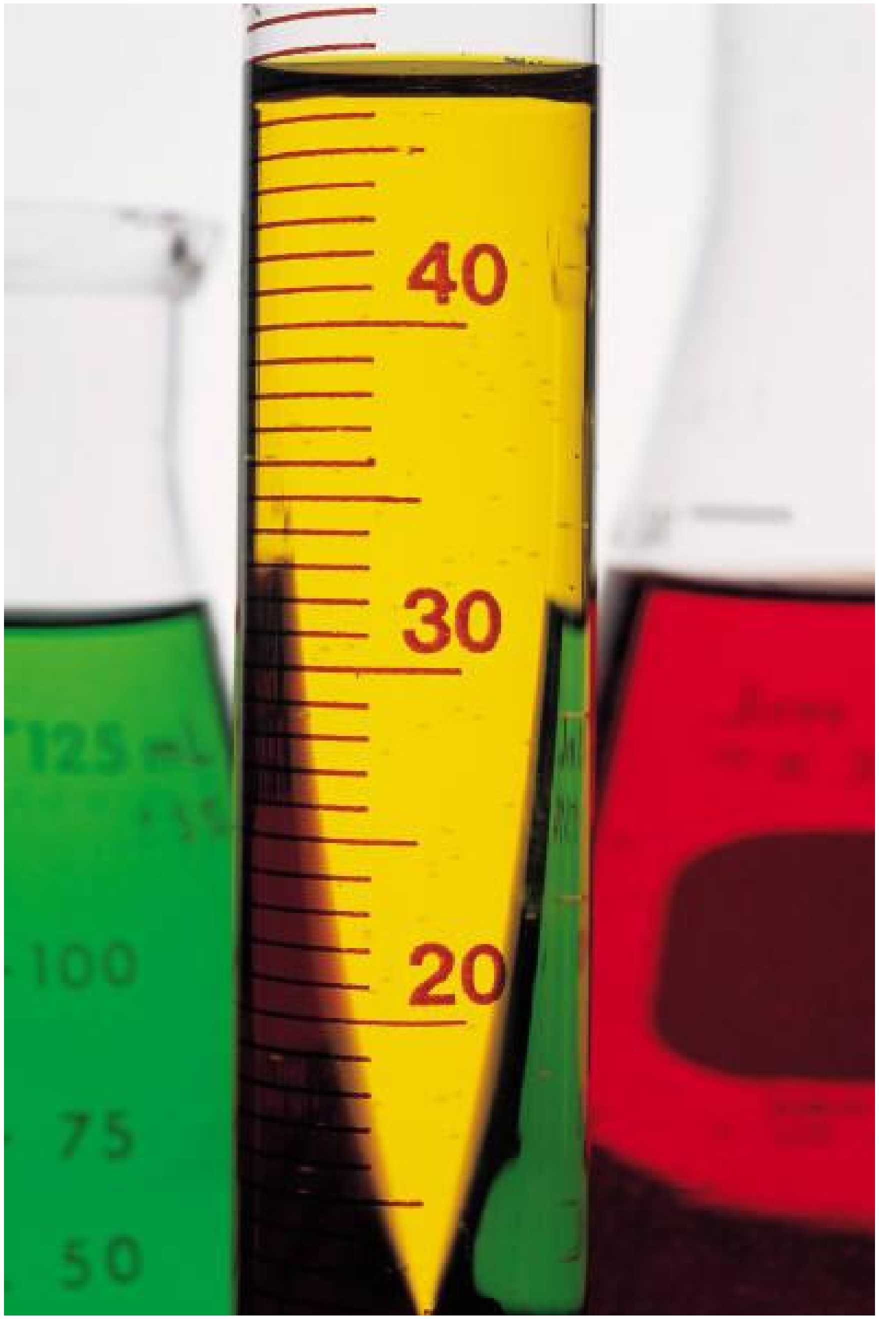
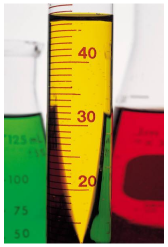
Experiment 4
Acid-Base Titration



CH204 Spring 2006
Dr. Brian Anderson

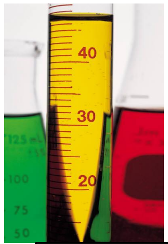


What We Learned Last Week

Spectator Ions and Net Ionic Equations

Simple Solubility Rules

Microscale Techniques



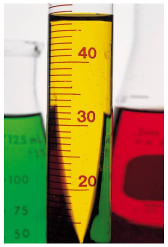
What We're Still Working On

Reporting results to the correct number of significant digits:

45.729 ± 0.0335	45.73 ± 0.03
45.729 ± 0.4883	45.7 ± 0.5
45.729 ± 1.4432	46 ± 1
45.729 ± 9.853	50 ± 10

Q-test – ONE OUTLIER ONLY

Naming Ionic Compounds (Pages F30-F34 in Atkins and Jones).



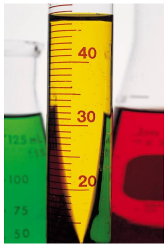
Review of pH

Think of it as a Richter scale for acid concentrations.

$$p = -\log_{10}$$

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

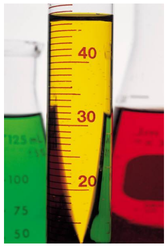
Neutral	$pH = 7$
Acidic	$pH < 7$
Basic (alkaline)	$pH > 7$



What is $\log_{10}$?

A reverse exponential function

$[H^+]$	$\log[H^+]$	pH
10^{-1}	- 1	1
10^{-2}	- 2	2
10^{-3}	- 3	3
10^{-4}	- 4	4
1.78×10^{-5}	- 4.75	4.75
4.68×10^{-7}	- 6.33	6.33
8.13×10^{-12}	- 11.90	11.90



What does all that mean?

Given the $[H^+]$, $pH = -\log[H^+]$

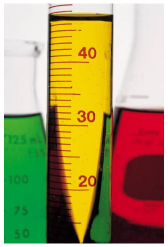
What is the pH of a 0.025 M HCl solution?

$pH = -\log[.025] = -(-1.6) = 1.6$

Given the pH, $[H^+] = 10^{-pH}$

What is the $[H^+]$ concentration in an HCl solution with a pH of 5.35?

$[H^+] = 10^{-pH} = 10^{-5.35} = 4.47\times10^{-6}$ M



Today: Titration Marathon!

Determining the concentration of an unknown acidic solution:

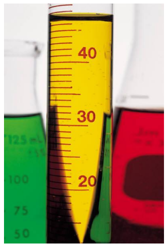
$$HCl + NaOH \longrightarrow NaCl + H_2O$$

$$H^+_{(aq)} + OH^-_{(aq)} \longrightarrow H_2O_{(l)}$$

$$\text{Moles } H^+ = \text{Moles } OH^-$$

$$M_{H^+} \times V_{H^+} = M_{OH^-} \times V_{OH^-}$$

$$M_{acid} \times V_{acid} = M_{base} \times V_{base}$$



Diprotic & Triprotic Acids

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

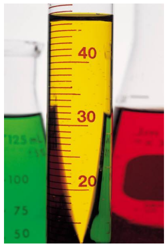
$$2H^+_{(aq)} + 2OH^-_{(aq)} \longrightarrow 2H_2O_{(l)}$$

$$H^+_{(aq)} + OH^-_{(aq)} \longrightarrow H_2O_{(l)}$$

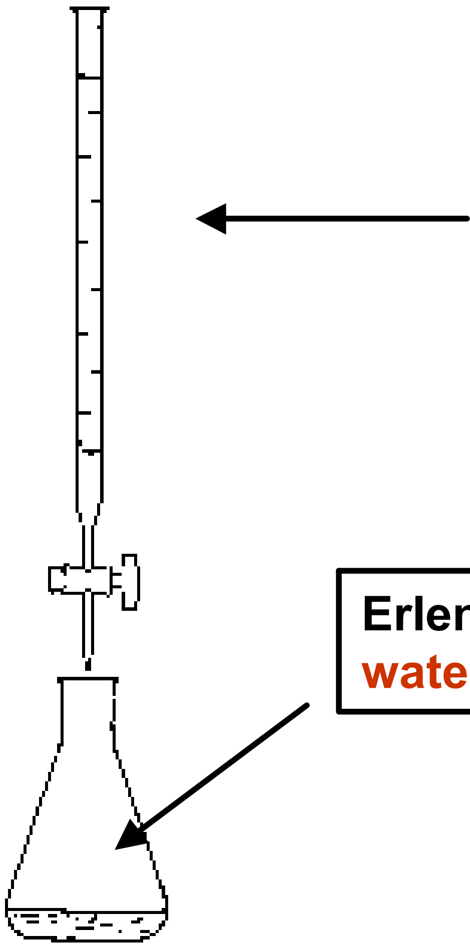
Moles H^+ = Moles OH^-

$$M_{H^+} \times V_{H^+} = M_{OH^-} \times V_{OH^-}$$

$$(2 \times M_{acid}) \times V_{acid} = M_{base} \times V_{base}$$



Titration Setup

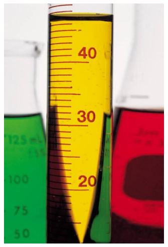


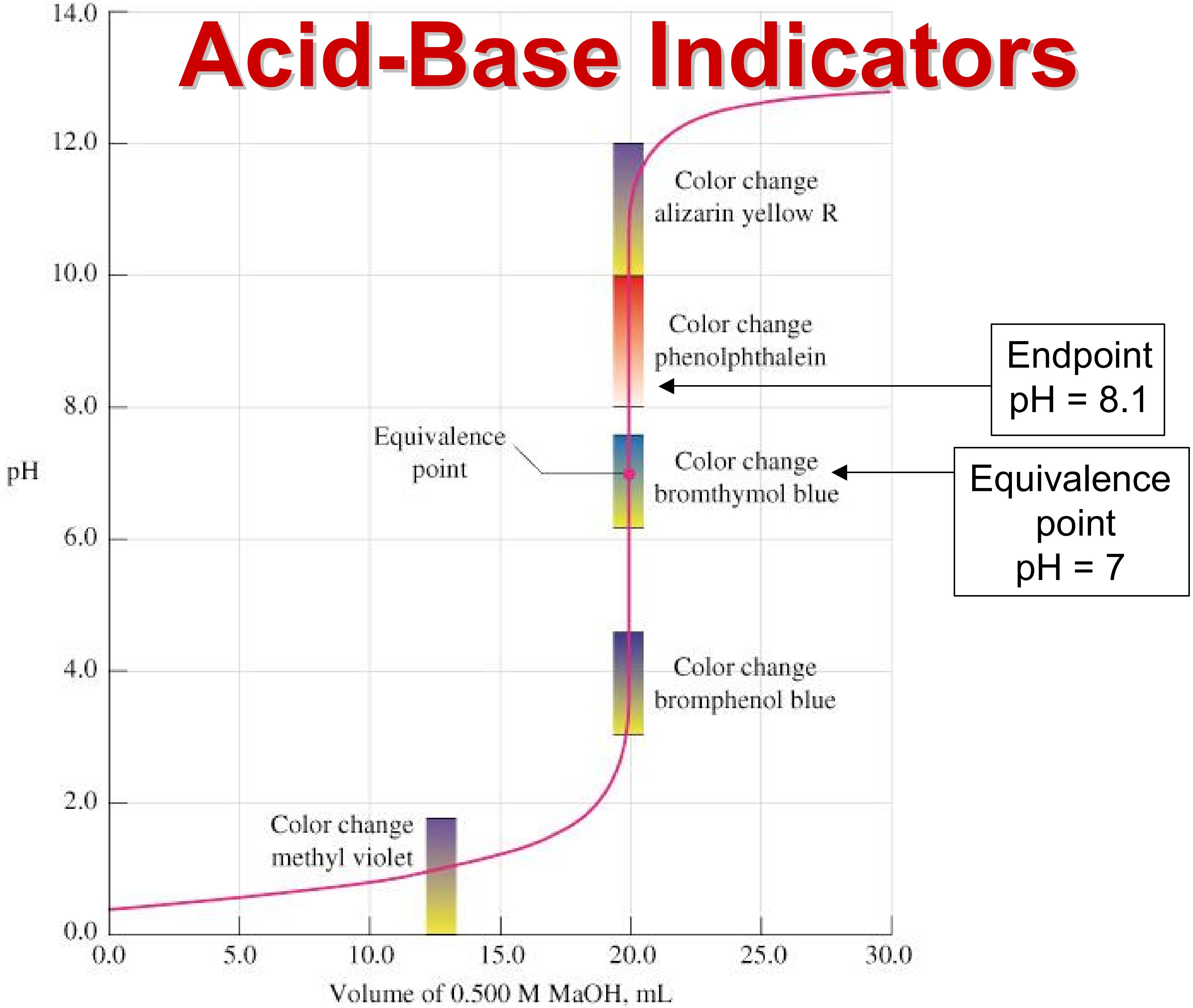
Burette containing NaOH.

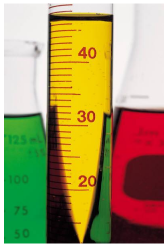
Read all volumes to 0.01 mL!

Erlenmeyer flask containing acid sample, water, and two drops of phenolphthalein.

Acid-Base Indicators





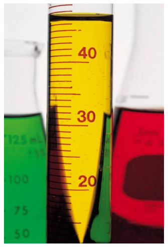


Phenolphthalein

Colorless below pH 8, pink above pH 8.

Your acid solution will go from colorless to faint pink at the endpoint. If it turns bright pink, you have gone too far.

http://www.chemistry.wustl.edu/~courses/genchem/Labs/AcidBase/phph.htm



Experiment 4 Overview

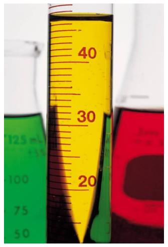
PART 1: STANDARDIZATION OF NaOH

Mix up 1 liter of NaOH solution.

Weigh out 2 grams of KHP powder, dissolve in 75 ml water, **ADD PHENOLPHTHALEIN**, and titrate (3×).

Calculate concentration of NaOH using

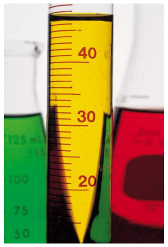
Moles of Acid = Moles of Base



Moles solid = Moles aqueous

$$\frac{\text{Mass of KHP}}{\text{MW of KHP}} = M_{NaOH} \times V_{NaOH}$$

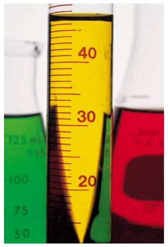
$$\frac{\text{Mass of KHP}}{\text{MW of KHP} \times V_{NaOH}} = M_{NaOH}\ (0.\text{xxxx M})$$



Part Two: Potions Lab

Identify your unknown acid sample using the qualitative reactions from last week.

HNO_3 HCl H_2SO_4



Part 3: Unknown Acid Titrations

5 ml unknown acid, 75 ml water, and

2 drops of phenolphthalein

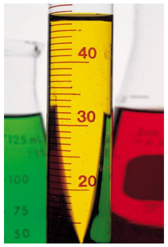
in a 250 ml flask.

Titrate using NaOH (3×)

Watch for flashes of color!

In an ideal world, you will get the exact same V_{NaOH} all three times.

Calculate the molarity of your acid.



$Moles_{Acid} = Moles_{Base}$

Moles H^+ = Moles OH^-

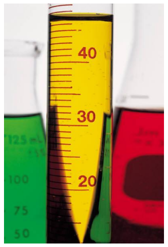
For HCl and HNO3,

$$M_{acid} \times V_{acid} = M_{base} \times V_{base}$$

For H_2SO_4

$$2 \times M_{acid} \times V_{acid} = M_{base} \times V_{base}$$

$V_{acid} = 5.00$ ml



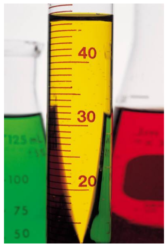
Part 4: Citric Acid in Juice

Orange, Grapefruit, or Pineapple

15 ml juice, 60 ml water, and

2 drops of phenolphthalein.

Titrate just once. Endpoint is hard to see in orange juice.



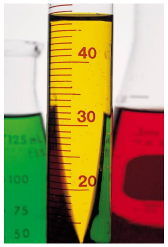
A word about citric acid

Citric acid is ***tri*** protic!

1 Mole of citric acid = *3* moles of H^+

So the number of moles of H^+ is ***3 times*** the number of moles of citric acid:

$$\underline{3} \times M_{\text{Citric acid}} \times V_{\text{Citric acid}} = M_{\text{base}} \times V_{\text{base}}$$



All your base are belong to us

Leftover NaOH goes into the waste container in the hood.

DO YOUR CALCULATIONS <u>BEFORE</u> YOU DUMP YOUR LEFTOVER BASE!!

Fill in all of the data tables before you leave the lab.