Titrations

"The controlled addition & measurement of the amount of a solution of known concentration that is required to react completely with a measured amount of a solution of unknown concentration"

* Allows you to experimentally determine the concentration of a solution

* Utilize neutralization rxn.

$HCl + NaOH \rightarrow NaCl + HOH$

$H^+ + Cl^- + Na^+ + OH^- \rightarrow Na^+ + Cl^- + HOH$

$H^+ + OH^- \rightarrow HOH$

↑ Known concentration of this "Standard Solution"

↑ Unknown concentration

When neutralize, can determine $[H^+]$ knowing how much $[OH^-]$ was required

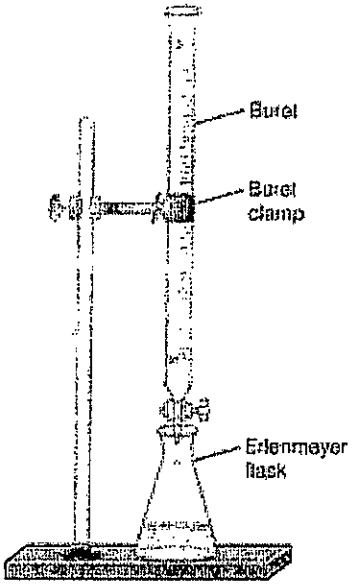
Demo
- ~ HCl
- ~ 0.1M NaOH (phenolphthalein)

equivalence point → The point in a titration at which there are equal quantities of H_3O^+ & OH^-

End Point → point in a titration where indicator changes color (of indicator)

↑ want this to be a pH of equiv. pt.

TITRATIONS



Goal of Titration:

Titration Terms:

Titrant

Indicator

Endpoint

Equivalence Point

Stoichiometric Point

*One knows the chemical reaction that will occur before the titration is begun.

1. 4.82 ml of 0.100 M NaOH solution is required to titrate 125.00 ml of rainwater, which is believed to contain sulfuric acid. Use the titration data to determine the concentration of sulfuric acid in the rainwater.

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

125.00 ml 4.82 ml
M? 0.100 M

$$4.82\ ml\ NaOH\ Soln \left(\frac{1.00\ L\ Soln}{1000\ ml}\right)\left(\frac{0.100\ mol\ NaOH}{1.00\ L\ Soln}\right)\left(\frac{1\ mol\ H_2SO_4}{2\ mol\ NaOH}\right)\left(\frac{1}{125.00\ ml}\right)\left(\frac{1000\ ml\ Soln.}{1.00\ L\ Soln.}\right)$$

$=$

$0.00193\ M\ H_2SO_4$

2. 25.00 ml of a solution of barium hydroxide is titrated with 0.400 M HCl. 18.40 ml of acid was required for the neutralization.
   Calculate the concentration of the barium hydroxide solution.

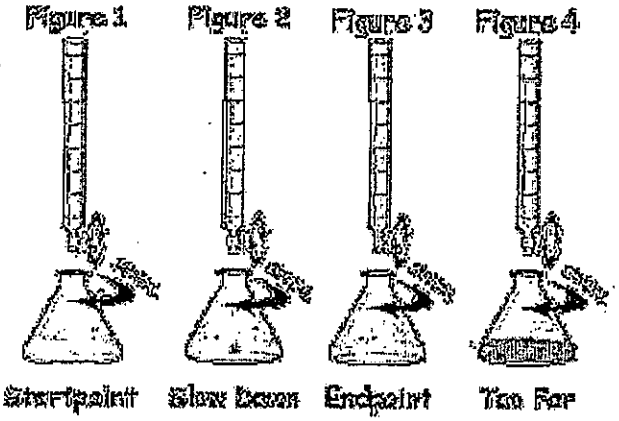
$Ba(OH)_2 + 2HCl \rightarrow$

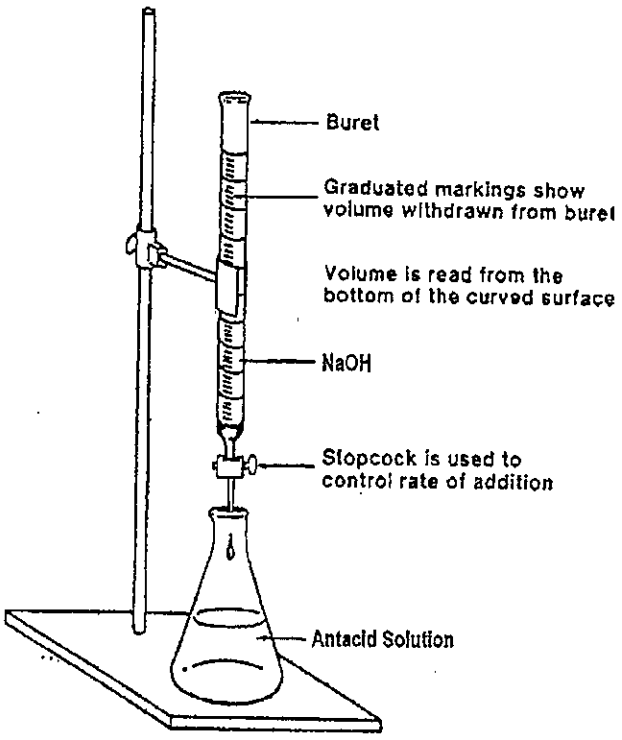
25.00 ml 0.400 M
18.40 ml

$$18.40\ ml\ HCl\ Soln. \left(\frac{1.00\ L\ Soln.}{1000\ ml\ Soln.}\right)\left(\frac{0.400\ mol\ HCl}{1.00\ L\ Soln.}\right)\left(\frac{1\ mol\ Ba(OH)_2}{2\ mol\ HCl}\right)\left(\frac{1}{25.00\ ml}\right)\left(\frac{1000\ ml}{1.00\ L}\right) = 0.147\ M\ Ba(OH)_2$$

Titration of an Acid with a Base

using phenolphthalein indicator





Acid-Base Titration

(3) What is the molarity of a NaOH solution if 4.37 ml is completely titrated by 11.1 ml of 0.0904 M HNO_3?

$NaOH + HNO_3 \rightarrow NaNO_3 + HOH$

M? 11.1 ml

4.37 ml 0.0904 M

$$11.1\text{ ml } HNO_3 \left(\frac{1.00\text{ L } HNO_3}{1000\text{ ml}}\right)\left(\frac{0.0904\text{ mol } HNO_3}{1.00\text{ L } HNO_3}\right)\left(\frac{1\text{ mol } NaOH}{1\text{ mol } HNO_3}\right)\left(\frac{1}{4.37\text{ ml Soln}}\right)\left(\frac{1000\text{ ml}}{1.00\text{ L Soln}}\right)$$

$= 0.230$ M NaOH

(4) How many ml of 0.682 M HCl would be needed to exactly neutralize 50.0 ml of 0.250 M $Sr(OH)_2$?

$2HCl + Sr(OH)_2 \rightarrow SrCl_2 + 2HOH$

0.682 M 50.0 ml

0.250 M

$$50.0\text{ ml } Sr(OH)_2\text{ Soln.}\left(\frac{1.00\text{ L Soln}}{1000\text{ ml Soln}}\right)\left(\frac{0.250\text{ mol } Sr(OH)_2}{1.00\text{ L Soln.}}\right)\left(\frac{2\text{ mol HCl}}{1\text{ mol } Sr(OH)_2}\right)\left(\frac{1.00\text{ L Soln}}{0.682\text{ mol HCl}}\right)\left(\frac{1000\text{ ml}}{1.00\text{ L}}\right)$$

$= 36.7$ ml HCl

Ex: In a titration, 27.4 mL of standard 0.0154 M $Ba(OH)_2$ soln. is added to 20.0 mL of an HCl solution. M of HCl?

$$2HCl + Ba(OH)_2 \rightarrow 2HOH + BaCl_2$$

$$27.4\,mL\,Ba(OH)_2\left(\frac{1.0\,L}{1000\,mL}\right)\left(\frac{0.0154\,mol}{1.0\,L}\right)\left(\frac{2\,mol\,HCl}{1\,mol\,Ba(OH)_2}\right)\left(\frac{1000\,mL}{1.0\,L}\right)\left(\frac{1}{20.0\,mL}\right) = \boxed{0.0422\,M\ HCl}$$

Ex: A 15.5 mL sample of 0.215 M KOH solution required 21.2 mL of aqueous acetic acid in a titration. M of $HC_2H_3O_2$?

$$KOH + HC_2H_3O_2 \rightarrow KC_2H_3O_2 + HOH$$

$$15.5\,mL\left(\frac{1.0\,L}{1000\,mL}\right)\left(\frac{0.215\,mol}{1.0\,L}\right)\left(\frac{1\,mol\,HC_2H_3O_2}{1\,mol\,KOH}\right)\left(\frac{1000\,mL}{1.0\,L}\right)\left(\frac{1}{21.2\,mL}\right) = \boxed{0.157\,M\ HC_2H_3O_2}$$

Ex: What volume of 0.50 M KOH would be required to neutralize 20.0 mL of 0.75 M HNO_3?

$$KOH + HNO_3 \rightarrow KNO_3 + HOH$$

$$20.0\,mL\left(\frac{1.0\,L}{1000\,mL}\right)\left(\frac{0.75\,mol}{1.0\,L}\right)\left(\frac{1\,mol\,HNO_3}{1\,mol\,KOH}\right)\left(\frac{1.0\,L}{0.50\,mol}\right)\left(\frac{1000\,mL}{1.0\,L}\right) = \boxed{30.0\,mL\ 0.50\,M\ KOH}$$

Pg 519
#19, 24