Accel. Unit 11- Acids and Bases Name: _____Period: _____

Unit 11 Test Date: _____

Additional Resources Available at:

- **www.blendedaccelchem.weebly.com OR www.accelwarriorchem.weebly.com**

Two Rivers that Refuse to Mix Name: _____Period: _____

Look at the following video clips then read the article posted on the class website to answer the questions.
https://www.youtube.com/watch?v=AQ16NM60FsM https://www.youtube.com/watch?v=236fT4604Qk

Directions: As you read, complete the chart below comparing the two rivers in Brazil.

Property or characteristic	**Rio Negro**	**Amazon**	**Reason for the difference** (if stated in the article)
Color			
Flow rate			
Temperature			
pH			
Density			
Fish			
Animals along the banks			

Two Rivers that Refuse to Mix
POST READING QUESTIONS

1. Why is the Rio Negro water dark?

2. What acid is produced by decaying organic matter along the Rio Negro?

3. Does the Rio Negro's pH of 3.5 make it acidic or basic?

4. Compare the acidity of water from the Rio Negro to water in
   a. A healthy lake.

   b. An acidic lake.

5. Name four ways the Rio Negro's chemistry affects plants, animals and people.

6. Name four differences between the two rivers that explain why their waters don't easily mix.

7. Besides reducing the variety and number of species of plants and animals living in the Rio Negro, what <u>four</u> other effects are produced by the decaying plant material?

Guided Notes: Properties of Acids and Bases

Properties of Acids:

- _____
- _____
- _____
- _____
- _____
- _____

Properties of Bases:

- _____
- _____
- _____
- _____
- _____
- _____

Acid Base Solutions:

_____: (solutions with H_2O) all contain H^+ (_____ions) and OH^- (_____ions)

acidic solutions: contain more _____

basic solutions: contain more _____

neutral solutions: contain _____ (water; pH = ____)

The Proton H^+

- an H^+ is just a _____
- _____exist in solution by itself
- will joint with a water molecule to become _____
- _____ is called the hydronium ion
- _____ and _____ can be used interchangeably in chemical reactions

Arrhenius Acids and Bases

_____: contains hydrogen, ionizes to form a hydrogen ion solution

ex: _____

_____: contains hydroxide, ionizes to form a hydroxide ion solution

ex: _____

--- Works for _____ acids and bases but not all the time.

Bronsted Lowry Acids and Bases:

-- more _____ model

Bronsted - Lowry Acid: _____

Bronsted - Lowry Base: _____

Using HX as a general formula for an acid

HX(aq) + H2O(l) <--> H3O+(aq) + X- (aq)

Bronsted-Lowry Acid:

Bronsted Lowry Base:

Conjugate Acids and Bases:

•*Both the forward and the reverse reactions are acid-base reactions*

_____: substance produced when a base accepts a proton (H_3O^+)

_____: substance produced when an acid donates a hydrogen ion (X^-)

$$HX(aq) + H_2O(l) \ \text{<--->} \ H_3O^+(aq) + X^- (aq)$$

_____: substances related to each other by donating and accepting a single hydrogen ion

$$\mathbf{NH_3(aq) + H_2O(l) \ \text{<--->} \ NH_4^+(aq) + OH^- (aq)}$$

What are the conjugate acid/base pairs?

Does NH_3 fit the Arrhenius model of a base?

Is water an acid or a base?

_____: substances that can act as both an acid and a base. ex: _____

Practice: Identify the acid-base pairs in the following reactions.

1. $HBr(aq) + H_2O(l) \ \text{<--->} \ H_3O^+(aq) + Br^- (aq)$

2. $CO_3^{2-}(aq) + H_2O(l) \ \text{<--->} \ HCO_3^-(aq) + OH^- (aq)$

Monoprotic and Polyprotic Acids:

For a hydrogen ion to be _____, it must be bonded to a highly _____element. (F, Cl, Br, I, O, N, S)

_____: a substance that can only donate 1 hydrogen ion per molecule

ex: HBr, HCl, HI, CH_3COOH

_____: a substance can donate more than 1 hydrogen ion per molecule

ex: H_3PO_4 adn H_2SO_4

-- will ionize in steps, not all at once

Check for Understanding:

1. Identify the conjugate acid-base pairs in the reactions below.
2. Determine if the Bronsted acid is monoprotic or polyprotic, and binary or tertary.

$$HSO_4^- (aq) + H_2O (l) \ \text{<--->} \ H_3O^+ (aq) + SO_4^{2-}$$

Acid-Base Properties Worksheet

1. Compare the properties of acidic solutions and basic solutions.

Acids:	Bases:

2. How do the concentrations of hydrogen ion and hydroxide ion determine whether a solution is acidic, basic, or neutral?

3. Write the formula and name for how a hydrogen ion is sometimes written in solution. Why do we use this instead of H^+?

4. Based on their formulas, which of the following compounds *may* be Arrhenius acids: CH_4, SO_2, H_2S, $Ca_3(PO_4)_2$? Explain your reasoning.

5. Classify the following as an Arrhenius acid or an Arrhenius base:
   a. H_2S _____
   b. RbOH _____
   c. $Mg(OH)_2$ _____
   d. H_3PO_4 _____
   e. CH_3COOH _____

6. Identify the following as monoprotic or polyprotic and binary or ternary
   a. HCl _____ _____
   b. H_2S _____ _____
   c. H_3PO_4 _____ _____
   d. HNO_3 _____ _____
   e. CH_3CH_2COOH _____ _____

7. Identify the conjugate acid-base pairs in the following reactions. You may use BA, BB, ca and cb.
   a. $NH_4^+ (aq) + OH^- (aq) \leftrightarrow NH_3 (aq) + H_2O (l)$
   b. $HBr (aq) + H_2O (l) \leftrightarrow H_3O^+ (aq) + Br^- (aq)$
   c. $CO_3^{2-} (aq) + H_2O (l) \leftrightarrow HCO_3^- (aq) + OH^- (aq)$
   d. $HSO_4^- (aq) + H_2O (l) \leftrightarrow H_3O^+ (aq) + SO_4^{2-} (aq)$
   e. $HNO_2 (aq) + H_2O (l) \leftrightarrow NO_2^- (aq) + H_3O^+ (aq)$
   f. $H_2PO_4^- (aq) + OH^- (aq) \leftrightarrow H_2O (l) + HPO_4^{2-} (aq)$
   g. $H_3O^+ (aq) + Cl^- (aq) \leftrightarrow HCl (aq) + H_2O (l)$
   h. $HNO_3 (aq) + OH^- (aq) \leftrightarrow NO_3^- (aq) + H_2O (l)$
   i. $OH^- (aq) + CH_3COOH (aq) \leftrightarrow H_2O (l) + CH_3COO^- (aq)$
   j. $C_2O_4^{2-} (aq) + HI (aq) \leftrightarrow HC_2O_4^- (aq) + I^- (aq)$

8. Define the following vocabulary words:
   a. Bronsted acid:
   b. Bronsted base:
   c. Conjugate acid:
   d. Conjugate base:
   e. Conjugate acid-base pairs:
   f. Hydronium ion:

Guided Notes: pH and pOH

K_w: _____

- H_2O breaks down to give _____ and _____
  - _____
- K_w = _____
- K_w = _____ = _____
- So, $[H^+]$ and $[OH^-]$ have an _____ relationship

Practice: What is the $[OH^-]$ when $[H^+] = 1.0 \times 10^{-6}$?

pH:

- pH = _____
- acids have a _____
- bases have a _____
- neutral has a _____
- Increases by a factor of _____ between numbers on the pH scale
  - pH of 3 has ten times the [H+] of pH 4

pOH:

- **pOH = -log[OH^-]**
- acids have a _____
- bases have a _____
- neutral has a _____
- increases by a factor of _____ between numbers on the pOH scale
  - pOH of 3 has ten times the $[OH^-]$ of pOH 4

pH and pOH:

_____

pH Practice:

Calculate the pH of solutions having the following ion concentrations at 298K.

$[H+] = 1.0 \times 10^{-2}$ M

$[OH-] = 8.6 \times 10^{-6}$ M

Which of the solutions is more acidic?

pOH Practice:

What is the pOH of a solution with a $[OH^-] = 3.75 \times 10^{-6}$ M?

What is the pH of a solution with a pOH of 12.5?

Which of the solutions is more basic?

Finding Ion Concentration:

$[H+]$ = _____

$[OH^-]$ = _____

Practice:

Calculate the $[H^+]$ and the $[OH^-]$ in a solution with a pH of 2.37.

Calculate the $[H^+]$ of a solution with a pOH of 8.5.

Strength of Acids and Bases:

- _____: refer to the # of moles of acid or base dissolved in a volume of solution
- _____: refers to degree of ion formation
- _____ acids and bases _____ ionize (also called strong electrolytes)
  - ex: HCl --> H+ + Cl-
- _____ acids and bases have _____ ionization (establish equilibrium)
  - ex: $HC_2H_3O_2$ <--> $H^+ + C_2H_3O_2^-$

Strong Acids: HCl, HI, HBr, HNO_3, H_2SO_4, $HClO_4$
Strong Bases: LiOH, NaOH, KOH, RbOH, $Ca(OH)_2$, Sr(OH)2, $Ba(OH)_2$
Any acids or bases not on this list are weak!

K_a: _____

- = the value of the equilibrium constant expression for the _____ of a _____ acid
- _____ acids have the _____ K_a value

K_b: _____

- = the value of the equilibrium constant expression for the _____ of a _____ base
- _____ bases have the _____ K_b value

Calculating the pH and pOH of Strong Acids and Bases

- For all strong _____, the concentration of the acid is the concentration of the _____.
- For all strong _____, the concentration of the base is the concentration of the _____.

Practice Calculating pH and pOH: Calculate the pH and pOH of the following solutions.

0.10 M HI

2.4×10^{-5} M KOH

Measuring pH:

- _____: will change the color depending on the hydrogen ion concentration in solution, the color is then compared to a standard scale
- _____: more accurate than pH paper, contains electrode that are immersed in solution, will give a digital readout

Check for Understanding:

1. Calculate the pH and pOH of a solution that contains:
   a. $[H^+] = 3.0 \times 10^{-8}$ M

   b. 0.050 M HNO_3

   c. $[H^+] = 9.8 \times 10^{-2}$ M

2. What is the $[H^+]$ in a solution that has a pH of 4.75? $[OH^-]$?

pH and pOH Practice

Show formula, setup and answer with units if appropriate.

1. Determine the pH of the following acid solutions:

a. 0.033M HNO_3

c. 0.017M HI

b. 0.0045M HCl

d. 0.537M HBr

2. What is the pH of a solution if its $[H^+]$ is:

a. $4.2x10^{-2}$M

b. $2.6x10^{-11}$M

3. Calculate the $[OH^-]$ for the following acids:

a. 0.022M HCl

b. 0.05M HNO_3

4. Determine the pH if the $[OH^-]$ is:

a. $2.0x10^{-5}$ M

b. $4.5x10^{-11}$ M

c. 0.047M NaOH

d. 0.362M KOH

8. Identify each as an acid, base, conjugate acid and conjugate base. You may use BA, BB, ca, cb.

a. $HC_2H_3O_2 + H_2O \leftrightarrow H_3O^+ + C_2H_3O_2^-$

b. $H_2O + C_2H_3O_2^- \leftrightarrow HC_2H_3O_2 + OH^-$

9. Classify each of these as an Arrhenius acid or base:

a. $Ca(OH)_2$ _____ b. HNO_3 _____

c. KOH _____ d. C_2H_5COOH _____

10. What is true about the relative concentrations of hydrogen ions [H+] & hydroxide ions [OH-] in each of these solutions:

a.Basic_____b.Acidic_____c.Neutral _____

Guided Notes: Neutralization Reactions and Titration

Neutralization Reactions:

HCl + NaOH →

- The general formula for a neutralization: _____
- Acids and bases are _____ each other
  - acids _____, bases _____
- When they combine they _____ each other – neither _____ nor _____ anymore

Practice: Neutralization Reactions

1. Complete and balance the neutralization reaction below, label the acid and the base in each reaction:
   a. $H_2SO_4 + NaOH \rightarrow$

   b. $HCl + Ca(OH)_2 \rightarrow$

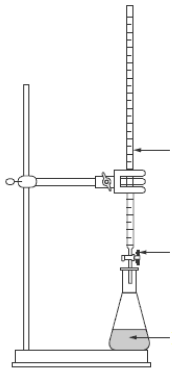
   c. $H_2SO_3 + NH_4OH \rightarrow$

Titrations:

Definition: adding a _____ amount of solution of _____ to a solution with a _____.

GOAL : _____

Titration set-up: Label the parts the arrows are pointing to:



Equivalence Point:

_____: the point of neutralization in a titration

_____: the point where the moles of H^+ and OH^- are equal – usually close to the endpoint (not always at pH = 7)

- _____acid and _____ base, pH around ____
- _____acid and _____ base, pH _____
- _____acid and _____ base, pH _____

How do we know we reached the endpoint?

a. _____

b. _____

Sketch a graph and label the equivalence point:

Titration Calculations:

After we do the experiment, how do we determine the concentration of the known??? _____

Steps:

1. Write and balance the equation.
2. List what you know (vol of acid, vol of base, conc of standard, mole ratio)
3. Begin with the volume (L) of the standard solution
4. Set up dimensional analysis to determine the number of moles of the unknown (Use the known molarity and the mole to mole ratio as conversion factors)
5. Divide by the volume (L) of the unknown to find molarity of the unknown

Practice:

1. 20.0 mL of 0.100 M HCl are titrated with 19.5 mL of an NaOH solution. What is the molarity of the NaOH solution?

a. Write and balance the equation. List what you know and don't know.

b. Set up dimensional analysis to find moles for the substance of unknown concentration. (NaOH)

c. Divide the number of moles of NaOH by the volume of NaOH to find molarity.

2. In a titration, 33.21 mL of 0.3020 M strontium hydroxide ($Sr(OH)_2$) solution is required to exactly neutralize 20.00 mL of hydrofluoric acid solution (HF). What is the molarity of the hydrofluoric acid solution?

a. Write and balance the equation. List what you know and don't know.

b. Set up dimensional analysis to find moles for the substance of unknown concentration. (NaOH)

c. Divide the number of moles of NaOH by the volume of NaOH to find molarity.

Check for understanding:

A 35.00 mL sample of HBr solution is titrated to an endpoint by 14.76 mL 0.4122 M NaOH solution. What is the molarity of the HBr solution? *Show all your work*

Titration Simulation Lab & Practice

Pre-Lab: Complete the following practice problems.

1. **Using titration it is found that 40.0 mL of HCl is required to neutralize 24.64 mL of 0.55 M NaOH. What is the molarity of the HCl? (Fill in the missing numbers in the gray boxes and follow the steps).**

   a. Step 1: Write the known quantities below the substances in the balanced chemical equation.

   $HCl\ (aq) + NaOH\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (aq)$

   40.0 mL 24.64 mL

   ? M 0.55 M

   b. Step 2: Set up dimensional analysis to solve for moles using molarity & the mole ratio as conversion factors.

   $$? \text{ mol HCl} = \frac{24.64 \text{ mL NaOH}}{1} \left| \frac{1 \text{ L NaOH}}{1000 \text{ mL NaOH}} \right| \frac{0.55 \text{ mol NaOH}}{1 \text{ L NaOH}} \left| \frac{1 \text{ mol HCl}}{1 \text{ mol NaOH}} \right. = \_\_\_\_\_ \text{mol HCl}$$

   c. Step 3: Solve for molarity, using the molarity equation.

   M = mol/L $M = \frac{\_\_\_\_\_ \text{mol HCl}}{0.040 \text{ L HCl}} = \_\_\_\_\_ \text{M HCl}$

2. **What volume of 1.366 M NaOH would be required to titrate 47.2 mL of 2.075 M H_2SO_4? (Fill in the missing numbers in the gray boxes and follow the steps).**

   a. Step 1: Write the known quantities below the substances in the balanced chemical equation.

   $H_2SO_4\ (aq) + 2\ NaOH\ (aq) \rightarrow Na_2SO_4\ (aq) + 2\ H_2O\ (aq)$

   47.2 mL ? mL

   2.075 M 1.366 M

3. **20.0 mL of HNO_3 is titrated with 34.4 mL of 0.822 M $Ca(OH)_2$. What is the concentration of the HNO_3? (Fill in the missing numbers in the gray boxes and follow the steps).**

   $2\ HNO_3\ (aq) + Ca(OH)_2\ (aq) \rightarrow Ca(NO_3)_2\ (aq) + 2\ H_2O\ (aq)$

   _____ mL _____ mL

   _____ M _____ M

4. **It requires 24.6 mL of $Ca(OH)_2$ solution to neutralize 14.2 mL of 0.0140 M $HC_2H_3O_2$. What is the concentration (M) of the calcium hydroxide solution? Use the problems above as a guideline. Show *ALL* of your work!!!**

   $Ca(OH)_2 + 2\ HC_2H_3O_2 \rightarrow Ca(C_2H_3O_2)_2 + 2\ H_2O$

Directions: You will complete acid-base titrations using a computer simulation. Make sure you read the entire procedure **before** you begin. The steps must be done in order.

Type the following website into the browser (case-sensitive):
http://introchem.chem.okstate.edu/DCICLA/acid_base.html (link is posted on the class website)

Trial 1:

1. Select "Strong Acid vs. Strong Base"
2. Fill the burette with Base.
3. Select HNO_3 for the acid and KOH as the base.
   - Write the balanced equation for this reaction: _____
4. Select phenolphthalein as the indicator.
   - What is the initial color of the solution in the flask? _____
5. Record the molarity and volume of the acid in the data table.
6. Slowly add base (click and hold the slider to move it up 1-2 mL at a time, release it to add the base) until the solution begins to turn pink.
7. When the pink color begins to stay, add the base using the dropwise button.
8. When the solution stays ***bubble gum pink*** (you should still see the magnet), stop adding base.
   a. This will take ***PATIENCE*** – do not over titrate!
   b. If your solution turns a bright pink (and you can't see the magnet), you must reset the titration.
9. Record the final volume of base in your data table.
10. Calculate the molarity of the base (show your work in the calculations section) and enter it into the computer.
11. Click Ok.
12. If your answer is correct, you are done! If it is incorrect, click reset and begin again.

Trial 2:

1. Select "Strong Acid vs. Strong Base"
2. Fill the burette with Base.
3. Select any Acid and any Base from the list. Write the balanced equation for the reaction below:

4. Select phenolphthalein as the indicator.
5. Continue with steps 5-12 as above.

Data Table:

	Trial 1	**Trial 2**
Volume of Acid		
Molarity of Acid		
Volume of Base		

Calculations: Show ***all*** of your work below for step 10!

Trial 1:

Trial 2:

Summing Up Questions:

1. At the end of the titration, is the solution acidic or basic? How do you know?

2. Explain the difference between the equivalence point and the end point of a titration.

3. Give the pH at the equivalence point for the following types of titrations:

   a. Strong acid-strong base _____ b. Strong acid-weak base _____ c. Weak acid-strong base _____

Practice: *Solve the following problems. Show all of your work!* ***Use the problems in the pre-lab as guidelines.***

1. By titration it is found that 12.4 mL of H_2SO_4 is required to neutralize 19.8 mL of 0.0100M $Ca(OH)_2$. What is the molarity of H_2SO_4? $H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2$

2. What is the molarity of phosphoric acid if 15.0 mL of the solution is neutralized by 38.5 mL of 0.15 M NaOH?
   $3NaOH + H_3PO_4 \rightarrow Na_3PO_4 + 3H_2O$

3. Find the volume of 0.80 M KOH needed to neutralize 15.0 mL of 0.65 M H_2SO_4.
   $2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2HOH$

4. What volume of 0.12 M $Ba(OH)_2$ is needed to neutralize 12.2 mL of 0.25 M HCl?
   $Ba(OH)_2 + 2HCl \rightarrow BaCl_2 + 2H_2O$

5. List the steps for setting up a titration experiment:

6. Define the following terms:
   a. neutralization reaction
   b. titration
   c. titration standard
   d. buret
   e. equivalence point
   f. end point
   g. acid-base indicator

Titration and Neutralization Practice

DIRECTIONS: Write the complete neutralization reaction and solve for the molarity or volume.

1. 10.0 mL of 1.00 M HCl neutralized 20.0 mL of a NaOH solution. What was the molarity of the NaOH?
   reaction: _____

2. 12.0 mL of 0.500 M NaOH neutralized 6.0 mL of HCl solution. What was the molarity of the HCl?
   reaction: _____

3. Two solutions were titrated to the endpoint. 18.5 mL of 2.0 M HCl and 21.2 mL of NaOH solution were used. What was the molarity of NaOH ?
   reaction: _____

4. In a titration experiment, HCl and LiOH solutions were used. The initial volume of HCl was 1.25 mL and LiOH was 2.65 mL. The final volume of HCl was 13.60 mL and LiOH was 11.20 mL. If the LiOH was 0.140 M what was the molarity of HCl ?
   reaction: _____

5. If the same volumes were used from question 4, but the HCl was 0.140 M, what would the molarity of LiOH be?
   reaction: _____

Acid-Base Review Worksheet-Accel

Complete the following. Show *all* of your work! Box or circle your answer.

- **Objective: Identify & describe the properties of acids and bases**

1. Compare and contrast the following:
    a. Acid properties and base properties

    b. Strong acid and weak acid (Include a list of strong acids)

    c. Strong base and weak base (include a list of strong bases)

    d. Acid-base indicator and pH meter

    e. Monoprotic acid and polyprotic acid

    f. Binary acid and ternary acid

- **Objective: Identify the difference between Arrhenius' model and Bronsted-Lowry Model**

2. Compare and contrast the following:
    a. Arrhenius acid and Arrhenius base

    b. Bronsted-Lowry acid and Bronsted-Lowry base

    c. Conjugate acid and conjugate base

3. Identify the acid/base pairs (use BA, BB, ca and cb):
    a. $HC_2H_3O + H_2O \leftrightarrow H_3O^+ + C_2H_3O_2^-$

    b. $H_2O + C_2H_3O_2^- \leftrightarrow HC_2H_3O_2 + OH^-$

- **Objective: Calculate pH and pOH**

4. What are the hydroxide ion concentrations for solutions that have the following pH values?
    a. 4.0

    b. 8.0

5. What are the pH values for the following?
    a. $[H^+] = 2.4 \times 10^{-6}$ M

    b. 9.1×10^{-9} M HCl

6. What are the $[H^+]$ for the following?
    a. pH= 13.2

    b. pOH = 6.7

    c. $[OH^-] = 3.2 \times 10^{-6}$ M

    d. 1.3×10^{-12} M NaOH

7. Calculate the pH from the following $[OH^-]$.
    a. 4.3×10^{-4} M

    b. 3.33×10^{-7} M

- **<u>Objective:</u> Calculate using the ion product constant for water**

8. Calculate the $[OH^-]$ for the following.
    a. $[H^+] = 1 \times 10^{-2}$ M

    b. 2.7×10^{-4} M H_2SO_4

9. What are the $[H^+]$ for the following?
    a. $[OH^-] = 2.3 \times 10^{-6}$ M

    b. 3.1×10^{-12} M NaOH

- **<u>Objective:</u> Write balanced equations for neutralization reactions and do the calculations required for titrations**

10. Determine the concentration of 15 mL of nitric acid (HNO_3) that is titrated with 10.5 mL of 2.5 M NaOH.

11. What volume of 0.25 M acetic acid would be necessary to neutralize 50.0 mL of 2.0 M potassium hydroxide?

$$\mathbf{KOH + CH_3COOH \rightarrow KCH_3COO + H_2O}$$

12. 25.5 mL of 0.75 M hydrochloric acid is used to titrate 10.0 mL of calcium hydroxide. What is the concentration of the base? $\mathbf{2HCl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O}$

13. When titrating, what would you expect the equivalence point pH to be for the following:
    a. A strong acid with a strong base _____
    b. A strong acid with a weak base _____
    c. A weak acid with a strong base _____

14. Complete the following statements.
    a. The process used to determine the concentration of an unknown solution is called _____.
    b. A reaction where an acid and a base react to form salt and water is called a _____ reaction.
    c. A substance that can act as both an acid and a base is called a(n) _____ substance.
    d. A hydrogen ion and a water molecule form a _____ ion.
    e. The equilibrium (ion product) constant of water has a symbol of _____ and a value of _____.
    f. The _____ has values of 0-14 and tells us whether a substance is an acid or a base.
    g. The _____ is reached when the $[H^+]$ and $[OH^-]$ are equal.
    h. The _____ is reached when the indicator changes color during a titration.