Experiment 4

Acid-Base

Titration

CH 204  Spring 2008

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Whut We Lernd in Skool Last Week

Molecular Equations

Simple Solubility Rules

Spectator Ions and Net Ionic Equations

Microscale Techniques
This Week:
Acid-Base Titrations

What exactly *is* a titration, anyway?

Acid + Base $\rightarrow$ Salt + H$_2$O

At the equivalence point
Moles H$^+$ = Moles OH$^-$
Titration Setup

Burette containing \textbf{NaOH}.

Read all volumes to 0.01 mL!

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

Colorless below pH 8.2

Pink above pH 8.2

http://www.chemistry.wustl.edu/~courses/genchem/Labs/AcidBase/phph.htm
Acid-Base Indicators

- **Endpoint** pH = 8.2
- **Equivalence point** pH = 7

Graph showing the equivalence point and color changes for different indicators:
- Color change phenolphthalein
- Color change bromthymol blue
- Color change bromphenol blue
- Color change methyl violet

Graph axis:
- pH
- Volume of 0.500 M NaOH, mL
Today: Titration Marathon!

Any time you see words like *titrate, titration, neutralize, neutralization, end point or equivalence point*, think:

\[ \text{Moles } H^+ = \text{Moles } OH^- \]

This is the starting point for post-lab problems 1, 2, 4, and 5.
PART 1: STANDARDIZATION OF NaOH

Mix up 500 ml of NaOH solution. Weigh out 2 grams of KHP powder, dissolve in about 75 ml water, ADD PHENOLPHTHALEIN, and titrate (3x). Calculate the concentration of NaOH using Moles of H⁺ = Moles of OH⁻
Moles aqueous = Moles solid

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

\[ M_{NaOH} = \frac{\text{Mass of KHP}}{\text{MW of KHP} \times V_{NaOH}} \]
Was ist KHP?

Das ist KHP.
Es ist Potassium Hydrogen Phthalate.

$\text{C}_8\text{H}_5\text{O}_4\text{K}$

Nicht haben der Phosphorus!
Part Two: A Return to the Potions Lab

Fill out an unknown request slip and get an unknown acid from the stockroom.

Ignore any writing on the bottle.

Identify your unknown acid sample using the qualitative reactions from last week.
Part 3: Titrate Your Unknown

5.00 ml unknown acid, 75 ml water, and 2 drops of phenolphthalein in a 250 ml flask.

Titrate using NaOH (3×)

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

Calculate the molarity of your acid.
General Form for Acid-Base Titrations

Moles $H^+$ = Moles $OH^-$

monoprotic acid/monobasic base

NaOH,

$moles \ OH^- = moles \ NaOH$

HCl or HNO$_3$,

$moles \ H^+ = moles \ acid$

diprotic acid/dibasic base

H$_2$SO$_4$,

$moles \ H^+ = 2 \times moles \ acid$

Ba(OH)$_2$,

$moles \ OH^- = 2 \times moles \ Ba(OH)_2$

triprotic acid

H$_3$PO$_4$,

$moles \ H^+ = 3 \times moles \ acid$

C$_3$H$_5$O(COOH)$_3$,

$moles \ H^+ = 3 \times moles \ acid$
Und so...

General formula for titrations/neutralizations:

Moles $H^+$ = Moles $OH^-$

Moles Acid $\times$ # of $H^+$ = Moles Base $\times$ # of $OH^-$

Moles = $M \times V$ or Moles = grams/MW

Let’s try one of these...
Moles_{H^+} = Moles_{OH^-}

For HCl and HNO_3,
\[ M_{\text{acid}} \times V_{\text{acid}} = M_{\text{NaOH}} \times V_{\text{NaOH}} \]

For H_2SO_4
\[ 2 \times M_{\text{acid}} \times V_{\text{acid}} = M_{\text{NaOH}} \times V_{\text{NaOH}} \]

\[ V_{\text{acid}} = 5.00 \text{ ml} \]
Part 4: Citric Acid in Juice

Orange or Pineapple
15 ml juice, 60 ml water, and
2 drops of phenolphthalein.

Titrate just once. Solution goes from yellowish to orangey.
That word 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:

\[
3 \times M_{\text{Citric acid}} \times V_{\text{Citric acid}} = M_{\text{NaOH}} \times V_{\text{NaOH}}
\]
All your base are belong to us

Leftover NaOH goes into the waste container in the hood.
Keep your unknown acid for now.

DO YOUR CALCULATIONS BEFORE YOU DUMP YOUR LEFTOVER BASE!!

If you have time, fill in all the data tables before you leave the lab.
Final Exam Part 3

No calculator this week.

You will need a calculator on every quiz after this one.

Learn your section number and your TA’s name!