Acids and Bases Lesson Plan

Jerel Ray Perez	**Anderson High School**	**Pre-AP Chemistry**	**90 minutes**
Objective **Student will formulate their own learning of acids and bases by completing a writing assignment tying previous knowledge of chemistry to new concepts given in note form.**			
Warm up **Students in this class will jump straight into this activity once they have completed a unit test on solutions.**		Materials Needed Teacher Copies of the notes and Response to Acids and Bases for student use	Students Pencils or pens, calculator, Periodic Table with Polyatomic Ions Chart

Explain/Input/Instruction				
Pacing	**Level of Thinking** (Bloom's Taxonomy)	**Description of Activity: Group collaboration on Acids and Bases notes. Objective: Students will work in small groups to analyze a set of notes on the topic. They will demonstrate their understanding of the material by completing a written assignment.**		**Probing Questions**
45 min.	Knowledge comprehension	Teacher says/does: Pass out notes on acids and bases to students along with the Response to Acids and Bases written assignment. Instruct students to work in small groups (no more than three) and complete the written assignment. The instructor should remain monitor groups by asking probing questions and check for understanding	Students say/do: Do: Discuss material within small groups in order to formulate an understanding of key concepts. Use writing skills to develop definitions of new vocabulary and illustrate knowledge by making connections between prior knowledge and new ideas. Do: Students may use laptops available in the classroom in order to view a PowerPoint and other resources for understanding the material.	1. What key component makes and acid an acid? 2. How does one interpret pH levels in common solutions? 3. How do hydrogen and hydroxide determine acids and bases? 4. What key concepts would arrive on a quiz or test?

§112.35. Chemistry (c) Knowledge and skills. (10) Science concepts. The student understands and can apply the factors that influence the behavior of solutions. (C) calculate the concentration of solutions in units of molarity define acids and bases and distinguish between Arrhenius and Bronsted-Lowry definitions and predict products in acid base reactions that form water; (H) understand and differentiate among acid-base reactions, precipitation reactions, and oxidation-reduction reactions; (I) define pH and use the hydrogen or hydroxide ion concentrations to calculate the pH of a solution; and (J) distinguish between degrees of dissociation for strong and weak acids and bases.	**Independent/Group Practice:** Practice questions on note sheet
EVALUATE/ASSESS/CHECK FOR UNDERSTANDING:	Students will complete the written assignment in class and complete a worksheet as homework.

Part 2

End of Part IExtend/Elaborate (Lab)				
Pacing	**Level of Thinking** (Bloom's Taxonomy)	**Description of Activity: Properties of common household solutions lab Objective: Students will learn to determine the uses and properties of household cleaning solutions.**		**Probing Questions**
45 min.	Application Knowledge comprehension	Teacher says/does: Do: Prepare materials for Do: Put students into small groups. Have them perform the procedure and clean up the lab station. Allow them a few minutes to answer the questions at the bottom of the sheet. Pick up the papers to grade or go over in class.	Students say/do: Do: Students will extend their knowledge on properties of acids and bases as well as identify common household uses for them. Students will test the pH levels of many household liquids in order to determine how they are used in everyday lives.	1. Will either acids or bases conduct an electrical current in solution? Why? 2. If 7 on a pH scale is neutral then where do acids and bases lie? 3. What are common properties of bases? Acids?

§112.35. Chemistry (c) Knowledge and skills. (b) Introduction. (1) Chemistry. In Chemistry, students conduct laboratory and field investigations, use scientific methods during investigations, and make informed decisions using critical thinking and scientific problem solving.	(c) Knowledge and skills. (1) Scientific processes. The student, for at least 40% of instructional time, conducts laboratory and field investigations using safe, environmentally appropriate, and ethical practices. The student is expected to: (A) demonstrate safe practices during laboratory and field investigations	(F) collect data and make measurements with accuracy and precision; (G) express and manipulate chemical quantities using scientific conventions and mathematical procedures, including dimensional analysis, scientific notation, and significant figures;
EVALUATE/ASSESS/CHECK FOR UNDERSTANDING: Probe for understanding; Students will submit a lab report from each group		

Closure	**Homework**
Students will demonstrate their understanding by completing a exit ticket prior to the end of class	Complete lab and written assignment if necessary.

End of Part 2

Name: **Period:**

Response to Acids and Bases

Expectations: Students are expected to formulate their own knowledge of acids and bases by reading the prescribed notes on the topic and working in small groups or independently in order to understand the material. Use the following guidelines to create your own learning of the subject matter.

Illustrate properties of acids and bases by creating a chart which ties a property to a common example that you would find in nature.

Refer to the polyatomic ion chart and periodic table of elements. Knowing what you know about naming acids, name six different acids and four different bases. Use both chemical formulas and written words for each species. (An example would be "HF, hydrosulfuric acid")

Discuss pH levels as it relates to acids and bases. Use complete sentences to dictate two things that you know and two things that you do not understand about this section. Note: any chemical with a [ ] symbol around it refers to the concentration, or molarity, of that chemical in a one liter solution.

Calculate the pH and the pOH of a solution where $[H^+] = 6.2 \times 10^{-7}$. Calculate $[OH^-]$ of the same solution. Remember that your notes state that the concentration of the hydroxide ions multiplied by the concentration of the hydrogen ions is equal to 1×10^{-14}.

What is the difference between strong and weak acids and bases?

Lewis, 1923: *An acid substance is one which can employ an electron lone pair from another molecule in completing the stable group of one of its own atoms.* Roughly, a Lewis acid can accept electrons while a Lewis base will give them away.

Johannes Nicolaus Brønsted and Thomas Martin Lowry, 1923: *An acid is a molecule or ion that is able to lose, or "donate," a hydrogen cation (proton, H^+), and a base is a species with the ability to gain, or "accept," a hydrogen cation.*

Each of the following unbalanced equations represents a reaction between a Bronsted - Lowery acid and base. Identify those in each reaction:

1. $CaCO_3 + HCl \rightarrow CaCl_2 + H_2CO_3$
2. $H_2S + NO_3^- \rightarrow S + NO$
3. $IO_3^- + H_2S \rightarrow I_2 + SO_3^{-2}$

Bronsted - Lowery Practice Problems:

1. (base) $CaCO_3$ + (acid) HCl
2. (acid) H_2S + (base) NO_3^+
3. (base) IO_3^- + (acid) H_2S

Each of the following unbalanced equations represents a reaction between a Lewis acid and base. Identify those in each reaction:

1. $Cl^- + Br_2 \rightarrow Cl_2 + Br^-$
2. $Mn + Co^{+2} \rightarrow Mn^{+2} + Co$
3. $Cl_2 + Sn^{+2} \rightarrow Cl^- + Sn^{+4}$

Lewis Practice Problems:

1. (base) Cl^- + (acid) Br_2
2. (base) Mn + (acid) Co^{+2}
3. (acid) Cl_2 + (base) Sn^{+2}

Stoichiometry

What volume of a 0.3 *M* solution of HCl is needed to neutralize 50 mL of a 0.12 *M* solution of LiOH?

Homework rubric

	More than a blank sheet, 50%	Apprentice, up to 70%	Novice, 80-89%	Exemplary, up to 100%	Score
Completion level	More than a blank sheet of paper is turned in	It looks like you made an attempt and ran out of time	Missing some steps and took shortcuts through the material	Understanding of conceptual knowledge is present	
Calculation accuracy	There are numbers written on the page	A little lost though relevant information is present	A few small mistakes, but set up correctly	All units, conversions and correct answers present	
Use of vocabulary words in phrasing and structure	Little to no effort was shown	A bit lacking in conceptual knowledge	Scientific thought is shown with few inconsistencies	Vocabulary identified and used to formulate personal thoughts	

Total	

Notes: Acids and Bases

Properties of Acids
Sour/Tart
Electrolytes
Change indicator color
React with metals to produce H_2

Properties of Bases
Bitter
Feel Slippery
Electrolytes
Change indicator color

Naming Acids

Anion ending	Acid
-ide	hydro___ic acid
-ate	-ic acid
-ite	-ous acid

Naming Bases

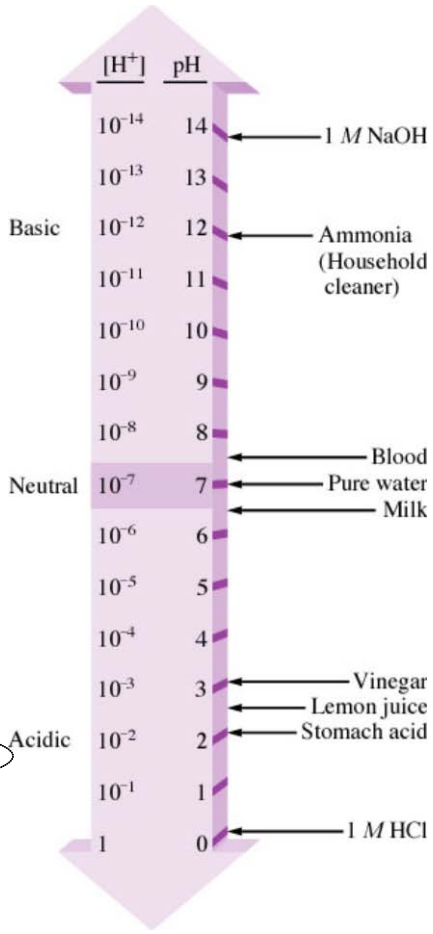
Easy! - Metal + Hydroxide

Calculating pH

$pH = - \log[H^+]$
$[H^+] = 10^{-pH}$
$[H^+] \times [OH^-] = 1 \times 10^{-14}\ M^2$

$pOH = - \log[OH^-]$
$[OH^-] = 10^{-pOH}$
$pH + pOH = 14$

significant figures in [concentration] = decimal places in pH



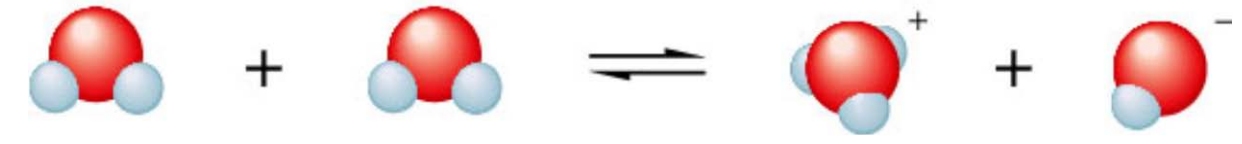
Classifying a solution as acid, base or neutral

Acids	**Bases**
Accept e⁻ (Lewis)	Donate e⁻ (Lewis)
Donate H^+ (B-L)	Accepts H^+ (B-L)

Acid
$pH < 7$
$[H^+] > 1 \times 10^{-7}$ M
$[OH^-] < 1 \times 10^{-7}$ M

Neutral
$pH = 7$
$[H^+] = [OH^-] = 1 \times 10^{-7}$ M

Base
$pH > 7$
$[H^+] < 1 \times 10^{-7}$ M
$[OH^-] > 1 \times 10^{-7}$ M



Water molecule *Water molecule* *Hydronium ion* *Hydroxide ion*

Strong acids dissociate/ionize completely in aqueous solution.

MEMORIZE these strong acids: HCl, HBr, HI, HNO_3, H_2SO_4, $HClO_4$

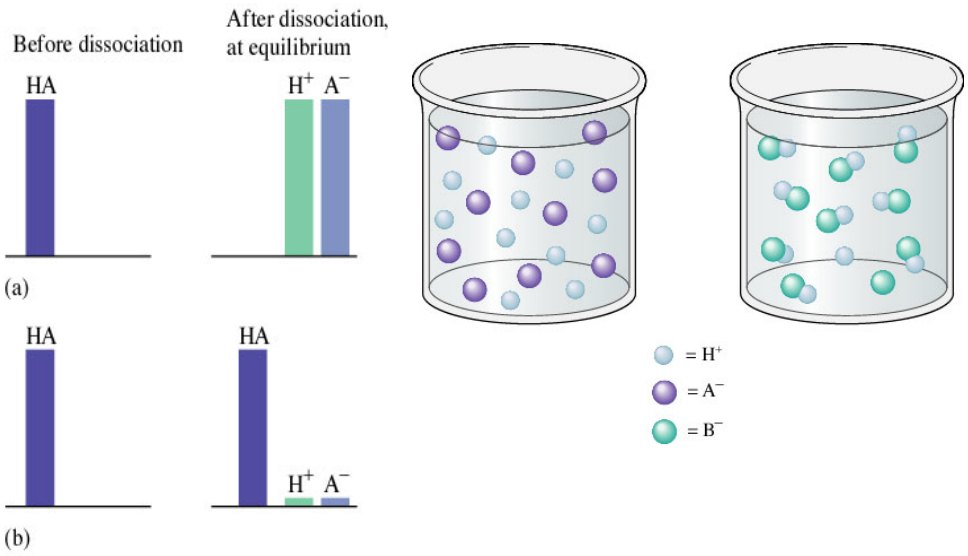
$$HNO_3(aq) \rightarrow H^+(aq) + NO_3^-(aq)$$

If you know the concentration of the acid, you know the concentration of the H^+ because one mole of acid produces one mole of H^+. Simply take the $-\log[H^+]$ to find pH.

Weak acids only partially dissociate/ionize in aqueous solution. Equilibrium is established between the ions and the undissociated acid molecule. Any acid that is not on the list of strong acids is considered weak. Some weak acids (called organic or carboxylic acids) have chemical formulas ending in –COOH. The hydrogen at the end of the molecule is the one that breaks off into hydrogen ion in solution.

$$HNO_2(aq) \qquad H+(aq) + NO_2^-(aq)$$

$$HCOOH(aq) \qquad HCOO^-(aq) + H^+(aq)$$



We can compare the RELATIVE strengths of weak acids using a constant called the acid dissociation constant (K_a). The larger the value of K_a, the more the acid dissociates in solution, therefore the stronger the acid. We won't be calculating the pH of weak acid solutions.

Table 14.2 Values of K_a for Some Common Monoprotic Acids

Formula	*Name*	*Value of K_a**
HSO_4^-	Hydrogen sulfate ion	1.2×10^{-2}
$HClO_2$	Chlorous acid	1.2×10^{-2}
$HC_2H_2ClO_2$	Monochloracetic acid	1.35×10^{-3}
HF	Hydrofluoric acid	7.2×10^{-4}
HNO_2	Nitrous acid	4.0×10^{-4}
$HC_2H_3O_2$	Acetic acid	1.8×10^{-5}
$[Al(H_2O)_6]^{3+}$	Hydrated aluminum(III) ion	1.4×10^{-5}
HOCl	Hypochlorous acid	3.5×10^{-8}
HCN	Hydrocyanic acid	6.2×10^{-10}
NH_4^+	Ammonium ion	5.6×10^{-10}
HOC_6H_5	Phenol	1.6×10^{-10}

Increasing acid strength

*The units of K_a are customarily omitted.

Strong bases also dissociate/ionize completely in aqueous solution. Group IA and IIA metals with hydroxide ion are the strong bases.

$$NaOH(aq) \rightarrow Na^{+}(aq) + OH^{-}(aq)$$

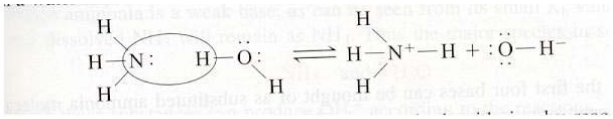
Be careful calculating the pH of bases in general and Group IIA bases in particular.

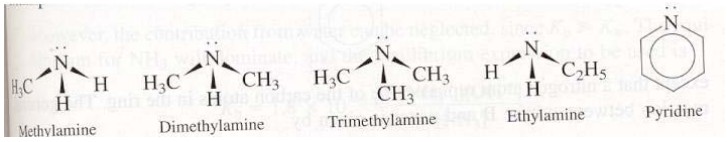
$$Ca(OH)_2(aq) \rightarrow Ca^{2+}(aq) + 2OH^{-}(aq)$$

Notice that there are 2 moles of hydroxide ion for every one mole of calcium hydroxide. Therefore, if you are told that the calcium hydroxide concentration is 0.035 M, the [OH-] is actually 2 x .035 or .070 M.

> To find the pH you would first find pOH = –log[.070] = 1.15 and then subtract from 14 to get pH = 14 – 1.15 = 12.85

Weak bases only partially dissociate/ionize in solution. Any metal other than group IA or IIA with hydroxide is considered a weak base. Also, there are some bases that don't contain hydroxide in the chemical formula at all. These bases contain nitrogen. The nitrogen interacts with the water in the solution and strips off a hydrogen ion, creating excess hydroxide ion in the solution. This is an example of the Bronsted-Lowry definition of acids and bases.





ARRHENIUS DEFINITION
acid--donates a proton (H^{+}) in water
base--donates an hydroxide ion in water (OH-)

BRONSTED-LOWRY DEFINITION
acid--donates a proton in water
base--accepts a proton in water

When using the Bronsted-Lowry definition we often recognize conjugate acid-base pairs in the equilibrium solution. Conjugate acid-base pairs are on opposite sides of the equilibrium arrow and are related to one another by the gain/loss of one hydrogen ion (proton).

acids--donate H^+ can be neutral compound, cation, or anion

$HNO_3 + H_20 \leftrightarrow H_3O^+ + NO_3-$ neutral compound.
acid base CA CB

$NH_4^+ + H_2O \leftrightarrow H_3O^+ + NH_3$ cation
acid base CA CB

$H_2PO_4- + H_20 \leftrightarrow H_3O^+ + HPO_4^{-2}$ anion
acid base CA CB

bases--accept H^+ can be neutral compound, cation, or anion

$NH_3 + H_2O \leftrightarrow NH_4^+ + OH-$ neutral compound
base acid CA CB

$CO_3^{-2} + H_2O \leftrightarrow HCO_3- + OH-$ anion
base acid CA CB

$PO_4^{-3} + H_2O \leftrightarrow HPO_4^{-2} + OH-$ anion
base acid CA CB

A reaction between an acid and a base is called neutralization. It is a special category of double replacement reaction and it always produces a salt (ionic compound) and water.

$2H_3PO_4(aq) + 3Sr(OH)_2(aq) \rightarrow$		$Sr_3(PO_4)_2(aq) +$	$6H_2O(l)$
ACID	BASE	SALT	WATER

STRONG ACID + STRONG BASE = NEUTRAL SALT
STRONG ACID + WEAK BASE = ACIDIC SALT
WEAK ACID + STRONG BASE = BASIC SALT

The laboratory technique used to find the concentration of an unknown acid or base through a neutralization reaction is called titration. We learned the calculations when we were working on reaction stoichiometry.

In reaction stoichiometry, we use Molarity as one of the routes to get to moles. If you know volume and Molarity, you can always find moles. ALWAYS REMEMBER AND NEVER EVER FORGET…

. . . Volume (in liters) x Concentration (Molarity) = moles

Example What volume of a 0.100 M HCl solution is needed to neutralize 25.0 mL of 0.350 M NaOH?

Properties of Common Household Liquids

You will be given nine different liquids on which to conduct four different tests. Each liquid has its own properties, some of which will be similar. Your job is to look at the data you collect and try to find similarities and differences between the liquids with the intent of explaining what you see.

1. Each group has a micro-well plate with twelve micro-wells, 9 test liquids, litmus paper, indicator paper, cabbage juice, 3 clip leads, LED, and 12V battery.
2. You will put 4-5 drops of each of the 9 test liquids in a separate micro-well.
3. Use a 2 centimeter strip of litmus paper and dip it into the test liquid, record the results. Repeat for each test liquid.
4. Use a 2 centimeter strip of universal indicator paper and dip into the test liquid, record the results (color and number). Repeat for each test liquid.
5. Connect the battery to the light bulb and two copper "probes" using the clip leads. Insert both "probes" into the test liquid and record the results. Repeat for each test liquid cleaning the "probes" each time.
6. Add 2-3 drops of cabbage juice to the test liquid, record the results. Repeat for each test liquid.

Analysis Questions:

1. Group the liquids in 2-4 categories based on the observations you collected during the investigation.

2. List two possible reasons for the liquids to behave similarly.

3. In one of the empty wells, add 2-3 drops of vinegar. Add 2-3 drops of cabbage juice. Finally, add 2-3 drops of Windex. Record the results. Check the end product with indicator paper and record. What happened?

4. Identify which of the following characteristics relate to acids and which relate to bases:

Characteristic	Relates to Acid or Base
Taste sour	
Release hydroxide ions (OH^-) when dissolved in water	
Feel slippery	
Release hydrogen ions (H^+) when dissolved in water	
Turn pink in the presence of phenolphthalein	
Taste bitter	
React with metal to produce hydrogen gas	
Turn cabbage juice indicator green	

5. Use Arrhenius' definition of an acid to help you write a chemical equation that shows the acidic nature of the following:

a) sulfuric acid (H_2SO_4)

6. Distilled water should have a neutral pH of 7, but water often has a pH less than 7. Suggest a reason for this lowering of the pH.

7. You may have heard the term "pH balanced" used to describe a shampoo or a deodorant. What does this term mean? What do you think the pH of most soaps and shampoos is? Do you think it is important for them to be pH balanced? Why or why not?

	Universal Indicator	Cabbage Juice	Light Bulb (bright or dim)	pH Paper	pH (number)	Acid or Base
Water						
Vinegar						
Windex						
Baking Soda						
Lemon Juice						
Soda						
Milk						
Sodium Hydroxide						
Dawn						

For You To Read

ACIDS AND BASES

Arrhenius' Definition of Acids and Bases

Acids and bases were first classified according to their characteristic properties. As you've experienced, acids and bases have different, distinct interactions with indicators (substances that change color with changes in the acidic or basic nature of another material). Some acids react with metals, while bases do not. Bases have a characteristic bitter taste and slippery feel, while acids have a characteristic sour taste. In fact, the term, acid, comes from the Latin word, acidus, which means sour. Acids and bases are also good conductors of electricity.

In the 19th century a chemist named Svante Arrhenius attributed the characteristic properties of acids to their ability to produce hydrogen ions when dissolved in water. If you look at the formulas for many common acids (HCL, H_2SO_4, H_2CO_3), you'll notice that they all have H as a common element. When these acids are added to water, a hydrogen atom can be drawn off into the water solution. The hydrogen atom leaves an electron behind, forming a positive hydrogen ion (H^+) and a negative ion. Consider the action of hydrochloric acid in solution:

$$HCL + H_2O \rightarrow H^+ + Cl^-$$

Acids: A glass of water with lots of H^+ and not much OH^- is acidic. A strong acid, like H_2SO_4(battery acid) badly wants to break up into H^+ and $SO4^-$, and give away its H^+. Hydrochloric acid, HCl , is another strong acid. So water that contains HCL is acidic. Very acidic water and strong acids like HCl are highly reactive and can be dangerous. But, believe it or not, your stomach contains HCl and can be very, very acidic. You need the HCl in your stomach to help you digest your food.

Acids in the Kitchen: weak acids can add a nice tart flavor to food, and can help clean up messes. One acid that you can probably find in your kitchen is called acetic acid, or vinegar.

Arrhenius also addressed bases and their characteristic properties. He defined a base as a substance that produces hydroxide ions (OH^-) when dissolved in water.

Lets look at a base using Arrhenius' definition. When solid sodium hydroxide is dissolved in water, both sodium and hydroxide ions are produced, as shown in the chemical equation below:

$$NaOH + H_2O \rightarrow Na^+ + OH^-$$

Bases: A solution with lots of OH^- and not much H^+ is basic. A strong base, like NaOH badly wants to break up into Na^+ and OH^- and give away its OH^-. Very basic water and strong bases are highly reactive. For a long, long time people have used a chemical reaction between NaOH and animal fat to make soap. Nearly 5000 years ago, in some of the human races first chemical reactions, people in Babylon made soap with that kind of

chemical reaction. The ancient Egyptians also used NaOH to make soap, but the ancient Greeks did not seem to know how to run the chemical reaction and so did not have any soap. More recently NaOH is used to clean out clogged drains.

Bases in the Kitchen: a weaker base, that you use in your kitchen for cooking and cleaning and making those little bubbles you see when you cook pancakes is baking soda.

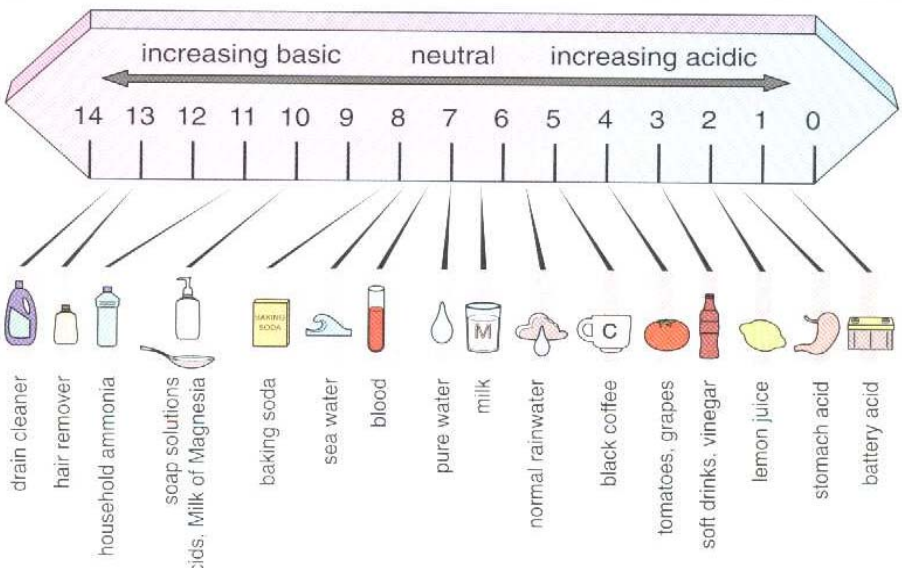
Making Acids and Bases Disappear: If you add acid and base together, ZAP!, they both disappear. Acid plus base gives water because H^+ plus OH^- equals H_2O. So you can *neutralize* acid with base and you can *neutralize* base with acid. That is why a base is sometimes called an antacid (anti-acid). Your small intestine gives off $NaHCO_3$ to neutralize the HCl from your stomach.

Acid/Base Indicators: If you put an acid/base indicator in water, the water can have a very beautiful color, but the water is one color when you add acid and a different color when you add base. So, you can use the color of an acid/base indicator to indicate if the water is acidic or basic. You can get a useful acid/base indicator from red cabbage. If you cut up the cabbage and boil it, the acid/base indicator conveniently goes into the water. Just pour the juice into the jar and you have a large supply of acid/base indicator.

Over time, scientists have extended their definition of acids and bases beyond Arrhenius' definition to be more inclusive. You will learn about the contributions of scientists like Johannes Bronsted of Denmark, Lowry of England, and Gilbert Lewis of the United States in further chemistry courses.

The pH Scale

In this activity you observed that one way of describing acids and bases is by examining their effects on indicators. Scientists also use the pH scale to express how acidic or basic a solution is. This number scale ranges from 0 – 14. Acid solutions have a pH less than 7. The more acid a solution is, the lower the pH. Base solutions have a pH greater than 7. The more basic a solution is, the higher the pH. Neutral solutions have a pH of 7. The pH of a substance can be measured using methods like the pH meter or probe, pH paper, or universal indicator solution



Worksheet: pH and pOH

1. If the hydrogen ion concentration of a solution is 1.30×10^{-4} M
   a. What is the pH of the solution?

   b. What is the pOH of the same solution?

   c. What is the hydroxide ion concentration of the solution?

2. If the hydroxide ion concentration of a solution is 2.8×10^{-6} M
   a. Is it an acidic or basic solution?

   b. What is the pH of this solution?

   c. What is the hydrogen ion concentration of this solution?

   d. What is the pOH of this solution?

3. If the pH of a solution is 4.67
   a. What is the hydroxide ion concentration?

   b. What is the pOH?

   c. What is the hydrogen ion concentration?

   d. Is the solution acidic or basic?

4. If the pOH of a solution is 3.6
   a. What is the pH?

   b. What is the hydrogen ion concentration?

   c. What is the hydroxide ion concentration?

   d. Does this solution have a higher hydrogen or hydroxide ion concentration?

5. If the pH of a solution is 12.5
   a. What is the hydroxide ion concentration?

   b. What is the hydrogen ion concentration?

   c. What is the pOH?

6. Which would have a higher pH, a solution whose pOH is 5.42 or a solution whose hydrogen ion concentration is 9.44×10^{-8} M?

7. Which would have a more basic pH, a solution whose hydrogen ion concentration is 3.4×10^{-8} M or a solution whose hydroxide ion concentration is 2.6×10^{-5} M?

8. Find the pH of each of the following strong acids or bases:
   a. 0.80 M hydrobromic acid
   b. 0.066 M barium hydroxide
   c. 0.33 M lithium hydroxide
   d. 0.0225 M hydroiodic acid
   e. 0.35 M sodium hydroxide

9. If the pH of a potassium hydroxide solution is 9.6, what is the hydroxide ion concentration?

10. If the pH of a hydrochloric acid solution is 1.3, what is the hydrogen ion concentration?

WORKSHEET: Strong vs. Weak

Directions: Show work on a separate sheet of paper.

1. Write the equation for the dissociation of each of these acids in water (include water as a reactant).
    a. $HClO_4$
    b. HNO_2
    c. CH_3CH_2COOH
    d. HBr

2. Identify the conjugate acid/base pairs for each of the equations in question #1.

3. Write the equation for the dissociation of each of these bases in aqueous solution (include water as a reactant where necessary).
    a. LiOH
    b. NH_3
    c. $Al(OH)_3$
    d. $Ca(OH)_2$

4. Identify the conjugate acid/base pairs in #3b only.

5. Use Table 14.2 in your notes to rank these acids from weakest to strongest:
    HF, HCN, $HClO_2$, $HC_2H_3O_2$

6. State the difference between the Bronsted-Lowry and Arrhenius definitions of acids and bases.

7. Write the balanced chemical equation for the following neutralization reactions.
    a. Lithium hydroxide + Acetic acid
    b. Sulfurous acid + Calcium hydroxide
    c. Perchloric acid + Potassium hydroxide
    d. Iron(III) hydroxide + sulfuric acid
    e. Copper(II) hydroxide + hydrochloric acid
    f. Nitric acid + Aluminum hydroxide

8. Name each of the salts formed as a product of the reactions in #7.

9. Classify each of the salts in #7 as acidic, basic, or neutral.

Name: Period: Date:

QUIZ: pH

Use proper significant figures and units.

Calculate the pH of each solution. **Classify each solution as acidic, basic or neutral**

1. $[H^+] = 1 \times 10^{-12}$ M pH = _____ 1. _____
2. $[H^+] = 3.9 \times 10^{-5}$ M pH = _____ 2. _____
3. $[OH^-] = 2.2 \times 10^{-8}$ M pH = _____ 3. _____
4. pOH = 9.99 pH = _____ 4. _____
5. pOH = 4.24 pH = _____ 5. _____

6. What is the pOH of a solution with $[OH^-] = 7.3 \times 10^{-3}$ M?
7. What is the $[H^+]$ concentration when the pH = 4.14?
8. What is the $[H^+]$ concentration when the pH = 11.28?

Name: Period: Date:

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Exit Ticket Name

Define an acid:

_____
_____

Define a base:

_____
_____

What is the purpose of adding a base to a lake that has a pH of 4?

_____
_____