Titrations

pH vs. mL NaOH

Strong base

Strong acid

Acids destroy Bases

acid   base

HCl + NaOH

Na Cl   H₂O

salt   water

Titration Terms

Titration

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

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
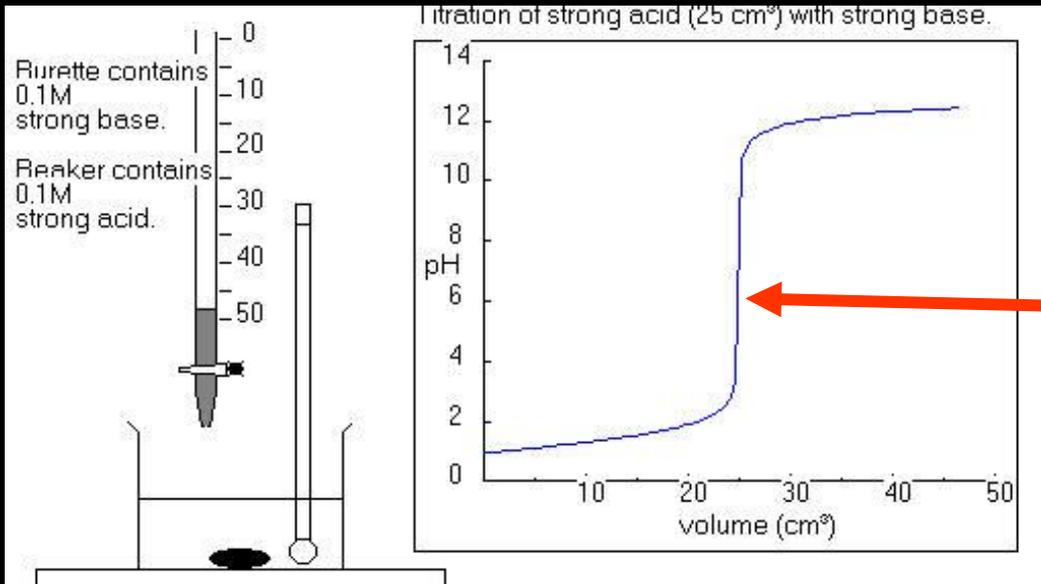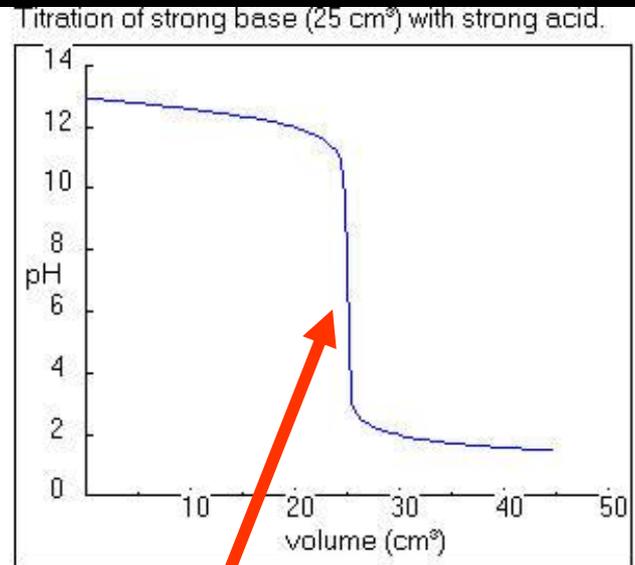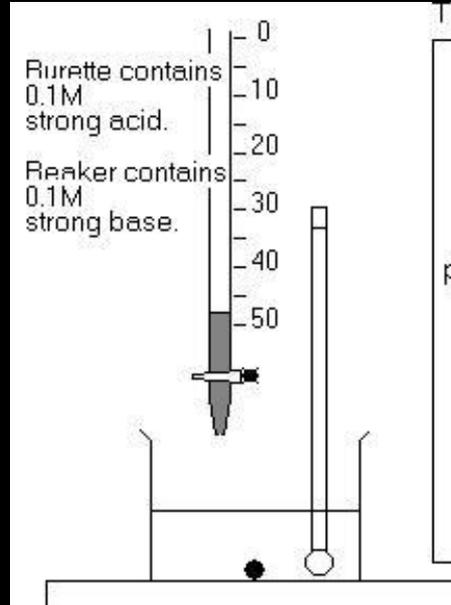
solution of known concentration used in a titration

Neutralization

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

$$\text{Acid} + \text{Base} \rightarrow \text{Salt} + \text{Water}$$

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Titration Experiment

End Point

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Titration of Strong vs. Weak Acids

Strong Acid (HCl)

Titration of strong acid (25 cm³) with strong base.

Weak Acid (HOAc)

Titration of weak acid (25 cm³) with strong base.

Same End-point

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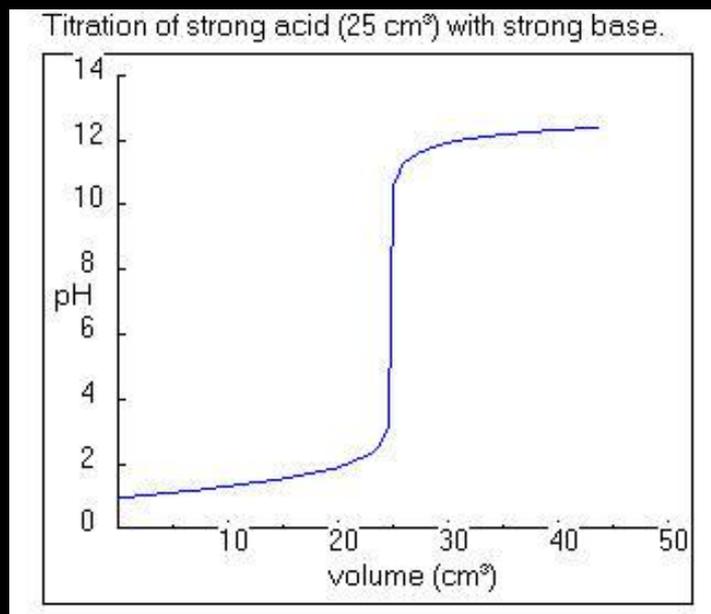
Phenolphthalein
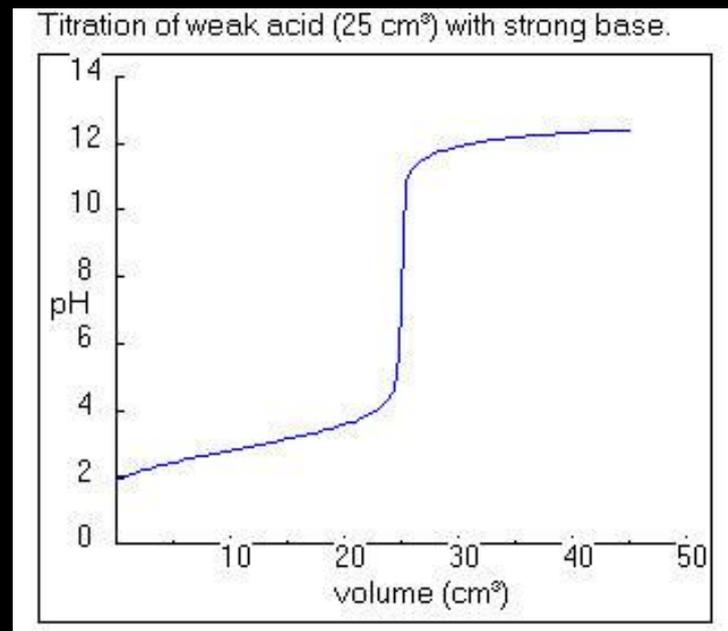
phenolphthalein
pH < 8.2

phenolphthalein
pH > 8.2

One of the most common indicators used
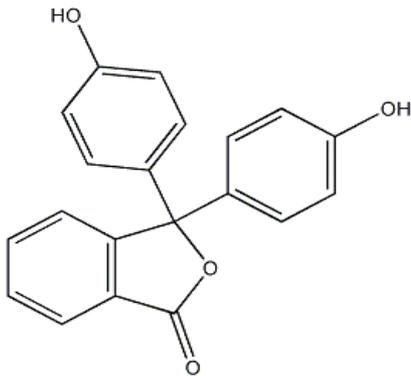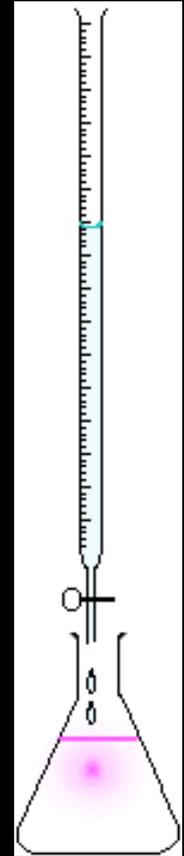
Laxative

C.S.I. = preliminary test for blood
  Kastle-Meyer Spot Test
   Phenolphthalein plus sample
   Add H_2O_2
   Hemoglobin present oxidizes to pink form
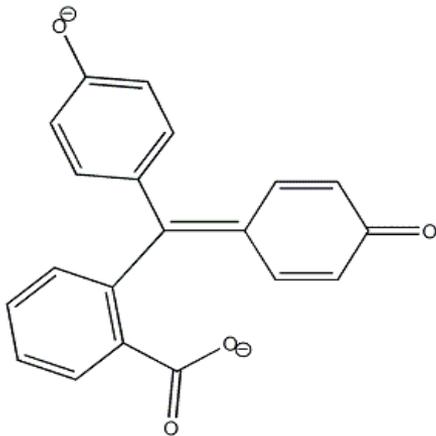
OH^- attacks acid form ➔ changes structure
  Acid form: colorless
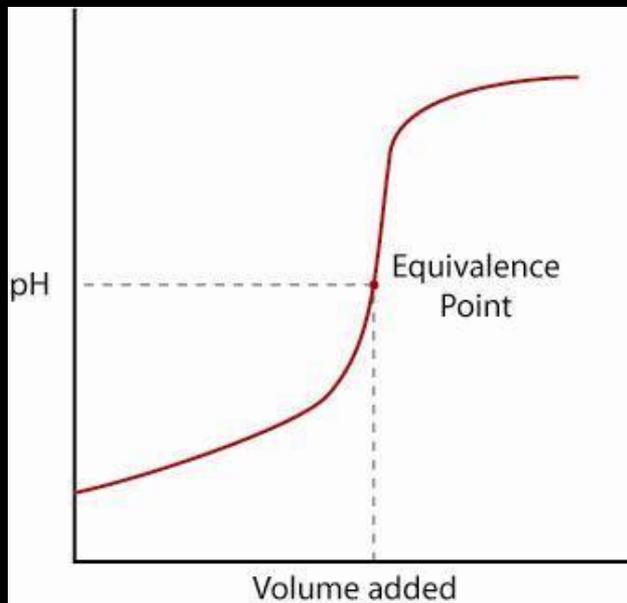 **Basic form: magenta**

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Titration Experiment

Key to "Titrations"

At end point:

Moles standard added = moles unknown present

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Neutralization Reactions: Solution Stoichiometry

At Endpoint: moles added = moles unknown

All titration problems solved the same way:

Balance the chemical Reaction
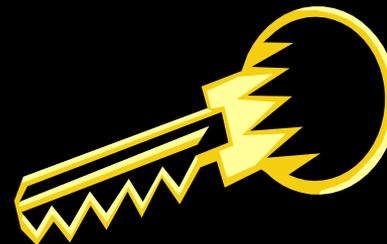Determine moles present in standard solution (moles /L x L)
Use reaction coefficients ("per expression") to get moles unknown
Convert moles of unknown
   to solution concentration (molarity)
   to grams present
   to gas volume

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Titration of Acetic Acid with Sodium Hydroxide

Vinegar = dilute solution of acetic acid (CH_3COOH or $HC_2H_3O_2$ or HOAc) in water

The acetic acid will react with a base such as sodium hydroxide (NaOH)

$$NaOH_{(aq)} + HC_2H_3O_{2\,(aq)} \rightarrow NaC_2H_3O_{2\,(aq)} + HOH_{(l)}$$

Acid + Base ➜ Salt + Water

Problems

Typically prepared NaOH solution is not well characterized:

Solid NaOH readily absorbs moisture from the air.

Initial weighing error

Atmospheric CO_2 reacts with water to make carbonic acid.

$$CO_{2\,(g)} + H_2O_{(l)} \rightarrow H_2CO_{3\,(aq)}$$

Acid reacts with some NaOH ➜ lowers concentration of the NaOH

$$H_2CO_{3\,(aq)} + 2\,NaOH \rightarrow Na_2CO_3 + 2\,H_2O$$

Solution

Concentration of the NaOH is determined by titration with known strong acid

Titrating NaOH with standard acid solution ➜ "standardization"

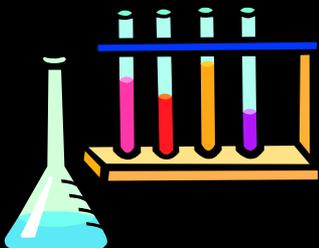$$HCl_{(aq)} + NaOH \rightarrow HOH_{(l)} + NaCl_{(aq)}$$

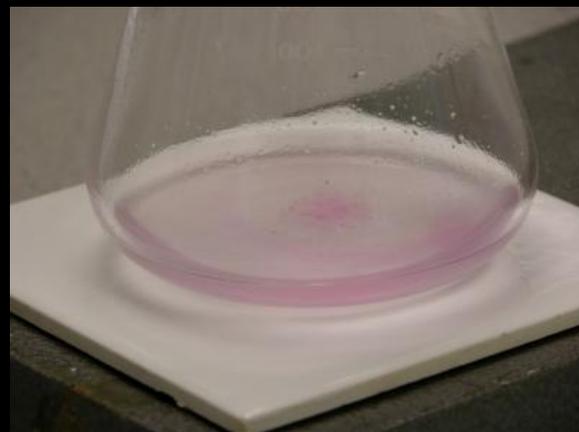Standardization gives accurate value of NaOH solution.
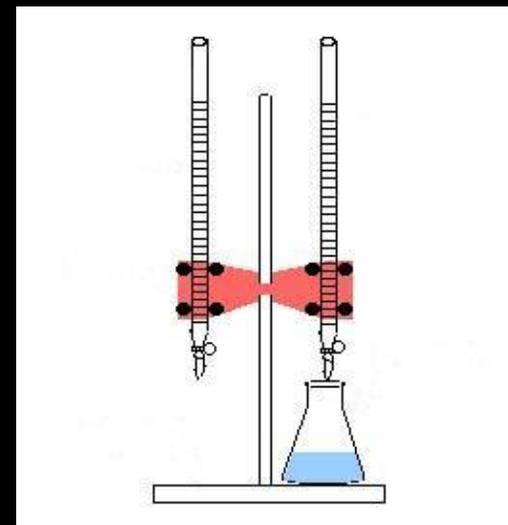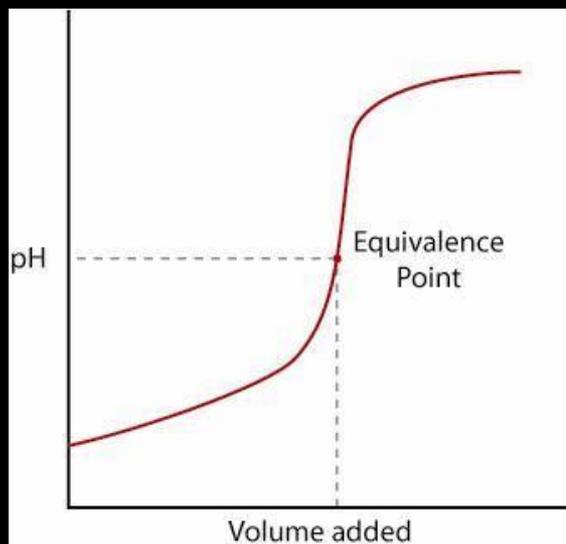Standardized NaOH titrated against unknown acid
At Endpoint: Moles standard NaOH = moles unknown

Standard NaOH then used to titrate acid concentrations

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Keep Your End-Point Indicator Barely Visible

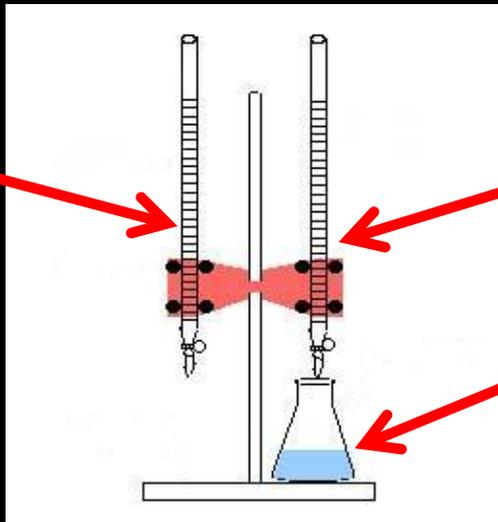# Titration Lab

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Online Lab

Purpose:
To determine the molarity of acetic acid

Since NaOH concentration can vary with time, the lab is done in 2 parts:

1. Determine the molarity of NaOH solution using standard HCl

2. Using the standardized NaOH solution, determine the molarity of HOAc

For Measuring Acid

For Dispensing Base

Reaction Happens Here

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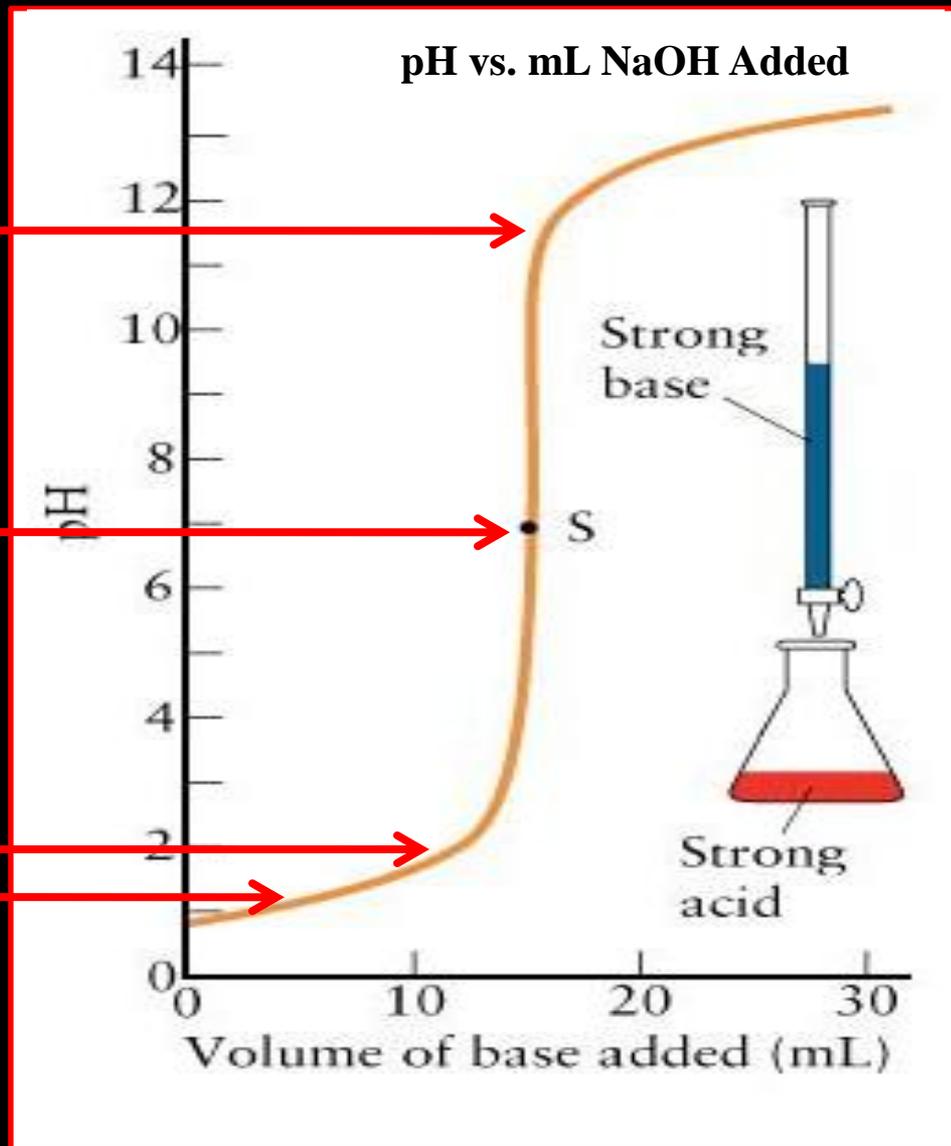# The Titration Curve

pH high, dark color

End Point, Perfect Faint Pink

pH changing, lingering color

pH low, no indicator color

pH vs. mL NaOH Added

Strong base

Strong acid

S

pH

Volume of base added (mL)

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Data
Titration Volumes

Calculations

First Titration: Molarity NaOH

Molarity of HCL (from instructor): 0.7664

HCl (mL) x $\dfrac{\text{HCl Moles}}{1000 \text{ mL}}$ x $\dfrac{1 \text{ mole NaOH}}{1 \text{ mole HCl}}$ x $\dfrac{1}{\text{NaOH added from buret (L)}}$ =   Molarity NaOH

25.00 HCl mL x $\dfrac{0.7664}{1000 \text{ mL}}$ x $\dfrac{1 \text{ mole NaOH}}{1 \text{ mole HCl}}$ x $\dfrac{1}{0.02398 \text{ L}}$ = Molarity NAOH

Second Titration: Molarity HOAc

Molarity NaOH (from Titration 1)

NaOH added (mL) x $\dfrac{\text{NaOH Moles}}{1000 \text{ mL}}$ x $\dfrac{1 \text{ mole HOAc}}{1 \text{ mole NaOH}}$ x $\dfrac{1}{\text{HOAc in Erlenmeyer (L)}}$ = Molarity HOAc

28.48 mL x $\dfrac{0.7990 \text{ moles}}{1000 \text{ mL}}$ x $\dfrac{1 \text{ mole HOAc}}{1 \text{ mole NaOH}}$ x $\dfrac{1}{0.02500 \text{ L}}$ = Molarity HOAc

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Results

Fill In table

Conclusion

Fill-In molarity value
Nothing needed but that value

Let's Boldly Go Explore Today's Lab

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