

Acid/Base Theory



C. Souders - Battlefield

Standard of Learning

CH.4g

The student will define and identify the properties of an acid, a base, and a salt.

Essential Question(s)

- What happens to ionic and molecular substances when they dissolve in water?
- What are acid-base theories?
- How are acids and bases classified?
- What do pH and pOH represent?

Unit: Acids/Bases
Lesson: Acid/Base Theory
Time Frame: 180 minutes (2 blocks)

PWCS Standards Based Planning Process

Standards: *What will students know and be able to do?*

Essential Understandings –

- Substances that do not ionize are called non-electrolytes.
- When acids, bases, or salts are placed in water, they ionize/dissociate to varying degrees. These solutions can be classified as strong or weak electrolytes.
- Acids and bases are classified according to the Arrhenius definition and/or the Bronsted-Lowry theory.
 - Arrhenius based on physical, palpable properties
 - Bronsted-Lowry based on chemical properties
- The acidity of a solution is defined in terms of pH; base properties in terms of pOH. The sum of pH and pOH is fourteen. pH is a number scale ranging from 0 to 14 with the lower numbers indicating an acid condition. pOH is a number scale ranging from 0 to 14 with the lower numbers indicating a basic condition.
- Each of the scales is the reverse of the other.
- A pH or pOH of 7 indicates neutrality.

Essential Skills –

- Given the formula/name of a compound, classify it according to whether it is an electrolyte or non-electrolyte. If it is classified as an electrolyte, then sub-classify it as either:
 - an acid
 - a base
 - a salt
- Predict whether it is a strong or a weak electrolyte and give a reason for the prediction.
- Compare and contrast classification systems developed by Arrhenius and those by Bronsted and Lowry.
- Describe pH and/or pOH and relate it to the molar concentration values obtained from a strong electrolyte.
- Given an acid and a base,
 - write a balanced neutralization equation
 - correctly name the resulting salt.
 - identify the conjugate base of the acid
 - identify the conjugate acid of the base

Assessment: How will the student and I know when he/she is successful?

- **Before Lesson (Pre-Assessment)** – Acid/Base Theory is one of the final lessons of the school year. Students should be comfortable with naming, bonding, writing formulas, etc. Students should be able to recognize the bond types between the acid and base compounds. They should also be familiar with their polyatomic ions and able to recognize them in a compound.
- **During Lesson (Formative)** – Students will start with the basic similarities and differences between acids and bases that will build throughout the unit. Most students know have heard of battery acid, acid rain, and they know that lemons are acidic, but they need that knowledge to be built upon and broadened. The teacher must clarify the difference between strengths of acids and bases, and make sure students understand that some are edible, but not all.
- **After Lesson (Summative)** – The included quiz will provide the teacher with evidence of mastery of the topic. Students will accurately demonstrate their knowledge of pH/pOH and the types of acids/bases. The quiz reflects the subject matter presented to the students throughout the lesson.

Task Analysis: What knowledge, skills and level of understanding do students need to be successful with this lesson?

- **Pre-Assessment Data:** This lesson comes at the end of the school year, there are many topics that are needed from prior knowledge.
 - Students should be able to identify ionic and covalent bonds.
 - Students should be able to identify polyatomic ions and name them.
 - Students should be able to name acids and bases
- **Important Vocabulary (Literacy) –**
 - Acid
 - Base
 - Conjugate acid
 - Conjugate base
- **Skill Development and Differentiation–**
 - *Acid/Base Lab* – For students who need more of a challenge the teacher could allow students to create an indicator out of a fruit or vegetable of their choice. This would allow them to explore deeper into the concept and really understand what in the cabbage juice allows it to act as an indicator. For a student who is struggling or has physical limitations a prepared cabbage juice indicator could be provided for them.
 - *Compare Properties of Acids/Bases* – This graphic organizer provides a visual way for students to compare/contrast acids and bases.
 - *The Proton in Chemistry Video* – This video allows for visual animations of acids and bases along with real world applications for students to relate to.

PWCS Standards Based Planning Process (continued)

Instruction Using Inquiry Model: *What learning experiences will facilitate student success?*

Framing the Learning:

1. **Engage** – The teacher should start the lesson with *The Proton in Chemistry* video. This provides real world examples of acids and bases and how they affect our daily lives. It also provides good animations and engages students into the topic.

Learning Experiences:

2. **Explore – pH Lab** is a great lab that leads to exploration of acids and bases. There are two parts to this lab; the first is making a cabbage juice indicator and the second is actually testing the pH of household products. This activity can be easily shortened/lengthened depending on the needs of students. The teacher must make sure that students understand the purpose to performing two different tests on the substances (cabbage juice and pH paper) and why they need to test the “knowns” before the unknowns. They must also use their previously learned lab skills to make sure their lab technique is appropriate. Although these are household items the teacher needs to be sure to promote safety in the classroom.

3. **Explain** – There is a PowerPoint included in this lesson to guide with lecture. There is also a graphic organizer that can be used to assist students in conceptualizing the difference between acids and bases. The teacher needs to make sure students can identify these differences easily.

4. **Elaborate** – There is one worksheet included to help students with the concept of acids and bases. It is up to the individual teacher to determine how the students are progressing and if they need more assistance or practice.
 - If a class is progressing quickly the teacher can move on to calculating the concentration of an acid or base from its pH or pOH. This is a bit more complicated for students to understand.
 - The teacher could also ask students to go home and find a given number of acids or bases in their household and explain how they came to the determination that they were acids or bases. The teacher could also go deeper and ask students to research this item and decide whether it is strong or weak, safe to ingest, etc.
5. **Evaluate** – There is a quiz included in this lesson to check for progress of students. This lesson is usually part of a larger unit in which this information would be included in a cumulative assessment. The teacher could choose to divide the quiz into smaller checkpoints should they choose.

PWCS Standards Based Planning Process (continued)

Resources:

- *The Proton in Chemistry* Video
- pH Lab – red cabbage, five household acids/bases
- Acids and Bases PowerPoint
- Compare Properties of Acids and Bases Handout
- Acid/Base Practice Handout
- Acid/Base Quiz

Reflection: *Based on data, how do I refine the learning experiences and/or the assessment?*

- **Analysis of Data** – This lesson is one of the concluding lessons for the school year. The quiz should be a good indicator of mastery and the information will be included on a unit test as well as on the SOL. As the topics move on to solutions and titrations students need to have a sound understanding of the difference between an acid and base.
- **Immediate Implications** - If evidence of student mastery is not present then remediation needs to happen immediately. This part of the school year is usually rushed due to time and this step is often missed. It is important that student mastery is achieved before the unit can continue.
- **Future Planning** – Students need to understand the difference between acids and bases and that they neutralize each other. This is one of the most important concepts taught leading to solutions and titrations. The unit cannot progress until this is understood and demonstrated by students. This needs to be included in SOL review and remediation as well because this is a topic that tends to be squeezed in at the end of the year.

CH.4g

The student will define and identify the properties of an acid, a base, and a salt.

Name: _____

Class Period: _____ Date: _____



ENGAGE
PHASE

Video

Source: www.learner.org

Title: *World of Chemistry – Episode 16 – The Proton in Chemistry*
<http://www.learner.org/resources/series61.html?pop=yes&pid=808>

A screenshot of a web browser window displaying a video player. The video player has a dark blue background. In the center, there is a green rectangular frame containing the title "THE PROTON IN CHEMISTRY" in white capital letters. To the left of the title, there is a 3D molecular model of a chlorine atom (blue sphere with a minus sign) and a nitrogen atom (grey sphere with a plus sign). Below the title, there is a control bar with icons for volume, brightness, and other video settings. At the bottom of the green frame, there are navigation links "<PREV >NEXT>" and "Video on Demand PAGE". In the top left corner of the browser window, the Annenberg Media Learner.org logo is visible. In the top right corner, the Virginia Tech logo is visible. The browser's address bar shows the URL "http://www.learner.org/vod/vod_window.html?pid=808".

Length: 28 minutes

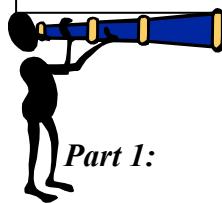
Summary: This video provides an introduction to acids and bases, showing real-life relations, acid/base reactions, pH scale, etc.

CH.4g

The student will define and identify the properties of an acid, a base, and a salt.

Name: _____

Class Period: _____ Date: _____


**EXPLORE
PHASE**
pH Lab
Part 1:**Materials**

Bunsen Burner	red cabbage	.1M HCl
Ring Stand with ring	flint striker	.1M NaOH
Wire Gauze	forceps	Para film
250 mL beaker	Beaker tongs	pipettes
water	Test tubes	

Procedure:

1. Tear a large leaf of red cabbage into smaller (about 1 inch squares) pieces.
2. Put red cabbage into 250mL beaker and add water to cover.
3. Set up ring stand with wire gauze. Make sure the ring is close enough to the Bunsen burner.
4. Light the Bunsen burner.
5. Allow cabbage water to boil, or at least bubble rapidly. Once this happens the water will turn a purple color.
6. Use beaker tongs to remove the beaker from the ring stand and set on the counter top. This is HOT, do not touch it.
7. Use forceps to remove the cabbage chunks from the water. This go in the trash, do NOT put in the sinks.
8. Allow your cabbage juice to cool.
9. Place five drops of NaOH in one test tube and five drops of HCl in the second test tube. Make sure you know which is which.
10. Once cabbage juice is cooled, add five drops of your cabbage juice to the NaOH and two drops to the HCl. Be sure to make record of the changes that you see.
11. Transfer your cooled cabbage juice to an Erlenmeyer flask. Label with your group members names and cover with parafilm. Place on the back counter to save for the next lab period.
12. Clean, dry and return all glassware and materials to their proper locations.
13. Clean and dry lab benches.

Use the data table below to record your results. Make sure you are DETAILED in your responses:

	.1M NaOH	.1M HCl
Cabbage Juice Indicator		

Part 2:**Materials**

Your pH indicator	dissolved antacids	test tubes
pH paper	lemon juice	pipettes
vinegar	tap water	
ammonia	2 unknown household substances	

Procedure

1. Place five drops of each known substance in five separate test tubes. Make sure they are labeled so you know which is which.
2. Take a stir rod and place in the first test tube, add a small drop of liquid to a piece of pH paper. Be sure to clean and dry your stir rod between each substance! Record your results.

3. Once you have tested your pH paper, place five drops of your indicator into each test tube. Record your results.
4. Compare your pH papers to the package to determine a pH range and identify if the substance is an acid or base.
5. Obtain five drops of an unknown and place in a clean and dry test tube, do the same for a second unknown.
6. Follow step 2 and 3 above for your unknown.
7. Repeat steps 4 and 5 for a second unknown.
8. Compare the results of your unknown to the results of your known. Based off of your results identify both of your unknowns.
9. All of your solutions may be dumped down the drain, including your left over indicator. Wash and dry all glassware and materials and return to proper locations.
10. Clean and dry your lab bench.

Use the data table below to record your results. Make sure you are DETAILED in your responses:

	Cabbage Juice	pH paper	Acid or Base?	pH

CONCLUSION QUESTIONS: Write COMPLETE sentences in paragraph form. Attach a separate sheet of paper if necessary.

1. Unknown # ___ Identity: _____
Unknown # ___ Identity: _____
2. How did you decide on the identity of your unknowns? (what was your proof)
3. Which of the testing methods you used was the most accurate way to test the pH of a substance. Why do you think so?
4. Do you think that other foods would also work as indicators? Why or why not? If you do think so, give two examples of foods you think would work and explain why.
5. Do you think that there is a more accurate way to identify an unknown acid or base? If so how would you do it?

CH.4g

The student will define and identify the properties of an acid, a base, and a salt.

Name: _____

Class Period: _____ Date: _____



EXPLAIN PHASE

Slide 1

The Chemistry of Acids and Bases

Science Instrument Acids & Bases

Acids Bases

To play the movies and simulations included, view the presentation in Slide Show Mode.

Slide 2

Some Properties of Acids

- ❖ Produce H⁺ (as H₃O⁺) ions in water (the hydronium ion is a hydrogen ion attached to a water molecule)
- ❖ Taste sour
- ❖ Corrode metals
- ❖ Electrolytes
- ❖ React with bases to form a salt and water
- ❖ pH is less than 7
- ❖ Turns blue litmus paper to red "Blue to Red A-CID"

Have students use mapping graphing organizer to complete notes on properties of acids/bases.

Slide 3

Some Properties of Bases

- ❖ Produce OH⁻ ions in water
- ❖ Taste bitter, chalky
- ❖ Are electrolytes
- ❖ Feel soapy, slippery
- ❖ React with acids to form salts and water
- ❖ pH greater than 7
- ❖ Turns red litmus paper to blue "Basic Blue"

Slide 4

4

Acid/Base definitions

- Definition #1: Arrhenius (traditional)

Acids – produce H⁺ ions (or hydronium ions H₃O⁺)

Bases – produce OH⁻ ions

Slide 5

5

Acid/Base Definitions

- Definition #2: Brønsted – Lowry

Acids – proton donor

Bases – proton acceptor



Slide 6

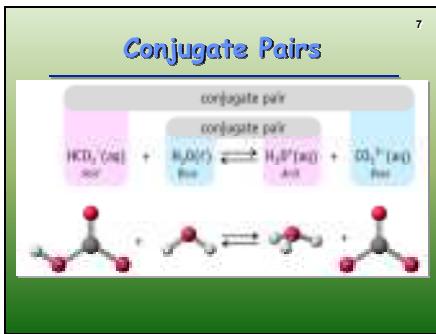
6

A Brønsted-Lowry acid is a proton donor
A Brønsted-Lowry base is a proton acceptor

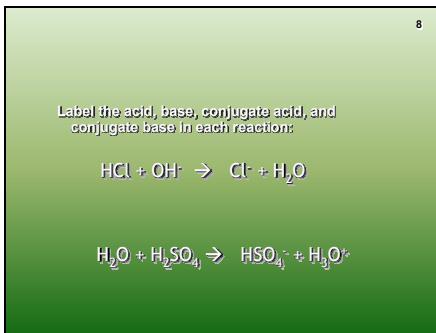


base acid conjugate acid conjugate base

Slide 7

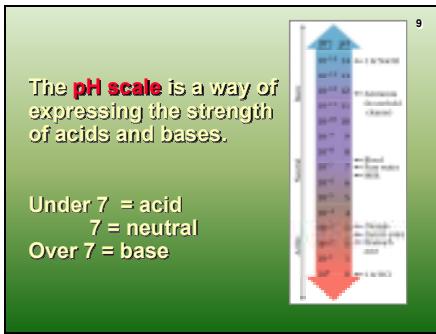


Slide 8



Give students time to work through these sample problems while you assist.

Slide 9

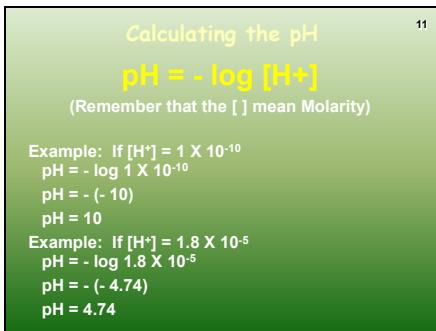


Slide 10

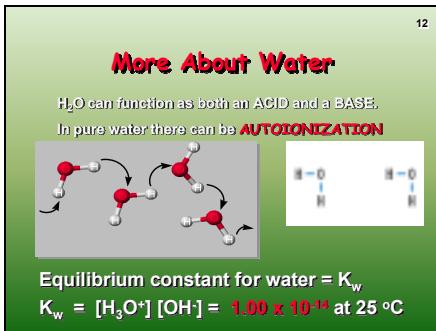


Remind them, the closer to 0 the stronger the acid, the closer to 14 the stronger the base.

Slide 11



Slide 12



Slide 13

More About Water

13

Autoionization

$K_w = [H_3O^+] [OH^-] = 1.00 \times 10^{-14} \text{ at } 25^\circ\text{C}$

In a neutral solution $[H_3O^+] = [OH^-]$
so $K_w = [H_3O^+]^2 = [OH^-]^2$
and so $[H_3O^+] = [OH^-] = 1.00 \times 10^{-7} \text{ M}$

Slide 14

pOH

14

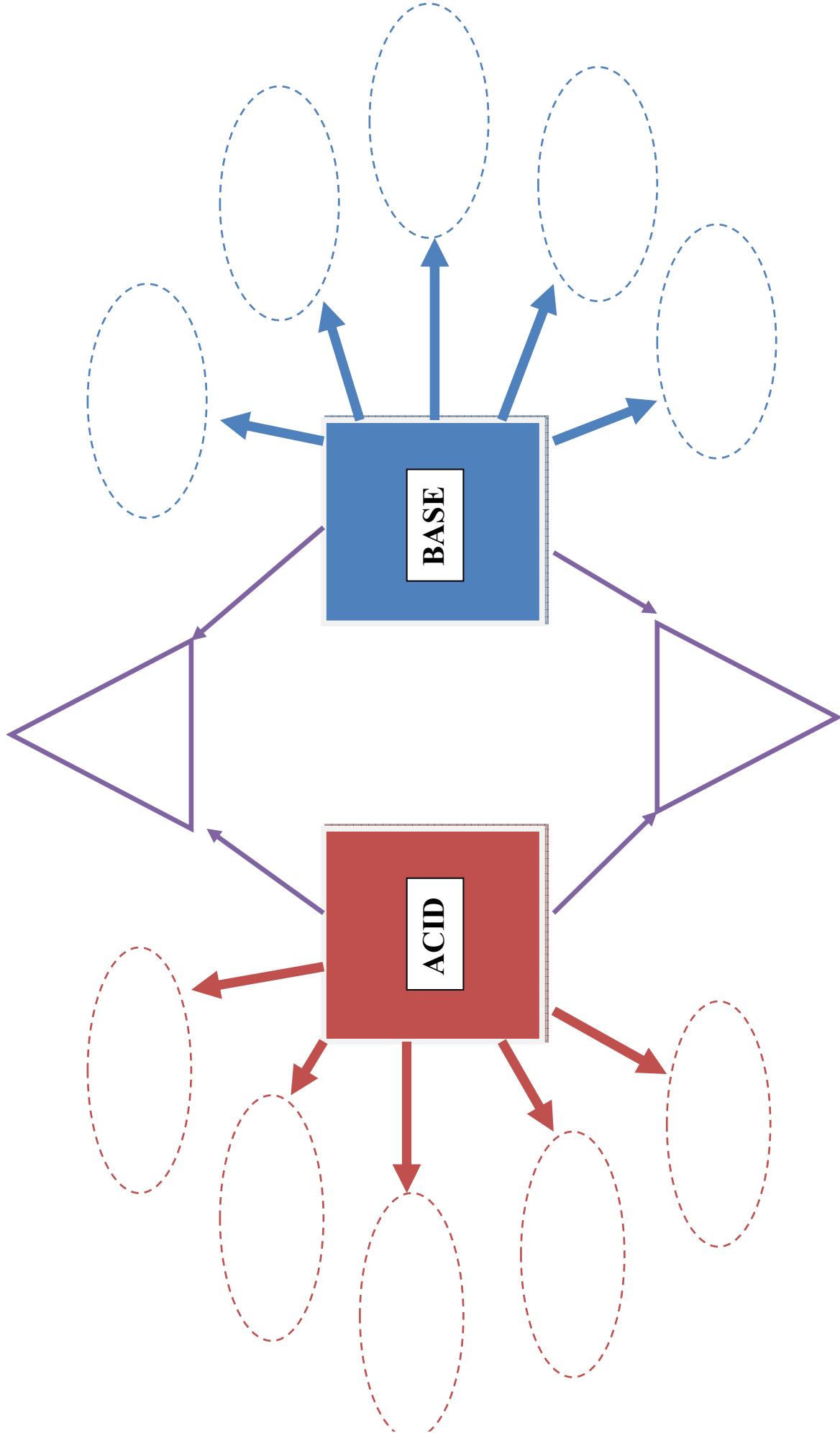
- Since acids and bases are opposites, pH and pOH are opposites!
- pOH does not really exist, but it is useful for changing bases to pH.
- pOH looks at the perspective of a base

$\text{pOH} = -\log [OH^-]$

Since pH and pOH are on opposite ends,

$\text{pH} + \text{pOH} = 14$

Compare Properties of Acids and Bases



CH.4g

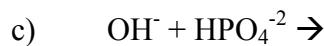
The student will define and identify the properties of an acid, a base, and a salt.

Name: _____

Class Period: _____ Date: _____

**ELABORATE
PHASE****Acid/Base Practice**

- 1) Using your knowledge of the Brønsted-Lowry theory of acids and bases, write equations for the following acid-base reactions and indicate each conjugate acid-base pair:



- 2) Write an equation for the reaction of potassium metal with hydrochloric acid.

- 3) Borane (BH_3) is a basic compound, but doesn't conduct electricity when you dissolve it in water. Explain this, based on the definitions of acids and bases that we discussed in class.

Find the pH of #4-8:

- 4) A 0.001 M solution of HCl (hydrochloric acid).
- 5) A 0.09 M solution of HBr (hydrobromic acid).
- 6) A 1.34×10^{-4} M solution of hydrochloric acid.
- 7) A 2.234×10^{-6} M solution of HI (hydroiodic acid).
- 8) A 7.98×10^{-2} M solution of HNO₃ (nitric acid).
- 9) What is the pH and pOH of a 1.2×10^{-3} HBr solution?
- 10) What is the pH and pOH of a 2.34×10^{-5} NaOH solution?
- 11) Explain the difference between an Arrhenius Acid and a Bronsted-Lowry Acid.

CH.4g

The student will define and identify the properties of an acid, a base, and a salt.

Name: _____

Class Period: _____ Date: _____

**pH Quiz****Matching:**

- | | |
|---------------------------------------|------------------------|
| 1. _____ Proton donor | a. Arrhenius Acid |
| 2. _____ Produce H ⁺ Ions | b. Arrhenius Base |
| 3. _____ Produce OH ⁻ Ions | c. Bronsted Lowry Acid |
| 4. _____ proton acceptor | d. Bronsted Lowry Base |

Short Answer:

5. For this equation identify the acid, base, conjugate acid and conjugate base.



6. Calculate the pH of A 0.001 M solution of HCl.

pH=_____

7. Calculate the pH of a 1.0×10^{-2} M solution of nitric acid.

pH=_____

8. What is the pH and pOH of a 1.2×10^{-3} M HBr solution?

pH=_____

pOH=_____