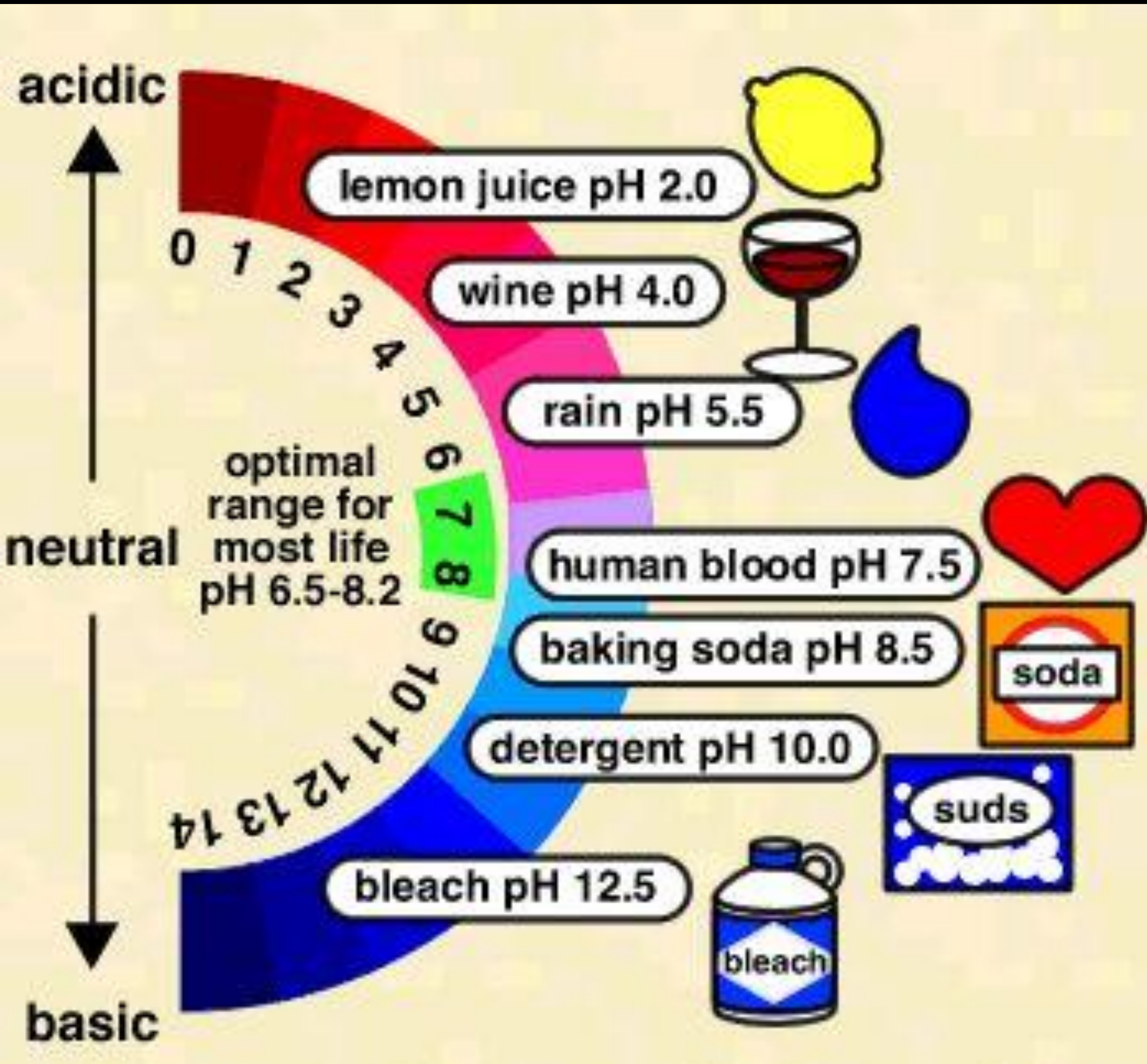
- Sodium hydroxide (lye), NaOH
  - Draino
- Potassium hydroxide, KOH
- Magnesium hydroxide, $Mg(OH)_2$
- Calcium hydroxide (lime), $Ca(OH)_2$
- TUMS
- AND AMMONIA NH_3!



Bases Effect Indicators

Red litmus paper turns blue in contact with a base.

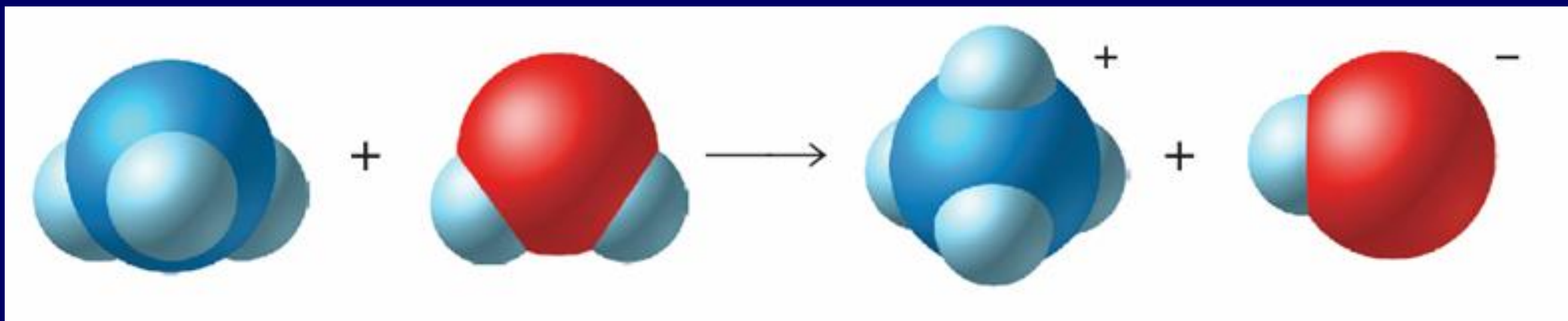
Phenolphthalein turns magenta in a base.



Bases have a pH greater than 7

Ammonia a Base? How can it be???

- NH_3 accepts a hydrogen ion to become NH_4^+
- H_2O donates a hydogen ion to become OH-.



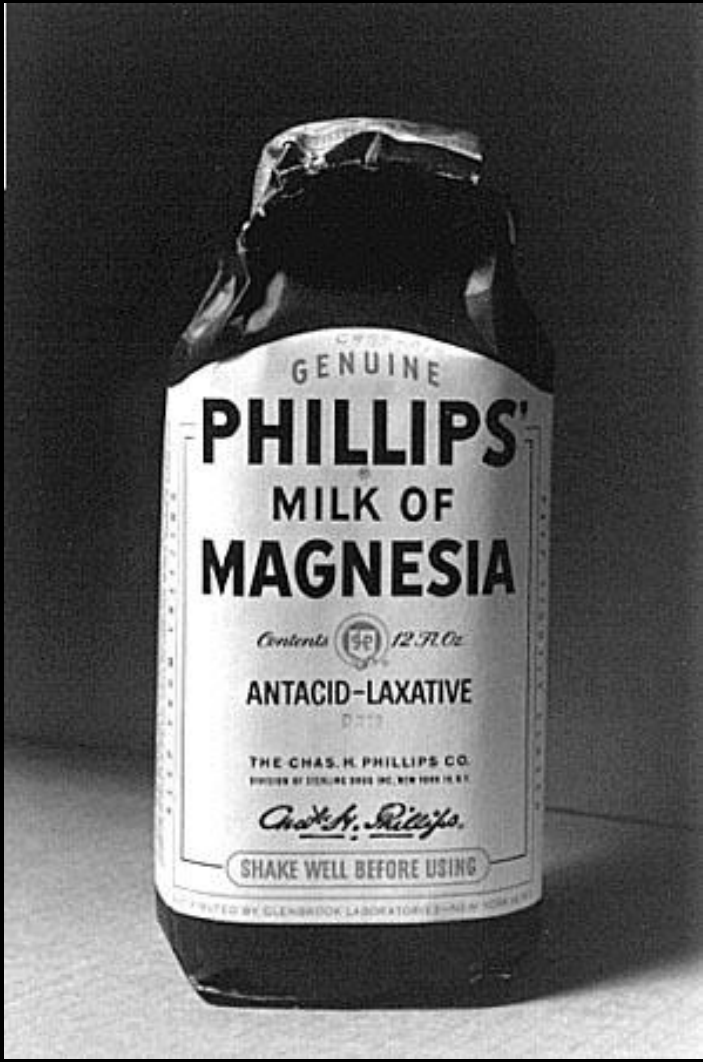
$$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

$NH_3(aq)$	$H_2O(l)$	$NH_4^+(aq)$	$OH^-(aq)$
Ammonia (hydrogen-ion acceptor, Brønsted-Lowry base)	Water (hydrogen-ion donor, Brønsted-Lowry acid)	Ammonium ion	Hydroxide ion (makes the solution basic)

Bases Neutralize Acids

Milk of Magnesia contains magnesium hydroxide, $Mg(OH)_2$, which neutralizes stomach acid, HCl.

$$2\ HCl + Mg(OH)_2 \longrightarrow MgCl_2 + 2\ H_2O$$



Titration

- **The concentration of an acid and base can be determined performed a neutralization reaction called a titration.**

- **The process of adding a known amount of solution of known concentration to determine the concentration of another solution is called** titration.

To perform a titration:

1. Measure out a known volume of the acid solution of unknown concentration into an erlenmeyer flask.

2. Add a few drops of indicator. (For acid-base titrations, use phenolphthalein.)

3. Use a buret to add a base until the indicator changes color. (Phenolphthalein will change from clear to pink.)

4. Plot or perform calculation ($N_AV_A = N_BV_B$)

Titration

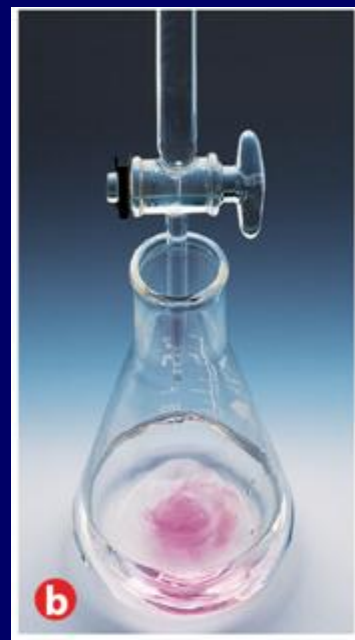
- The solution of known concentration is the standard solution.

- The point when the indicator changes color is the end point of the titration.

- The equivalence point is when the number of moles of hydrogen ions equals the number of moles of hydroxide ions.
  - This happens right before the end point.

Titration

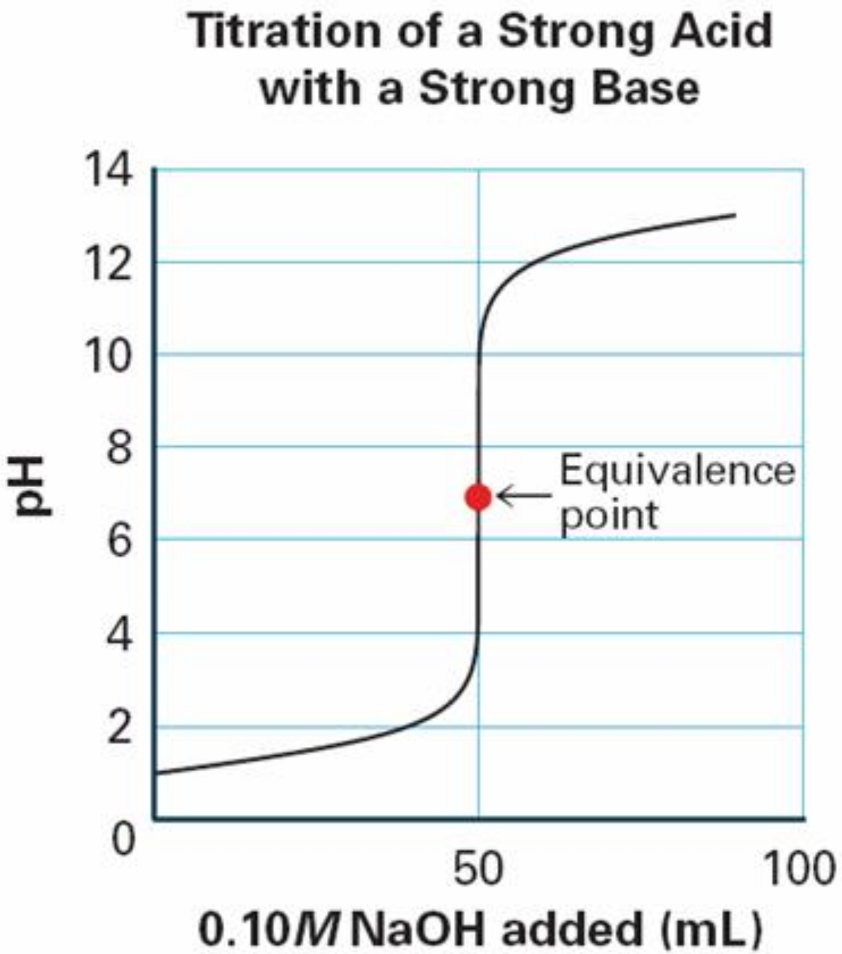
Acid solution with indicator



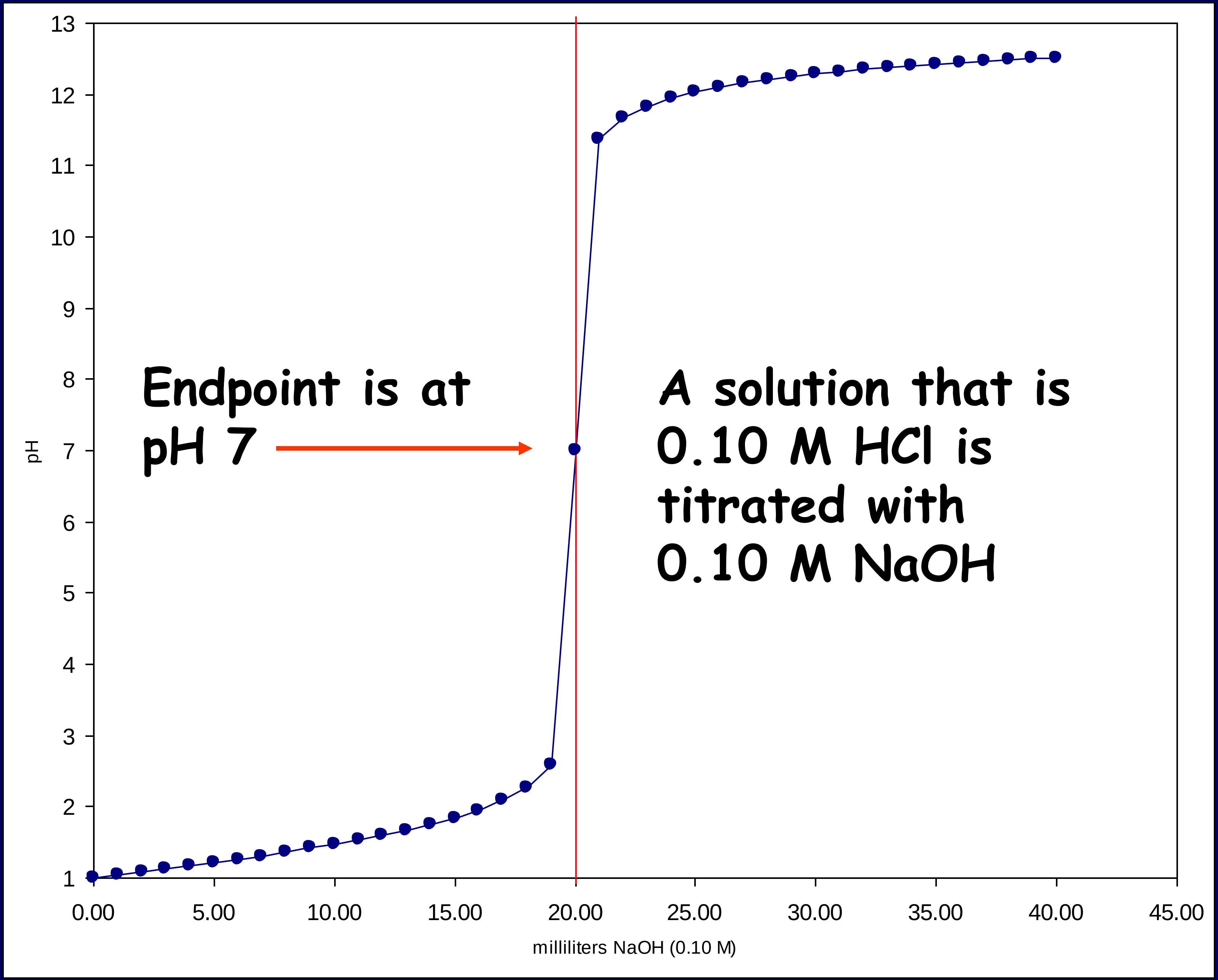
Added base is measured with a buret.

Color change shows neutralization.

Titration- a plot of volume added and pH helps determine the equivalence point



Strong Acid/Strong Base Titration



Titration calculation

- 25.00 mls of a 0.25 M HCl solution are needed to completely neutralize 50.00 mls of an unknown sodium hydroxide solution.

What is the concentration of the base?