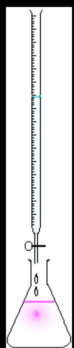
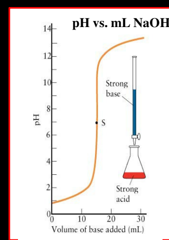


Titrations



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Titration Terms

Titration
Controlled addition of a liquid into a vessel to measure the volume that reacts with a substance already in the vessel. Titration measures concentration.

Indicators
substances that change color to signal when to stop a titration
Organic dyes whose color is sensitive to pH

Endpoint
point in a titration when the indicator changes color

Standard Solution
solution of known concentration used in a titration

Neutralization
double replacement reaction: an acid and a base react to form water and a salt

Acid + Base → Salt + Water
$H^+ + OH^- \rightarrow H_2O$

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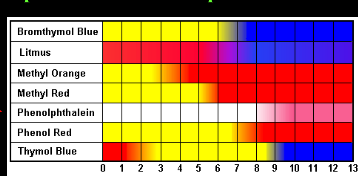
Indicators

Complex Organic Compounds
Change color (chemical change) with pH changes
Choice depends on desired end-point

Most Used →



Indicators INDICATE Endpoint
An Indicator is the substance that indicates end of titration

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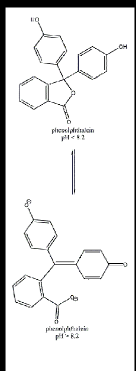
Phenolphthalein



One of the most common indicators used

Laxative

C.S.I. = used to determine if stain is blood

- Kastle-Meyer Spot Test
  - Phenolphthalein plus sample
  - Add H_2O_2
  - Hemoglobin present oxidizes to pink form

OH^- attacks acid form and changes structure

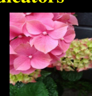
- Acid form: colorless
- Basic form: magenta

Many Plant Colors (Anthrocyanins) are pH Indicators

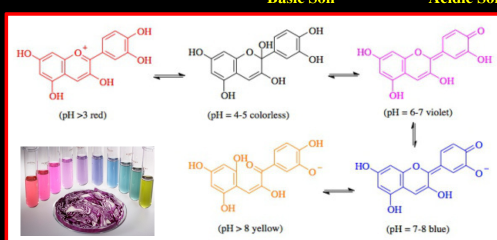
Indicators ➔ color depends on pH
Color change ➔ Chemical change

The "colors" in vegetables have significant cancer risk reductions

Hydrangea
Basic Soil



Hydrangea
Acidic Soil



pH

pH = measurement of molar H^+ concentration

The H means $[H^+]$ (molar concentration of hydrogen ions)

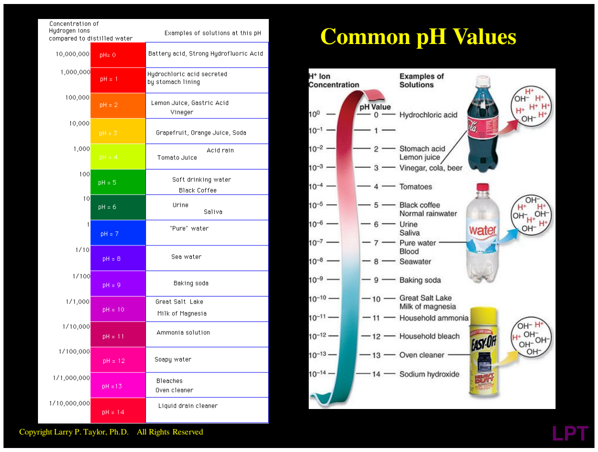
The p in pH means "the negative logarithm of"

$[H^+] = 1 \times 10^{-pH}$

pH 7 means the concentration of $H^+ = 10^{-7}$ M

- pH < 7 ➔ acidic
- pH = 7 ➔ neutral
- pH > 7 ➔ basic (alkaline)

pH is measured with electronics or indicators


Common pH Values
Concentration of Hydrogen ions compared to distilled water
Examples of solutions at this pH
Battery acid, Strong Hydrofluoric Acid
Hydrochloric acid secreted by stomach lining
Lemon Juice, Gastric Acid Vinegar
Grapefruit, Orange Juice, Soda
Acid rain
Tomato Juice
Soft drinking water
Black Coffee
Urine
Saliva
"Pure" water
Sea water
Baking soda
Great Salt Lake
Milk of Magnesia
Ammonia solution
Soapy water
Bleaches
Oven cleaner
Liquid drain cleaner
H+ Ion Concentration
pH Value
Examples of Solutions
Hydrochloric acid
Stomach acid
Lemon juice
Vinegar, cola, beer
Tomatoes
Black coffee
Normal rainwater
Urine
Saliva
Pure water
Blood
Seawater
Baking soda
Great Salt Lake
Milk of magnesia
Household ammonia
Household bleach
Oven cleaner
Sodium hydroxide
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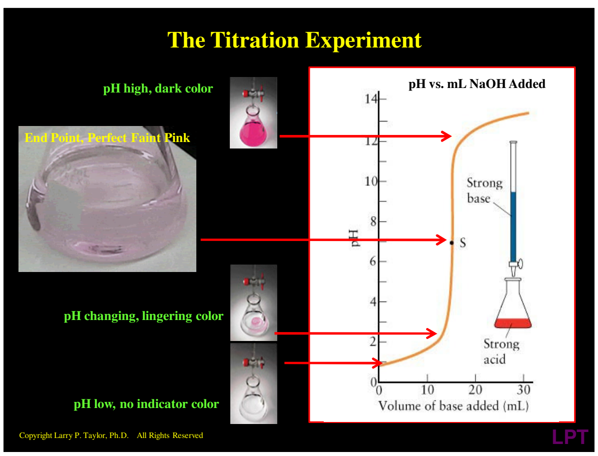
The Titration Experiment
pH high, dark color
End Point, Perfect Faint Pink
pH changing, lingering color
pH low, no indicator color
pH vs. mL NaOH Added
pH
Strong base
S
Strong acid
Volume of base added (mL)
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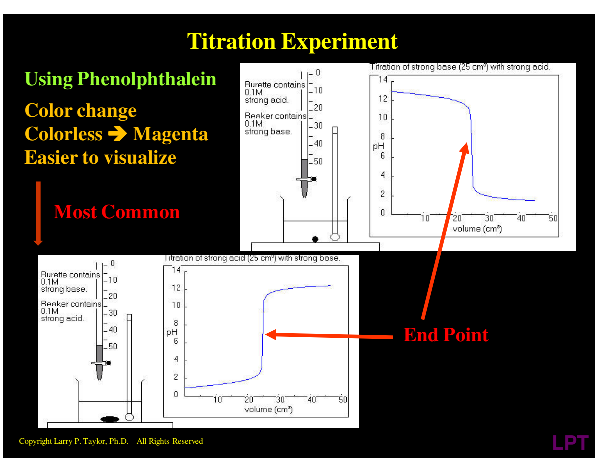
Titration Experiment
Using Phenolphthalein
Color change
Colorless → Magenta
Easier to visualize
Most Common
End Point
Titration of strong base (25 cm³) with strong acid.
Burette contains 0.1M strong acid.
Beaker contains 0.1M strong base.
Titration of strong acid (25 cm³) with strong base.
Burette contains 0.1M strong base.
Beaker contains 0.1M strong acid.
volume (cm³)
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Titration Experiment

Key to "Titrations"

At end point:

Moles standard added = Moles unknown present

↑

via "Per Expression" from reaction coefficients

Let the units drive the solution

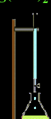
LPT

Neutralization Reactions: Acid + Base → Salt + Water

How many mL's of 0.835 M HNO_3 will neutralize 38.5 mL of 0.522 M $Mg(OH)_2$?

Write the balanced reaction

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



Given: 38.5 mL 0.522 M magnesium hydroxide

Wanted: ml's 0.835 M nitric acid

1. Find # moles (using molarity) of given:

$\frac{0.522 \text{ moles } Mg(OH)_2}{1000 \text{ mL}} \times 38.50 \text{ ml}$

2. Use per expression from reaction coefficients to find moles unknown:

$\times \frac{2 \text{ moles } HNO_3}{1 \text{ mole } Mg(OH)_2}$

3. Use unknown molarity to convert to volume unknown needed:

$\times \frac{1000 \text{ mL}}{0.835 \text{ moles}} = 48.1 \text{ mL}$

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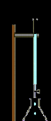
How many mL of 0.0957 M Sodium Hydroxide are needed to neutralize 20.00 mL of 0.180 M Hydrochloric acid?

Write the balanced reaction

$HCl + NaOH \rightarrow NaCl + H_2O$



Given: 20.00 mL 0.180 M hydrochloric acid

Wanted: ml's 0.0957 M sodium hydroxide

As Linear String: Starting with standard molarity

$\frac{0.180 \text{ moles HCl}}{1000 \text{ mL}} \times 20.00 \text{ mL} \times \frac{1 \text{ mole NaOH}}{1 \text{ mole HCl}} \times \frac{1000 \text{ mL}}{0.0957 \text{ moles NaOH}} = 37.6 \text{ mL}$

As Linear String: Starting with mL's standard added

$20.00 \text{ mL} \times \frac{0.180 \text{ moles HCl}}{1000 \text{ mL}} \times \frac{1 \text{ mole NaOH}}{1 \text{ mole HCl}} \times \frac{1000 \text{ mL}}{0.0957 \text{ moles NaOH}} = 37.6 \text{ mL}$

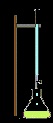
Let the units drive the solution

LPT

How many mL of 0.266 M Potassium Hydroxide are needed to neutralize 20.5 mL of 0.172 M Sulfuric acid?

Write the balanced reaction:

$H_2SO_4 + 2\ KOH \rightarrow K_2SO_4 + 2\ H_2O$



Given: 20.5 mL 0.172 M sulfuric acid

Wanted: ml's 0.266 M potassium hydroxide

As Linear String: Starting with standard molarity

$$\frac{0.172 \text{ moles } H_2SO_4}{1000 \text{ mL}} \times 20.5 \text{ mL} \times \frac{2 \text{ moles KOH}}{1 \text{ mole } H_2SO_4} \times \frac{1 \text{ L}}{0.266 \text{ moles}} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 26.5 \text{ mL}$$

As Linear String: Starting with standard ml's added

$$20.5 \text{ mL} \times \frac{0.172 \text{ moles } H_2SO_4}{1000 \text{ mL}} \times \frac{2 \text{ moles KOH}}{1 \text{ mole } H_2SO_4} \times \frac{1 \text{ L}}{0.266 \text{ moles}} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 26.5 \text{ mL}$$

Let the units drive the solution

LPT

How many mLs of 0.832 M HCl are required for 1.46 g of Na_2CO_3?

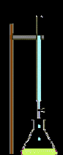
$2\ HCl + Na_2CO_3 \rightarrow H_2O + CO_2 + 2\ NaCl$

Given: 1.46 grams sodium carbonate (molar mass 105.98 g/mole)

Wanted: mL of 0.832 M HCl

As Linear String:

$$1.46 \text{ g } Na_2CO_3 \times \frac{1 \text{ mole}}{105.98 \text{g}} \times \frac{2 \text{ mole HCl}}{1 \text{ mole } Na_2CO_3} \times \frac{1 \text{ L}}{0.832 \text{ moles HCl}} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 33.1 \text{ mL}$$



Let the units drive the solution

LPT

Neutralization Reactions: Solution Stoichiometry

Determine moles present in given solution

Use reaction coefficients ("per expression") to get moles wanted

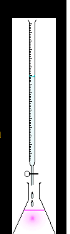
Convert moles wanted to solution concentration

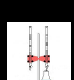
At endpoint:

Moles added ($\frac{\text{Moles}}{1000 \text{ mL}}$ x mL standard) = moles present in standard

Moles present standard x "per expression" = moles present in unknown

$\frac{\text{moles present in unknown}}{\text{ml unknown}} \times \frac{1000 \text{ ml}}{\text{L}}$ = Molarity (M /L) unknown





Let the units drive the solution

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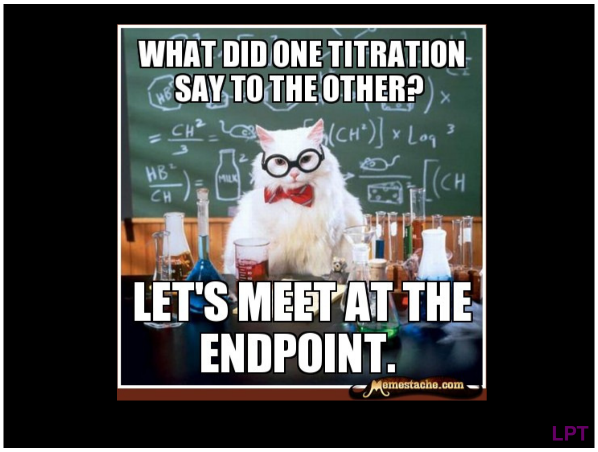
WHAT DID ONE TITRATION SAY TO THE OTHER?
LET'S MEET AT THE ENDPOINT.
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