Acids and Bases Unit

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CHEM495

Acids and Bases Unit Plan

Topics/Units students will have covered:

- Chemical reactions
- Balancing chemical equations
- Solutions
- Bonding

Fundamental Ideas:

- Acids and Bases have different characteristics and properties
- There are different models of acids and bases (primarily use the Bronsted-Lowry Model)
- Strong acids and bases dissociate fully, whereas weak acids and bases do not
- Neutralization reactions: acids and bases react to for a salt and water
- Water is an amphoteric substance that can act as an acid or a base, or a neutral solution (pure)
- The pH scale is a convenient tool to represent a solution's acidity/basicity

Over-riding Questions:

- What is an acid? What is a base?
- What are conjugate acid-base pairs?
- How do strong acids and bases differ from weak acids and bases?
- What is the pH scale and how does that work in conjunction with indicators?
- How do we calculate the acidity/basicity of a solution

Student Conceptions:

- Acids are the bubbly, green steaming solutions as depicted in pop culture
- Acids are harmful and poisonous for humans
- Acid and Base strength (strong/weak) and concentration means the same thing.

Color Key for Unit Instruction:

-Assessments

-Computer Activities

-Classroom Activities

-Laboratory Activities

Starting the Unit:

- Playing with pH paper: Bring household liquids and have the students test pH using pH paper strips; possibility of using other indicators?
  - Students record the pH levels, observations, and physical properties and characteristics of the acids/bases (important later)
  - Exposure to real-life uses of acids and bases
  - http://www.orientaldetox.com/ph-of-foods.html
  - http://www.onlinecancerinfo.com/docs/diet/pHbalance.htm
  - http://www.angelfire.com/az/sthurston/acid_alkaline_foods_list.html

Unit Instruction/Teaching Notes:

1. What is an Acid? What is a Base?
   a. Physical/Chemical Properties
      i. Taste and feel
      ii. Reacting with Indicators
         1. Don't go into specifics of pH yet
      iii. Real-life examples
         1. Incorporate discussion with Playing with pH paperlab activity
   b. The definition of acids and bases
      i. Arrhenius definition: depend on which ions were produced
         1. Limitation due to only allowing OH^- ions for base
      ii. Bronsted-Lowry definition: proton donor/acceptor (use this one)
         1. Conjugate acid-base pairs
      iii. Di/Triprotic Acids
2. Strong and Acids and Bases
   a. Strong acids completely ionize/dissociate
   b. Weak acids do not dissociate fully
   c. Conductivity test with Strong and Weak Acids and Bases
      i. http://www.ehow.com/how_4493757_do-water-conductivity-experiments.html
      ii. http://scifun.chem.wisc.edu/homeexpts/CondTester/SolutionConductivity.htm
   d. Strong and weak bases dissociate similarly to strong and weak acids

            i. PHET Acid-Base Solutions Simulation http://phet.colorado.edu/en/simulation/acid-base-solutions
                1. http://phet.colorado.edu/en/contributions/view/3320
                2. http://phet.colorado.edu/en/contributions/view/3306
    e. Examples of strong and weak acids and bases
3. Quiz over properties of acids and bases (matching), Bronsted-Lowry definition with conjugate acid-base pairs, strong/weak acids and bases
4. Neutralization Reactions
    a. Definition: acid and base mix to produce salt and water
    b. Double replacement reactions
    c. Molecular equations and neutralization problems
    d. Titrations
        i. Indicator necessary
        ii. Titration calculations to determine concentrations and volumes
    e. CHEM101 UIUC Find Molar Mass lab
5. Water
    a. Amphoteric substance: behave as acid or base
    b. Ion-product constant: K_w= 1.0E-14=$[H^+][OH^-]$
    c. Comparing the concentrations of hydrogen and hydroxide ions in a solution
6. pH scale
    a. place real-life examples on pH scale
    b. pH=-log$[H^+]$, power-of-ten-change
    c. pOH scale and pH=-log$[OH^-]$
        i. Find pH and pOH using only strong acids and bases
        ii. calculations of pH and pOH and using the ion-product constant
    d. Water, Wine, Milk, Beer(Apple Juice) Demo
        i. http://chemistry.about.com/cs/demonstrations/ht/blwwmbdemo.htm
        ii. http://cenblog.org/transition-states/2011/06/wwmb-nope/
7. Real Life Connections: Antacid Lab
8. Final Assessment :
    a. Summative Assessment
        i. Acid/Base properties, conjugate acid-base pairs
        ii. pH/pOH calculations, titrations and neutralization reactions

Classroom Demonstrations:

Conductivity test with Strong and Weak Acids

Materials:

- battery
- light bulb with metal tabs coming out from the bottom)
- three wires with alligator clips at each end.
- 3 beakers
- Distilled/deionized water
- A strong and weak acid

Setting Up the Conductivity Tester:

Clip on alligator clip to the negative battery end, leaving the other end of the wire hanging loose. Clip a second alligator clip to the positive end, then clip the opposite side of that wire to the one tab on the light bulb. Clip the final alligator clip on the last remaining wire to the other tab on the light bulb, leaving the opposite end of the wire hanging free.

Purpose: To discern the different strengths of electrolytes by doing a conductivity test in water. This demonstration shows that distilled water is not a very good conductor, but when electrolytes dissociate in water, the solution can conduct electricity. The strength of an acid can be shown through the brightness of the light bulb.

The Demonstration:

- Set up the conductivity tester.
- Fill one beaker with deionized(DI) water and place the two end of the circuit into opposite ends of the beakers to show that DI water is a poor conductor
- Grab another beaker and fill it up half way with DI water and place some strong acid in the beaker. Make sure the strong acid dissolves, and then run the conductivity test
- Grab another beaker and fill it up half way with DI water and place some weak acid in the beaker. Make sure the weak acid dissolves, and then run the conductivity test

Explanation of the Demonstration:

Pure water doesn't have many ions, so the number of charged particles in pure water is very low. Strong acids dissociate fully, so adding a strong acid solution to DI water will create a solution with more ions than it had before. The same thing happens for weak acids, but since weak acids do not dissociate fully, there will be less ions in the solution if both solutions started with the same number of moles of the acid. Make sure to test both the strong acid and weak acid and the amount of acid used, because the results could change depending on the amount of water used for the demonstration.

Discussion Questions:

- Before starting any of the conductivity tests:
  - What is electricity?
  - I have set up a conductivity tester. What do you think will happen to the light bulb when I try to test of the conductivity of this distilled water?
- After testing the conductivity of the water and before testing the strong acid in solution:
  - Did anything happen to the light bulb?
  - What do we know about strong acids when they are placed in water?
  - If I were to put a strong acid into this distilled water, what will happen to the lightbulb?
- After testing the conductivity of the strong acid and before testing the weak acid in solution:
  - Did anything happen to the light bulb? Is that what we expected?
  - What do we know about weak acids when they are placed in water?
  - What do you think happen when we do the same test with a weak acid?
- After testing the conductivity of the weak acid:
  - What happened to the light bulb? Does is look different than when we used the strong acid?
  - What could we use this conductivity test for?

Discussion Questions (Key):

- Before starting any of the conductivity tests:
  - What is electricity?
    - Electricity: flow of moving electrons; simply the movement of electrons
  - I have set up a conductivity tester. What do you think will happen to the light bulb when I try to test of the conductivity of this distilled water?
    - Explain that distilled water is essentially pure water if the students don't know. This is aguessing question so be prepared for different responses
- After testing the conductivity of the water and before testing the strong acid in solution:
  - Did anything happen to the light bulb?
    - The light bulb should not light up
  - What do we know about strong acids when they are placed in water?
    - The strong acid will dissociate fully; all of the strong acid will break up into its individual ions
  - If I were to put a strong acid into this distilled water, what do you think will happen to the light bulb?

    - This is a guessing question so be prepared for different responses. Most likely, that the light bulb will light up

- After testing the conductivity of the strong acid and before testing the weak acid in solution:
  - Did anything happen to the light bulb? Is that what we expected?
    - If done correctly, the light bulb should light up brightly. Expectations will be dependent on the students' responses to that prior question
  - What do we know about weak acids when they are placed in water?
    - They dissociate, but not to the degree of strong acids. Not all of the hydrogen cations will be released into the solution
  - What do you think happen when we do the same test with a weak acid?
    - This is a guessing question so be prepared for different responses. Most likely that the light bulb will light up but not as brightly as it did with the strong acid
- After testing the conductivity of the weak acid:
  - What happened to the light bulb? Does is look different than when we used the strong acid?
    - If done correctly, the light bulb will light up, but not as bright as before.
  - What could we use this conductivity test for?
    - Various possible responses: testing the strength of an unknown acid or base, seeing how many ions are in a solution (for example a pond)

Water, Wine, Milk, Beer(Apple Juice) Demonstration

Materials:

- distilled water
- 4 glass cups for the different solutions
- Saturated sodium bicarbonate with 20% sodium carbonate solution with pH=9
- phenolphthalein indicator
- Barium chloride solution (1.0 M)
- Either bromothymol blue or crystals of sodium dichromate
- Hydrochloric Acid (12 M)

Purpose: To utilize multiple chemical reactions to create different solutions the resemble water, wine, milk, and beer. This demonstration can be done step-by-step to have so that students can walk through the chemical reactions and discuss what is causing the different changes to occur from glass to glass.

How to prepare the different glasses:

- GLASS#1: Create a sodium bicarbonate with sodium carbonate solution that has a pH of 9. Do this by taking a 250 mL beaker, filling it to about 2/3 full, and then adding 20-25 mL of the sodium bicarbonate with 20% sodium carbonate solution. Test pH with pH strips. This will be the water cup.

- GLASS#2: Place a few drops of phenolphthalein indicator at the bottom of the glass. This will be the wine cup.

- GLASS#3: Pour about 5 mL of the BaCl solution into the bottom of the glass. This will be the milk solution

- GLASS#4: This will be the beer/apple juice cup
  - If using the BROMOTHYMOL BLUE: Pour about 10 mL of the 12 M HCl into the fourth glass with a few drops of bromothymol blue indicator.
  - If using the crystals of SODIUM DICHRMOMATE: Place a few crystals at the bottom of the fourth glass. Add about 5 mL of the 12 M HCl into the glass prior to starting the demonstration.

The Demonstration

- Start by showing the first glass which is the water glass.
- Pour the resulting solution from the water glass into the second glass to create the wine solution

- Pour the resulting solution from the wine glass into the third glass to create the milk solution
- Pour the resulting solution from the milk glass into the fourth glass to create the beer/apple juice solution

Explanation of the Demonstration:

The starting solution should be a basic solution with a pH of 9. Adding phenolphthalein to the solution will turn it purple because it is a basic solution. When the solution is then added to the barium chloride, Barium hydroxide will precipitate out, causing the solution to look like opaque white liquid. Since some of the hydroxide ions are precipitated out of the solution, the concentration of hydroxide ions will decrease and the solution will be less basic; this causes the pink color to disappear. When adding the milk solution to the glass with the bromothymol blue indicator and the hydrochloric acid, the solution will become more basic and the indicator will cause the solution to become a brown color. When adding the mild solution to the glass with the sodium dichromate crystals and the hydrochloric acid, the resulting reaction will give off CO_2 and the reaction will turn a brown color.

Discussion Questions:

- Before starting the demonstration
    - What can you say about this solution?
    - What do you think will happen when I pour this solution into Glass#2?
- After pouring the starting solution in glass#1 into glass#2:
    - What happened to the solution?
    - Why did starting solution change color?
    - Because of the resulting solution, what do we know about the initial solution?
    - What do you think will happen when I pour this solution into Glass#3?
- After pouring the wine solution into glass#3:
    - What happened to the solution?
    - Since the solution isn't a transparent purple anymore, what do you think is inside the new solution?
    - Why is the new solution white and not purple anymore?
    - What do you think will happen when I pour this solution into Glass#4?
- After pouring the milk solution into glass#4:
    - What happened to the solution?
    - Why is the solution brown and not white like it was before?

Discussion Questions (Key):

- Before starting the demonstration
  - What can you say about this solution?
    - Various responses: it's clear, it's a little cloudy, it's colorless and transparent
  - What do you think will happen when I pour this solution into Glass#2?
    - Various responses. This is a guessing question so be prepare for different responses
- After pouring the starting solution in glass#1 into glass#2:
  - What happened to the solution?
    - If done correctly, the solution should still be transparent, but purple
  - Why did starting solution change color?
    - Phenolphthalein indicator at the bottom of glass#2 caused the solution to turn purple
  - Because of the resulting solution, what do we know about the initial solution?
    - The initial solution was basic (solution has a pH of 9)
  - What do you think will happen when I pour this solution into Glass#3?
    - Various responses. This is a guessing question so be prepare for different responses
- After pouring the wine solution into glass#3:
  - What happened to the solution?
    - If done correctly, the solution should be a milky white color. The pink should be mostly gone, and the solution should no longer be transparent
  - Since the solution isn't a transparent anymore, what do you think is inside the new solution?
    - A precipitate was formed. The BaCl reacted with the starting solution to yield $Ba(OH)_2$ which is insoluble and it will become the precipitate.
  - Why is the new solution white and not purple anymore?
    - Less concentration of OH^- ions will make the solution more acidic than it was before, so the pH will decrease and the purple will disappear
  - What do you think will happen when I pour this solution into Glass#4?
    - Various responses. This is a guessing question so be prepare for different responses
- After pouring the milk solution into glass#4:
  - What happened to the solution?
    - The resulting solution turned brown; bubbles will also form if the sodium dichromate crystals are used.
  - Why is the solution brown and not white like it was before?

- If bromothymol blue is used: bromothymol blue turns brown in an acidic solution, and the large amount of concentrated HCl made the resulting solution acidic
- If using sodium dichromate crystals, a chemical reaction will occur and carbon dioxide will form. The reaction will cause the solution to turn into a brown color.

Laboratory Experiments:

NAME___________________________

Playing with pH Paper

Introduction:

In our everyday lives, we come into contact with many different acidic and basic products. In order to test how acidic or basic something is, scientists like to use the pH scale. If a substance has a pH less than 7, then it is considered acidic. If a substance has a pH greater than 7, then is it considered basic (also known as alkaline). If a substance has a pH of 7 means that the substance is neutral. Many products that we use daily for personal hygiene, home and auto care, or eating and drinking are suitable for pH testing. For this activity, we will be using strips of pH paper to test the pH levels of some of these products.

Materials:

- Strips if pH paper with pH scale
- Different products to test pH
- Glass rods

Procedure:

Prior to testing the pH levels of the different products, predict what the pH levels will be for each product. In order to test the pH levels of the different products, take a clean glass rod and dip it into the substance. After dipping the glass rod, remove the glass rod and touch a strip of pH paper with it. Record the real pH of the product.

Data:

Substance	Predicted pH	Actual pH

Lab Questions:

1. State which, if any, pH values surprised you. Why were you surprised?

2. What do you notice about the pH levels of cleaning supplies?

3. Do the foods we eat and drink have a small range of pH levels or large range of pH levels? Considering that the pH level of blood is about 7.34-7.45, did you expect this?

4. Acids are often thought to be corrosive. Explain why the pH level of our stomach acid is about 1.

NAME___________________________

Playing with pH Paper (KEY)

Introduction:

In our everyday lives, we come into contact with many different acidic and basic products. In order to test how acidic or basic something is, scientists like to use the pH scale. If a substance has a pH less than 7, then it is considered acidic. If a substance has a pH greater than 7, then is it considered basic (also known as alkaline). If a substance has a pH of 7 means that the substance is neutral. Many products that we use daily for personal hygiene, home and auto care, or eating and drinking are suitable for pH testing. For this activity, we will be using strips of pH paper to test the pH levels of some of these products.

Materials:

- Strips if pH paper with pH scale
- Different products to test pH
- Glass rods

Procedure:

Prior to testing the pH levels of the different products, predict what the pH levels will be for each product. In order to test the pH levels of the different products, take a clean glass rod and dip it into the substance. After dipping the glass rod, remove the glass rod and touch a strip of pH paper with it. Record the real pH of the product.

Data:A few examples of different substance and their pH levels. This chart depends on which products were used for this laboratory activity

Substance	Predicted pH	Actual pH
Coca-Cola		2
Black Coffee		5
Lemon Juice		2.3
Milk		6.8
Ammonia		11.6
Liquid PeptoBismol		3-4
Toothpaste		8-10
Laundry detergent		8-10
Soap		8-10

Lab Questions:

5. State which, if any, pH values surprised you. Why were you surprised?

These are based upon the predictions of the students

6. What do you notice about the pH levels of cleaning supplies?

Cleaning supplies tend to be alkaline in nature

7. Do the foods we eat and drink have a small range of pH levels or large range of pH levels? Considering that the pH level of blood is about 7.34-7.45, did you expect this?

We eat and drink different foods of a relatively wide range of pH levels.
Expectations are based on the opinions of the students.

8. Acids are often thought to be corrosive. Explain why the pH level of our stomach acid is about 1.

We start the chemical digestion of food in our stomach. Stomach acid needs to be concentrated and corrosive to help break down the proteins that enter our stomach.

NAME ______________________________

Unknown Weak Acid Lab

Introduction:

A simple definition of an acid is a species that dissociates in water to release hydrogen ions (H^+). An acid such as this will react with a metal hydroxide (such as sodium hydroxide, which is a base) to form a salt and water. The general reaction can be symbolized as:

$HA\ (aq) + NaOH\ (aq) \rightarrow NaA\ (aq) + H_2O$

This is why acid-base reactions are often called neutralization reactions. Chemical indicators are often used to determine when a reaction has gone to completion.

In this lab, you will be given approximately 0.1 M NaOH and a solid, water soluble, <u>monoprotic acid</u> (which you can symbolize as HA). Your goal is to determine the molar mass of the "unknown" acid.

Prelaboratory Questions:

1. Which of the following will have to be exactly measured? Why? Which will not? Why?
    a. Volume of NaOH used
    b. Water added to acid
    c. Amount of indicator
    d. Mass of unknown acid

2. You dissolve 0.213 g of acid in 25.0 mL of water. To react this acidic solution to the endpoint you add 23.80 mL of 0.1024 M NaOH. Determine the molar mass of the acid.

Materials:

- 0.1 M NaOH solution
- 250 mL beaker
- Unknown acid
- Titration station (Ring Stand, buret clamp, and buret).
- Phenolphthalein indicator

Procedure:

1. Obtain between 0.2 g to 0.3 g of the unknown acid. Record to exact measurement
2. Dissolve the unknown acid in water and add 3 drops of phenolphthalein indicator.
3. "Prime" the burette but placing a small amount of sodium hydroxide into the burette and washing the interior of the burette until all surfaces have come into contact with the NaOH solution. After priming the burette, remove the solution from the burette.
4. Set up a titration and place some NaOH solution into the burette.
5. Record the amount of NaOH solution (this will be your starting amount).
6. Using the burette, add the NaOH into the unknown acid solution until you note a color change (from clear to pink). When the color change occurs, you have added enough moles of base to completely react with the acid.
7. Record the amount of NaOH left in the burette (This will be your final amount).
8. Repeat steps 4-7 two more times to obtain three total sets of data.

Data: Present all data in an orderly fashion

Lab Questions:

1. Provide an average molar mass. Show all calculations and watch significant figures.

2. If the unknown acid was diprotic (symbolized as H_2A), how would the calculation of the molar mass have been affected (higher or lower than the actual value you from this lab and by how much)? Explain

3. Suppose someone added some table salt to your unknown solid acid before you came to the lab. (Table salt, like NaCl, is neither an acid nor a base and will not contribute to a chemical reaction here). How would the calculation of the molar mass of the acid been affected (higher or lower than the actual value you got from lab)? Explain

NAME ______________________________

Unknown Weak Acid Lab(Teacher's Key)

Introduction:

A simple definition of an acid is a species that dissociates in water to release hydrogen ions (H^+). An acid such as this will react with a metal hydroxide (such as sodium hydroxide, which is a base) to form a salt and water. The general reaction can be symbolized as:

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This is why acid-base reactions are often called neutralization reactions. Chemical indicators are often used to determine when a reaction has gone to completion.

In this lab, you will be given approximately 0.1 M NaOH and a solid, water soluble, monoprotic acid (which you can symbolize as HA). Your goal is to determine the molar mass of the "unknown" acid.

Prelaboratory Questions:

3. Which of the following will have to be exactly measured? Why? Which will not? Why?
   a. Volume of NaOH used
   b. Water added to acid
   c. Amount of indicator
   d. Mass of unknown acid

   Make sure the students explain why

a. Exact
b. Not exact
c. Not exact
d. Exact

4. You dissolve 0.213 g of acid in 25.0 mL of water. To react this acidic solution to the endpoint you add 23.80 mL of 0.1024 M NaOH. Determine the molar mass of the acid.

0.213 g/(0.00244 mol) = 87.4 g/mol

Materials:

- 0.1 M NaOH solution
- 250 mL beaker
- Unknown acid
- Titration station (Ring Stand, buret clamp, and buret).
- Phenolphthalein indicator

Procedure:

1. Obtain between 0.2 g to 0.3 g of the unknown acid. Record to exact measurement
2. Dissolve the unknown acid in water and add 3 drops of phenolphthalein indicator.
3. "Prime" the burette but placing a small amount of sodium hydroxide into the burette and washing the interior of the burette until all surfaces have come into contact with the NaOH solution. After priming the burette, remove the solution from the burette.
4. Set up a titration and place some NaOH solution into the burette.
5. Record the amount of NaOH solution (this will be your starting amount).
6. Using the burette, add the NaOH into the unknown acid solution until you note a color change (from clear to pink). When the color change occurs, you have added enough moles of base to completely react with the acid.
7. Record the amount of NaOH left in the burette (This will be your final amount).
8. Repeat steps 4-7 two more times to obtain three total sets of data.

Data: Present all data in an orderly fashion

Trial #	Mass of unknown acid	Initial volume NaOh solution	Final volume NaOH solution	Total NaOH solution added	Molar Mass of Acid
Trial #1					
Trial #2					
Trial #3					

Lab Questions:

4. Provide an average molar mass. Show all calculations and watch significant figures.

Average molar mass of acid depends on data obtained from each student. The first trial does not have to be used in the average, because the first trial is meant for the students to predict how much of the NaOH solution they will need to add to reach the color changing point.

5. If the unknown acid was diprotic (symbolized as H_2A), how would the calculation of the molar mass have been affected (higher or lower than the actual value you from this lab and by how much)? Explain

The molar mass would be calculated as 2x higher(1:2 acid:base mole ratio in balanced equation)

6. Suppose someone added some table salt to your unknown solid acid before you came to the lab. (Table salt, like NaCl, is neither an acid nor a base and will not contribute to a chemical reaction here). How would the calculation of the molar mass of the acid been affected (higher or lower than the actual value you got from lab)? Explain

The molar mass would be higher (less base used, thus same mass, smaller number of moles)

Name: ____________________

Antacid Laboratory Investigation

Have you ever had an upset stomach after eating something? Did you ever take an antacid to calm your stomach down? In this laboratory, we are going to explore exactly why an antacid helps with stomachaches.

Hydrochloric acid is produced by our stomachs to help us digest and break down the foods we eat. Although HCl is quite a strong acid, the stomach can handle the acidity because of a thick mucus lining in the stomach. However, sometimes, this acid is forced up out of the stomach into the esophagus area. The burning sensation that follows is what is commonly called heartburn. (!)

To help us combat heartburn, there are many OTC medications available to us called antacids (fighting against the acids!) Some of the antacids that we will be testing today in our lab include Tums, Equate, Rolaids, and Maalox.

Laboratory Instructions

Your goal is to find out how much acid is neutralized by each of the antacids. Using the provided materials, find out how much acid is "fought off" by 1 tablet or 1 serving of the antacids given. For the sake of time, try to find results for one antacid and repeat the trial again to ensure accuracy. At the end of class, we will compile a cumulative data sheet with all of the antacid results posted. Some helpful hints:

1) The mortar and pestle are meant for you to crush the antacid tablets
2) Phenolphthalein is an indicator that is colorless in acidic conditions but turns a bright pink above a pH of 8.2
3) Try and imitate what is occurring in your stomach
4) Titration would be a good idea!

Materials available *(For each group, please limit yourselves to 100mL of HCl and NaOH):*

.5M HCl	Mortar and Pestle	Stirring Rod
1M NaOH	Spoon	Buret
Concentrated Phenolphthalein	Disposable Pipettes	Beakers
Tums	Ring Stand with Clamp	Maalox
Rolaids	Equate Antacid	

Before you start your laboratory, map out a procedure and data table on the next page and have it checked by the instructor.

Procedure:

Data Table:

Post Lab Questions

1) What happened when the antacid made contact with the acid? Why did this occur? Explain your observations.

2) Explain the method you used to find out how much acid was neutralized by the antacid.

3) If we used an indicator that changed colors at a pH of 7 instead of 8.2, would your results for how much acid was neutralized increase or decrease? Explain how you came to this conclusion.

4) Which antacid would you pick to use if you had a terribly bad stomachache based on the results of this lab?

Name: ________________________

Antacid Laboratory Investigation(Teacher's Key)

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5) The mortar and pestle are meant for you to crush the antacid tablets
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1M NaOH	Spoon	Buret
Concentrated Phenolphthalein	Disposable Pipettes	Beakers
Tums	Ring Stand with Clamp	
Rolaids	Equate Antacid	Maalox

Before you start your laboratory, map out a procedure and data table on the next page and have it checked by the instructor.

Procedure:

1) Crush antacid tablets with mortar and pestle
2) Dissolve the antacid into 50 mL of .5M HCl
3) Let mixture react and place into a 100mL beaker with a couple drops of phenolphthalein
4) Fill buret with 1M NaOH to the 0mL mark
5) Titrate the solution
6) Record amount NaOH titrated
7) Calculate moles of HCl titrated
8) Calculate moles of HCl neutralized

Data Table:

Antacid	Vol. .5M HCl	MolHCl	Vol. 1M NaOH	MolNaOH	MolHCl Neutralized
Tums	50.4mL	.252	20.20mL	.202	.050
Rolaids	49.5mL	.2475	17.35mL	.1735	.074
Equate	50.2mL	.251	19.95mL	.1995	.0515
Maalox	Untested	Untested	Untested	Untested	untested

Post Lab Questions

5) What happened when the antacid made contact with the acid? Why did this occur? Explain your observations.
    a. The antacid fizzed in the HCl, causing a reaction between the acid and the active ingredient in the antacid. Once the tablet was crushed and added to the HCl, the solution fizzed for about thirty seconds and then calmed down. The fizzing was CO_2 being released from the reaction between HCl and the active ingredient.
6) Explain the method you used to find out how much acid was neutralized by the antacid.
    a. Students should explain their procedure and how it logically led them to calculating the number of moles of NaOH, which corresponded to the moles of HCl consumed, which they could subtract from the moles of HCl that they began with, which will then give them the amount of acid neutralized by the antacid.
7) If we used an indicator that changed colors at a pH of 7 instead of 8.2, would your results for how much acid was neutralized increase or decrease? Explain how you came to this conclusion.
    a. The amount of acid would have increased in our results because less NaOH would have been titrated, meaning that there would be a lesser amount of HCl being subtracted from the original amount of HCl used in the mixture of the antacid and HCl. This would lead to a greater amount of acid being neutralized.
8) Which antacid would you pick to use if you had a terribly bad stomachache based on the results of this lab?
    a. When I performed this lab, Rolaids neutralized the most acid, so I would choose to take Rolaids.

Difficulties in the set up and suggestions for improvement:
I think that the hardest part was when I had to mix the antacid with the HCl and try and completely dissolve the tablet. Even though the tablet was crushed, it was still very hard to have it dissolve in the HCl. Some parts of the antacid are insoluble in HCl, so it was hard to tell when the solution was done mixing together.

Total prep time:
When I had the free lab period to do this lab, it took around 10 minutes to figure out what I was going to do exactly with the procedure, and then it took maybe 5-10 minutes to get all of the materials ready. Since all of the materials used didn't necessarily have to be prepared beforehand, prep for each lab would not take too long. All that one needs to do is set out the materials needed.

Amounts of material needed for 24 students:

¼ bottle of Tums	$4.50 per bottle/4	$1.12	Walgreens
¼ bottle of Rolaids	$4.00 per bottle/4	$1.00	drugsdepot.com
¼ bottle Equate Antacid	$4.59 per bottle/4	$1.15	Amazon
¼ bottle Maalox	$6.99 per bottle/4	$1.75	Walgreens
1.5L .5M HCl	$32.07 per 1L 12M	$2.00	Lab Safety Supply
1.5L 1M NaOH	$70.60 per 4L 19M	$1.39	Lab Safety Supply
12 mortar and pestles	class set		
20mL Phenolphthalein	$16.10 per 500mL, 1%	$0.64	Lab Safety Supply
30 disposable pipettes	$28.50 per 500	$1.71	Lab Safety Supply
36 beakers	class set		
12 spoons	class set		
Total price		$10.76	

Curriculum:
I think that this would be a good way to wrap up a unit on acid-base chemistry. It can be an inquiry lab where students use the knowledge that they gained during the unit and apply it to this laboratory experiment. It could also be used as a summative assessment at the end of an acid-base unit.

Classroom Activities:

The following is a supplementary worksheet that goes in conjunction with the PhET Acid-Base Solutions Simulation. It is meant to be for a computer lab activity for the class to do in groups initially, and then individually.

NAME__________________

Equilibrium: Weak and Strong Acids

Part I: Your Initial Ideas

Answer the following True/False questions for yourself. Then check in with your group. You don't all have to agree—just get a sense of what others are thinking. You will re-evaluate your answers at the end of recitation, so it's okay to be unsure at this point.

My response: Always True Always False Sometimes True ***My group's response:*** Always True Always False Sometimes True	**1a.** Strong acids completely dissociate in water.
My response: Always True Always False Sometimes True ***My group's response:*** Always True Always False Sometimes True	**1b.** Strong acids have lower pH's than weak acids.
My response: Always True Always False Sometimes True ***My group's response:*** Always True Always False Sometimes True	**1c.** A ten-fold *dilution* of a strong acidic solution will *decrease* the pH by 1.
My response: Always True Always False Sometimes True ***My group's response:*** Always True Always False Sometimes True	**1d.** A solution with $[H_3O^+]$ = 0.01 M contains a stronger acid than a solution with $[H_3O^+]$ = 0.001 M.
My response: Always True Always False Sometimes True ***My group's response:*** Always True Always False Sometimes True	**1e.** A solution whose pH is 2.00 contains a stronger acid than a solution whose pH is 3.00.

Part II: Strong and Weak Acids

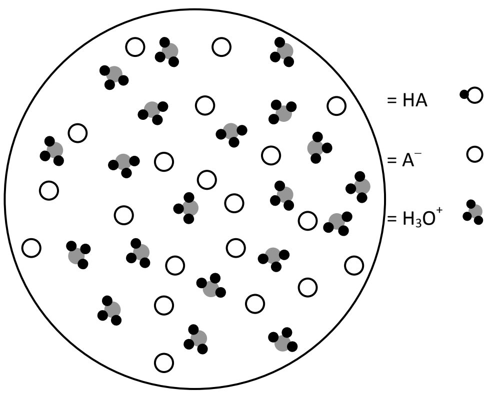
Go the http://phet.colorado.edu/en/simulation/acid-base-solutions for the simulation
Open the simulation on your computer. Use the 1st tab to explore how *strong* and *weak* acids **differ**.
List two ways below:

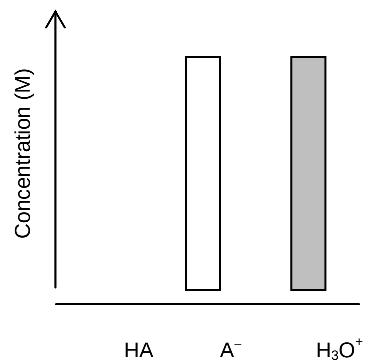
1. ____

2. ____

NOTE: In the representations below, HA denotes a generic acid, and the water molecules are not shown.

2a. This picture/graph depicts a **strong acid** solution.





How would the picture/graph change for a **weak acid** solution? *How would the pH change?*

____

2b. Draw picture/graph that depicts a **weak acid** solution.

Use the 1st tab of the computer simulation to check your understanding.

Part III: Concentration and Strength

How would the picture/graph change for a more *dilute* **strong acid** solution? *How would the pH change?*

____

3a. Draw picture/graph that depicts a more *dilute* **strong acid** solution.

How would the picture/graph change for a *stronger* **weak acid** solution? *How would the pH change?*

____

3b. Draw picture/graph that depicts a *stronger* **weak acid** solution.

Use the 2nd tab of the simulation to explore the concepts of *strength* and *concentration*. How do they compare?

____

How can a *weak acid* solution have the **same pH** as a *strong acid* solution?

____

Part IV: Reflection

Reflect on your initial ideas from Part I (True/False questions). Do you still agree with your responses? Why or why not? Make sure you can defend your reasoning. Look for examples within the recitation, or think of your own, to support your reasoning.

My response now: Always True Always False Sometimes True	**4a.** Strong acids completely dissociate in water.
My response now: Always True Always False Sometimes True	**4b.** Strong acids have lower pH's than weak acids.
My response now: Always True Always False Sometimes True	**4c.** A ten-fold *dilution* of a strong acidic solution will *decrease* the pH by 1.
My response now: Always True Always False Sometimes True	**4d.** A solution with $[H_3O^+]$ = 0.01 M contains a stronger acid than a solution with $[H_3O^+]$ = 0.001 M.
My response now: Always True Always False Sometimes True	**4e.** A solution whose pH is 2.00 contains a stronger acid than a solution whose pH is 3.00.

NAME______________________

Equilibrium: Weak and Strong Acids (KEY)

Part I: Your Initial Ideas

Answer the following True/False questions for yourself. Then check in with your group. You don't all have to agree—just get a sense of what others are thinking. You will re-evaluate your answers at the end of recitation, so it's okay to be unsure at this point.

My response: Always True Always False Sometimes True ***My group's response:*** Always True Always False Sometimes True	**1a.** Strong acids completely dissociate in water. True: it is a characteristic of strong acids
My response: Always True Always False Sometimes True ***My group's response:*** Always True Always False Sometimes True	**1b.** Strong acids have lower pH's than weak acids. Whether this statement is true or not depends on the concentrations of the strong and weak acid
My response: Always True Always False Sometimes True ***My group's response:*** Always True Always False Sometimes True	**1c.** A ten-fold *dilution* of a strong acidic solution will *decrease* the pH by 1. False: a ten-fold dilution will INCREASE the pH by 1
My response: Always True Always False Sometimes True ***My group's response:*** Always True Always False Sometimes True	**1d.** A solution with $[H_3O^+]$ = 0.01 M contains a stronger acid than a solution with $[H_3O^+]$ = 0.001 M. It can be true, but depending on the strength of the weak acid used and the concentrations of the starting acid, this statement can also be false.
My response: Always True Always False Sometimes True ***My group's response:*** Always True Always False Sometimes True	**1e.** A solution whose pH is 2.00 contains a stronger acid than a solution whose pH is 3.00. It can be true, but depending on the strength of the weak acid used and the concentrations of the starting acid, this statement can also be false.

Part II: Strong and Weak Acids

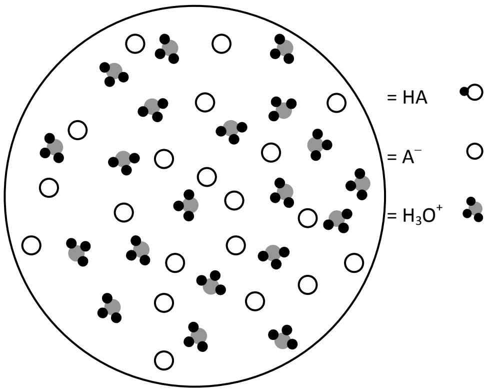
Go the http://phet.colorado.edu/en/simulation/acid-base-solutions for the simulation

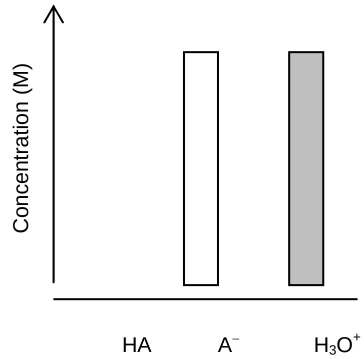
Open the simulation on your computer. Use the 1st tab to explore how *strong* and *weak* acids **differ**.
List two ways below:

1. _____The strong acids fully dissociates_______________________________________
2. _____There are still HA compounds left over with weak acids. ___________________

NOTE: In the representations below, HA denotes a generic acid, and the water molecules are not shown.

2a. This picture/graph depicts a **strong acid** solution.





How would the picture/graph change for a **weak acid** solution? *How would the pH change?*

_________There would still be a lot of HA compounds in the solution _______________________________

2b. Draw picture/graph that depicts a **weak acid** solution.

A picture drawn with A$^-$ ions and hydronium ions, but mostly HA compounds

A graph that shows that there are more HA compounds in the solution than A$^-$ ions and hydronium ions.

Use the 1st tab of the computer simulation to check your understanding.

Part III: Concentration and Strength

How would the picture/graph change for a more *dilute* **strong acid** solution? *How would the pH change?*

__There would be less ions visible, ion concentrations would be lower for a more dilute strong acid, lower pH____

3a. Draw picture/graph that depicts a more *dilute* **strong acid** solution.

A picture with less ions than the first drawing of a strong acid

A graph with a lower concentration of the ions than the previous graph for the strong acid.

How would the picture/graph change for a *stronger* **weak acid** solution? *How would the pH change?*

_______________More ions visible, higher ion concentrations, higher pH_______________________________________

3b. Draw picture/graph that depicts a ***stronger*** **weak acid** solution. A picture with more ions than the previous strong acid drawings A graph with higher concentrations of ions that the previous strong acid drawings

Use the 2nd tab of the simulation to explore the concepts of *strength* and *concentration*. How do they compare?

______Strength does not correlate with concentrations____

How can a *weak acid* solution have the **same pH** as a *strong acid* solution?

____A weak acid can have same pH as strong acid if it has a higher concentration than the strong acid and if the weak acid is a stronger weak acid____

Part IV: Reflection

Reflect on your initial ideas from Part I (True/False questions). Do you still agree with your responses? Why or why not? Make sure you can defend your reasoning. Look for examples within the recitation, or think of your own, to support your reasoning.

My response: Always True Always False Sometimes True	**4a.** Strong acids completely dissociate in water. True: it is a characteristic of strong acids
My response: Always True Always False Sometimes True	**4b.** Strong acids have lower pH's than weak acids. Whether this statement is true or not depends on the concentrations of the strong and weak acid
My response: Always True Always False Sometimes True	**4c.** A ten-fold *dilution* of a strong acidic solution will *decrease* the pH by 1. False: a ten-fold dilution will INCREASE the pH by 1
My response: Always True Always False Sometimes True	**4d.** A solution with $[H_3O^+]$ = 0.01 M contains a stronger acid than a solution with $[H_3O^+]$ = 0.001 M. It can be true, but depending on the strength of the weak acid used and the concentrations of the starting acid, this statement can also be false.
My response: Always True Always False Sometimes True	**4e.** A solution whose pH is 2.00 contains a stronger acid than a solution whose pH is 3.00. It can be true, but depending on the strength of the weak acid used and the concentrations of the starting acid, this statement can also be false.

Discussion Questions (KEY):

Hold this discussion after the students have gone through the simulation and explore strong and weak acids on their own.

- When you started the simulation with a strong acid, what did you notice about the HA compound?
    - There were no more HA compounds in the solution and there were only A^- ions and hydronium ions
- What does this tell you about the behavior of strong acids in water?
    - Strong Acids always dissociate fully in water
- How is this different than when you switched to the weak acid, and what does this tell you about the behavior of weak acids in water?
    - Weak acids don't dissociate fully in water. Along with the A^- ions and the hydronium ions, there were still HA compounds in the solution
- When you played with the simulation, did strong acids ALWAYS have a lower pH than weak acid?
    - NO
- How could you get a weak acid solution to have a higher pH than that of a strong acid solution?
    - Decrease the concentration of the strong acid, increase the concentration of the strong acid, and increase the strength of the weak acid.
- After playing with the different concentrations, how could you increase or decrease the pH levels by one?
    - Multiply or divide the starting solution by 10
- So If I were to double the molarity of a solution, how that change my pH by 1, more than one, or less than one?
    - It wouldn't change the pH by one, but it would change less than one; the concentration would need to change by a factor of ten to change the pH by one
- What did you notice about the questions 1d and 1e?
    - They end up with the same result!
- Both question 1d and 1e are the same question, but they are presented differently. This talks more about the pH scale which we will learn about later.

Quiz:

NAME________________________________

Acids and Bases Quiz #1

1. Place the words/properties in the Word Bank under the appropriate classification.

ACID	**BASE**

Word Bank:

Bitter H_2SO_4 Proton Acceptor HBr

Produce OH^- slippery NH_3 Sour

Proton Donor LiOH Produce H^+ Hydronium Ion

$Ba(OH)_2$ HF $HCOO^-$ HCl

2. Write the conjugate base for the following acids.
   a. $HClO_4$ ________________ c. NH_4^+ ________________
   b. $H_2PO_4^-$ ________________ d. H_2S ________________

3. Write the conjugate acid for the following bases.
   a. NO_3^- ________________ c. Cl^- ________________
   b. PO_4^{3-} ________________ d. NH_2^- ________________

4. What is the difference between a strong base and a weak base?

5. What is the Bronsted-Lowry definition of acids and bases? Why was the Arrhenius definition an incomplete definition?

NAME________________________________

Acids and Bases Quiz #1 (KEY, 20 points total)

1. Place the words/properties in the Word Bank under the appropriate classification.

ACID			BASE		
H_2SO_4	HBr	Proton Donor	Bitter	slippery	$HCOO^-$
HCl	HF	Sour	LiOH	$Ba(OH)_2$	NH_3
Produce H^+	Hydronium ion		Proton Acceptor	Produce OH^-	

Word Bank:

Bitter H_2SO_4 Proton Acceptor HBr
Produce OH^- slippery NH_3 Sour
Proton Donor LiOH Produce H^+ Hydronium Ion
$Ba(OH)_2$ HF $HCOO^-$ HCl

(Total 8 points) (½ point for each word/property places correctly)

2. Write the conjugate base for the following acids.

c. $HClO_4$ _____ClO_4^-_______ c. NH_4^+ ______NH_3______

d. $H_2PO_4^-$ _______HPO_4^{2-}___ d. H_2S ______HS^-_______

(Total 2 points) (½ point for correctly writing the conjugate base)

3. Write the conjugate acid for the following bases.

c. NO_3^- ______HNO_3______ c. Cl^- ______HCl_______

d. PO_4^{3-} _____HPO_4^{2-}________ d. NH_2^- ____NH_3______

(Total 2 points) (½ point for correctly writing the conjugate acid)

4. What is the difference between a strong base and a weak base? (4 points total)

   2 points for mentioning what a strong base does

   2 points for mentioning what a weak base does (only 1 points for mentioning that a weak base doesn't do the same thing as a strong base)

6. What is the Bronsted-Lowry definition of acids and bases? Why was the Arrhenius definition an incomplete definition?(4 points total)

   1 point: acid is proton donor 1 points: base is proton acceptor

   2 points: Arrhenius definition only allowed OH^- ions for bases

Exam:

NAME______________________

Acids and Bases Unit Exam

Multiple Choice

1. In a chemical reaction, ammonia (NH_3), was found to donate a hydrogen ion and turned into the amide (NH_2^-) ion. In this reaction, NH_3 is behaving as
   a. Arrhenius acid
   b. Bronsted-Lowry acid
   c. Arrhenius base
   d. Bronsted-Lowry base

2. What is the conjugate base for $H_2PO_4^-$?
   a. PO_4^{3-}
   b. H_3PO_4
   c. HPO_4^{2-}
   d. Conjugate bases don't exist for compounds with more than one hydrogen

3. Which of these statements is false?
   a. A weak base is a better conductor of electricity in water when compared to a strong base, given that the starting amounts of both are the same
   b. Pure water is a good conductor of electricity
   c. NaCl is an electrolyte that dissociates in water
   d. Both acids and bases can be used to make a solution that can conduct electricity

4. The pH of a solution where $[H^+]=2.39 \times 10^{-6}$ is
   a. 2.40
   b. 6.05
   c. 5.62
   d. 9.72

5. What is the concentration of hydroxide ions in a solution with a pH of 8.87?
   a. $[OH^-]= 8.63 \times 10^{-3}$
   b. $[OH^-]= 7.44 \times 10^{-6}$
   c. $[OH^-]= 9.35 \times 10^{-9}$
   d. $[OH^-]= 1.21 \times 10^{-11}$

6. Which of the following acids is not considered a strong acid?
    a. HBr
    b. HCl
    c. HI
    d. HF

7. Which of the following conditions indicate an acidic solution?
    a. pOH = 11.21
    b. pH = 9.42
    c. $[OH^-] > [H^+]$
    d. $[OH^-] > 1.0 \times 10^{-7}$ M

8. Which one of these properties does not correlate with a base?
    a. Proton acceptor
    b. Slippery
    c. Produces H^+ ions
    d. Bitter

9. Calculate the pH of a 0.000199 M $HClO_4$ solution
    a. pH = 2.40
    b. pH = 5.67
    c. pH = 3.70
    d. pH = 8.44

10. Which of the following statements is true concerning indicators?
    a. Using phenolphthalein indicator in an acidic solution will cause the solution will cause the solution to turn purple
    b. Red litmus paper turns blue under basic conditions
    c. Indicators only work if there is a high concentration of an acid or base present
    d. Indicators can tell us if a base is a strong base or a weak base

Short Answer

1. What does it mean to have a substance that is amphoteric?

2. A bottle of acid solution is label "3 M HNO_3." What are the substances that are actually present in the solution? Are any HNO_3 molecules present? Why or Why not?

3. James is doing a neutralization reaction in the chemistry lab. He was titrating acetic acid with barium hydroxide (the unbalanced chemical equation is shown below). He started with 4.73 grams of acetic acid. How many grams of barium hydroxide does he need to react with all of the acetic acid?

$$HC_2H_3O_2\ (aq) \quad + \quad Ba(OH)_2\ (aq) \quad \rightarrow \quad Ba(C_2H_3O_2)_2\ (aq) \quad + \quad H_2O$$

4. Is it possible for a solution to have $[H^+] = 0.0002$ M and $[OH^-] = 5.2 \times 10^{-6}$ M at 25 degrees Celsius? Explain why or why not. If not, then what is the correct $[H^+]$ if $[OH^-] = 5.2 \times 10^{-6}$ M?

5. In the following equation, identify the conjugate acid-base pairs

$$CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$$

6. What volume of 0.502 M NaOH solution would be required to neutralize 27.3 mL of 0.491 M HNO_3 solution?

NAME______________________

Acids and Bases Unit Exam (Key)

Multiple Choice

1. In a chemical reaction, ammonia (NH_3), was found to donate a hydrogen ion and turned into the amide (NH_2^-) ion. In this reaction, NH_3 is behaving as
    e. Arrhenius acid
    f. Bronsted-Lowry acid
    g. Arrhenius base
    h. Bronsted-Lowry base

2. What is the conjugate base for $H_2PO_4^-$?
    a. PO_4^{3-}
    b. H_3PO_4
    c. HPO_4^{2-}
    d. Conjugate bases don't exist for compounds with more than one hydrogen

3. Which of these statements is false?
    a. A weak base is a better conductor of electricity in water when compared to a strong base, given that the starting amounts of both are the same
    b. Pure water is a good conductor of electricity
    c. NaCl is an electrolyte that dissociates in water
    d. Both acids and bases can be used to make a solution that can conduct electricity

4. The pH of a solution where $[H^+]=2.39 \times 10^{-6}$ is
    a. 2.40
    b. 6.05
    c. 5.62
    d. 9.72

5. What is the concentration of hydroxide ions in a solution with a pH of 8.87?
    a. $[OH^-]= 8.63 \times 10^{-3}$
    b. $[OH^-]= 7.44 \times 10^{-6}$
    c. $[OH^-]= 9.35 \times 10^{-9}$
    d. $[OH^-]= 1.21 \times 10^{-11}$

6. Which of the following acids is not considered a strong acid?
   a. HBr
   b. HCl
   c. HI
   d. HF

7. Which of the following conditions indicate an acidic solution?
   a. pOH = 11.21
   b. pH = 9.42
   c. $[OH^-] > [H^+]$
   d. $[OH^-] > 1.0 \times 10^{-7}$ M

8. Which one of these properties does not correlate with a base?
   a. Proton acceptor
   b. Slippery
   c. Produces H^+ ions
   d. Bitter

9. Calculate the pH of a 0.000199 M $HClO_4$ solution
   a. pH = 2.40
   b. pH = 5.67
   c. pH = 3.70
   d. pH = 8.44

10. Which of the following statements is true concerning indicators?
    a. Using phenolphthalein indicator in an acidic solution will cause the solution will cause the solution to turn purple
    b. Red litmus paper turns blue under basic conditions
    c. Indicators only work if there is a high concentration of an acid or base present
    d. Indicators can tell us if a base is a strong base or a weak base

Short Answer

1. What does it mean to have a substance that is amphoteric?

Amphoteric substance: substance that can behave as either an acid or a base

2. A bottle of acid solution is label “3 M HNO_3.” What are the substances that are actually present in the solution? Are any HNO_3 molecules present? Why or Why not?

The bottle will contain hydronium ions (H_3O^+) and NO_3^- ions. Because HNO_3 is a strong acid, it completely ionizes in water, which means no HNO_3 molecules are present.

3. James is doing a neutralization reaction in the chemistry lab. He was titrating acetic acid with barium hydroxide (the unbalanced chemical equation is shown below). He started with 4.73 grams of acetic acid. How many grams of barium hydroxide does he need to react with all of the acetic acid?

$$HC_2H_3O_2\,(aq) \quad + \quad Ba(OH)_2\,(aq) \quad \rightarrow \quad Ba(C_2H_3O_2)_2\,(aq) \quad + \quad H_2O$$

6.75 g of barium hydroxide

4. Is it possible for a solution to have $[H^+] = 0.0002$ M and $[OH^-] = 5.2 \times 10^{-6}$ M at 25 degrees Celsius? Explain why or why not. If not, then what is the correct $[H^+]$ if $[OH^-] = 5.2 \times 10^{-6}$ M?

$[H^+] = 1.92 \times 10^{-9}$

5. In the following equation, identify the conjugate acid-base pairs

$$CH_3NH_2 \;+\; H_2O \;\rightleftharpoons\; CH_3NH_3^+ \;+\; OH^-$$

Acid: H_2O → Conjugate Base: OH^-
Base: CH_3NH_2 → Conjugate Acid: $CH_3NH_3^+$

6. What volume of 0.502 M NaOH solution would be required to neutralize 27.3 mL of 0.491 M HNO_3 solution?

26.6 mL of NaOH solution

Research Articles:

Furió-Más, C., Calatayud, M., &Bárcenas, S. L. (2007).Surveying Students' Conceptual and Procedural Knowledge of Acid-Base Behavior of Substances. *Journal Of Chemical Education*, *84*(10), 1717-1724.

This article examines how well students understand the fundamental knowledge of acids and bases after they have taken a general chemistry high school course. The students in the experiment were given questionnaires to fill out, along with semi-structure interviews that would further examine the students' understanding of the topic. The questions covered a range of topics, such as neutralization and conductivity, but they were generally questions that seemed to deal with the general knowledge of acid-base chemistry. The interviews were where the experimenters were able to further examine the answers that the students gave for the questionnaires to see what the students thought and why they thought that way. The results show that the majority of the students were unable to fully understand the concepts that were presented in the questions. Although many of the students were able to provide the correct yes/no answers for the questions, they struggled to correctly state why the answers were what they were. This was due to either an incomplete understanding of certain definitions, or because they were shown examples that they haven't seen before and they couldn't apply their procedural knowledge to take what they know and apply their knowledge to new situations and questions.

An Acids and Bases Unit may be confusing for many students because much of the information is likely to be foreign to them. In order to scaffold their learning of these concepts, it is important that teachers have a thorough understanding of the knowledge of chemistry so that they know what to teach and how to teach it. In this study, the students knew the basic definitions that helped them to an extent. The students struggled to grasp the underlying concepts for acids and bases. Because of this, teachers need to continually assess their students' knowledge of the subject matter to ensure that the students have the necessary prerequisite knowledge. Once they have the correct knowledge they need, teachers can continue by building on top of that knowledge to provide students with a deeper understanding of the concepts.

Reading this article also helped me to interpret what kinds of misconceptions students have or can acquire while learning the different topics in acid-base chemistry. Half of the students said that water was an ionic substance, even though it is a polar molecular substance. It seemed that a large portion of the students didn't know the difference between an atom and an ion, which I thought was troubling. One question that I thought was understandably hard dealt with why ionic compounds conduct electricity in water. I don't think students understand that electricity is basically the movement of electrons because it's a topic covered in physics, but I think it's important to cover in chemistry to help explain why having a higher concentration of ions increases the solution's conduction.

Boz, Y. (2009). Turkish Prospective Chemistry Teachers' Alternative Conceptions about Acids and Bases. *School Science & Mathematics*, *109*(4), 212-222.

This study was done to obtain prospective chemistry teachers' conception about acids and bases. Data was extracted from the 38 participants by asking the participants questions from a questionnaire along with an interview after the questionnaire was given. Many of the questions from the questionnaire were open ended to allow explanations for the prospective teachers' answers. Questions started at the macroscopic level, which involved questions about the properties of acids and bases. The other questions were about neutralization reactions and the strength of acids and bases.

The results of this article are very interesting and they show the misconceptions that many prospective teachers may have about acids and bases. Most of the teachers were able to understand the macroscopic principles of acids and bases, but when it came to neutralization reactions, many of the participants didn't understand what it entailed. Many participants thought the reaction always created a neutral solution, but I think they were misled by the name of the reaction. Many other prospective teachers were also unable to discern between strength and concentrations, but I think that may have been due to the way the questions was presented. It asked "Which acids below is the strongest one?" and showed three different concentrations of an HCl solution, which can be a misleading question. There was no choice for them to say that the acid's strength was the same for all of them, so many probably chose the choice with the highest concentration.

This article was enlightening for me personally, because I'm a prospective teacher and I know I have some misconceptions of chemistry too that may not have been addressed yet. Because many teachers continue to hold their misconceptions when they go to teach, many students hold these misconceptions when they continue onto higher education. In order to prevent this, I will need to make sure that I'm learning the right information before any of the students are, or else my misconceptions can carry on to my students.

Websites:

http://preparatorychemistry.com/Bishop_Neut_frames.htm

This is an interesting website that contains a slideshow with animations about the basics of acid-base chemistry. I think it can be a good tool to help students visualize what happens when a strong acid reacts with a strong acid. There aren't any animations that involve weak acids or weak bases, but I think that's fine since that's not the purpose of this slideshow. One part I liked about this slideshow was that it showed the hydronium ion When showing the net ionic equations for the main chemical reactions that take place in the slideshow, it continues to use the hydronium ion, and it even shows the formation of the hydronium ion.

Though this slideshow has a lot of strengths, I also think that there are a few problems with it as well. When I first tried to access this slideshow, I was required to download the shockwave plug-in, which may make this slideshow inaccessible for students in schools with computers that don't have the plug-in. They could download it, but I know not every school allows downloads on their computers. Another problem with this slideshow is that one of the animations wasn't very clear. The animation of the HNO_3 and the NaOH in solution was confusing because there was too much going on in the animation. Some of the important ions were there, but it was hard to see all of the reactions that occurred because the background water molecules were a large distractions.It was easier to understand after watching it a few times, but that animation should be revised to make it easier to understand.

http://www.visionlearning.com/library/module_viewer.php?mid=58

This website is a very simple site that introduces acids, bases, and the pH scale. I like that it shows the evolution of the definition of acids and bases by starting with the Arrhenius definition and continuing with the Bronsted-Lowry definition. The actual history of this evolution is discussed in this website. Students can benefit from this, because they can see why there was a need for the definition to be revised. There aren't many diagrams to aid students, but I think that since the basic terms are all present, it can still be a helpful tool. The history of an atom is often discussed, so I think it's important to also talk about the background of other scientific topics when possible. This website is also written by a professor from City University of New York, which helps assure that the information presented is accurate.

The pH scale at the bottom is a great addition to this page because it provides the pH levels of real-life examples that the students have most likely have seen at home or in nature. The website maintains the standard pH scale of less than 7 is acidic, and more than 7 is basic; the site even shows how to calculate pH which is a nice addition. I think this website can be improved by providing more examples of different acids, bases, and salts, but at least the proper definitions of these terms are all there. Overall, for an introductory website on acids, bases, and pH, I think this website does a nice job of talking about it along with its history in a succinct and easy to understand manner.

http://antoine.frostburg.edu/chem/senese/101/acidbase/indicators.shtml

This is a website that shows the different kinds of acid-base indicators that one can use. Although phenolphthalein is most commonly used in the classroom, I wanted to show that there were other different acid/base indicators that would be used for different purposes. For example, I could write different questions that required a solution of a certain pH and phenolphthalein couldn't be used to get to that pH range. The students would need to choose a different indicator to use for those situations. There is a demonstration that can be done using many different indicators, though that requires that the teacher has many of these indicators which can be costly. If that demonstration is shown, then this page can help explain and show what the pH levels of the solutions are.

At the top of the page, there is a link to frequently asked questions about indicators, and also a link to a page that explains why and how indicators work. I don't think that the students need to necessarily know why they work because it can be too complicated for them. I do like the frequently asked questions page, because they questions help clear up a few misconceptions about acid/base indicators. There are even examples of indicators that can be made at home, so if students want to experiment on their own, then they would have the freedom to do so.