Connected Chemistry
Acids & Bases Unit
Lesson 5: Calculating pH

Student's Lesson at a Glance

Lesson Summary

This lesson contains three activities which help students further examine acids and bases on the submicroscopic level. Students will also get a chance to practice calculating pH values. Students are introduced to calculating pH and pOH. Students explore how pH and pOH are related to concentration in the Connecting Activity. Using simulations, students will complete sketches before and after and record their observation of several compounds dissolved in water. In the provided data table, students should record the concentration of H_3O^+ and OH^- before and after the reaction and record the number of H_3O^+ and OH^- ions. Students use the value for H_3O^+ to calculate pH and the value for OH^- to calculate the pOH. Finally, students answer questions about the simulations. Students determine if each compound can be classified as either as a weak or strong acid or base based on submicroscopic observations.

SWBAT (Students Will Be Able To)

- Know that pH (power of H^+) is mathematically defined as the –log $[H_3O^+]$
- Know that pOH (power of OH^-) is mathematically defined as the –log $[OH^-]$
- Know pH is a scale to measure the acidity of a solution based on the relative concentration of OH^- and/or H_3O^+
- Identify a solution as acidic, neutral, or basic given $[H_3O^+]$, $[OH^-]$, pOH, or pH
- Calculate the pOH and pH of an acidic, basic or neutral solution given the $[H_3O^+]$, $[OH^-]$
- Know that pH is determined by the concentration of an acid and not a function of whether an acid is strong or weak

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in **bold**. Additional words that will expand your scientific vocabulary are in *italics*.

CCC Reminder

- Ions will have halos in the simulation. When drawing keys for sketches, make sure to include ions and neutral atoms.
- Hydroxide and hydronium are easily confused when naming ions. Hydroxide is OH^- and hydronium is H_3O^+.
- Square brackets around a substance represent concentration. For example: $[OH^-]$. This represents the concentration as Molarity (M) with units of mol/L.

Notes

Homework

Upcoming Quizzes/Tests

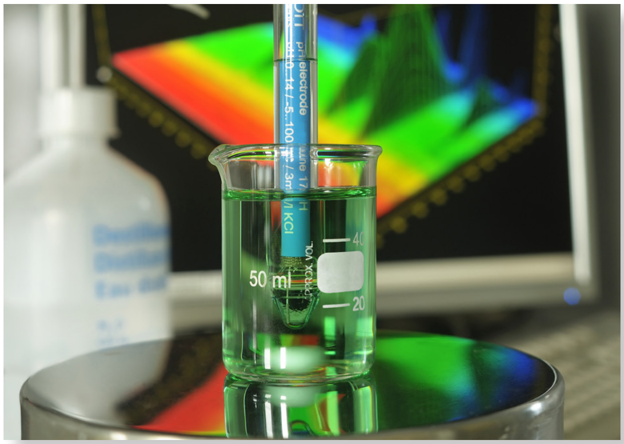
Activity 1: Connecting

1. If there is a higher concentration of hydronium (H_3O^+) ions than hydroxide (OH^-) ions in a solution, would the solution be classified as above or below 7 on the pH scale? *Support your claim with evidence.*

2. If there is a higher concentration of hydroxide ions than hydronium ions in a solution, would the solution be classified as above or below 7 on the pH scale? *Support your claim with evidence.*

3. For a solution to be classified as neutral, what relationship must exist between the pH and pOH?

Carbon dioxide from vehicle exhausts, decaying plants and animals, and chemicals released into the environment from factories can all affect the pH of the water in our environment. Extreme pH levels are harmful to both humans and animals who must consume water to survive. Because of this, the Environmental Protection Agency (EPA) has set standards for pH levels in drinking water to prevent illness. According to the EPA, a pH lower than 6.5 or higher than 8.5 is considered unhealthy to drink (EPA, 2012). Chemists and environmental scientists determine the pH of water samples with a special device called a *pH meter*. The pH meter is able to directly measure the relative amount of hydronium and hydroxide ions in a water sample to give a precise pH value.



Why is the value labeled pH? pH is the abbreviation for the phrase "**p**ower of the concentration of **H**ydrogen ion." Since hydrogen ions do not exist alone in solutions for very long, pH is calculated with the following equation that uses the concentration of hydronium ions instead of hydrogen ions:

$$pH = -\log [H_3O^+]$$

Because some basic solutions contain many more hydroxide ions than hydronium ions, chemists sometimes use a **pOH scale** to complement the pH scale. pOH is a measure of the concentration of hydroxide ions in a solution.

pOH is calculated with the following equation:

$$pOH = -\log [OH^-]$$

Note that the measures of pH and pOH are only useful for aqueous solutions which contain hydronium or hydroxide ions. If there are no hydronium ions or hydroxide ions in a solution, a pH meter has nothing to measure! Also, the formulas to calculate pH and pOH only work for strong acids and bases.

Activity 2: Simulating pH and pOH

- *In this simulation there are four sets, each containing a compound you will add to water.*
- *For each substance, complete a before and after sketch, and record your observations.*
- *Record the concentration of the substance before and after the reaction, and record the number of* H_3O^+ *and* OH^- *ions.*
- *Use the concentration for* H_3O^+ *to calculate pH, and the value for* OH^- *to calculate the pOH.*
- *Use your sketches and data to answer the questions that follow each set.*

Set 1: *Use Simulation 4, **Set 1***

	Before Reaction				After Reaction			
Submicroscopic Sketch								
Data	**[HNO_3]**		[H_3O^+]		**[HNO_3]**		[H_3O^+]	
	[OH^-]		[NO_3^-]		[OH^-]		[NO_3^-]	
	K_{eq}				K_{eq}			

Chemical Formula

HNO_3 (l) + H_2O (l) → ______________________

Observations

Key

4. Calculate the pH of the solution after the reaction.

5. Calculate the pOH of the solution after the reaction.

6. Is HNO_3 a strong acid, weak acid, strong base, or weak base? *Support your claim with two pieces of evidence.*

Set 2: *Use Simulation 4, **Set 2***

	Before Reaction				After Reaction			
Submicroscopic Sketch								
Data	[LiOH]		$[H_3O^+]$		[LiOH]		$[H_3O^+]$	
	$[OH^-]$		$[Li^-]$		$[OH^-]$		$[Li^-]$	
	K_{eq}				K_{eq}			

Chemical Formula

LiOH (s) + H_2O (l) → ______________________

Observations

Key

7. Calculate the pOH of the solution after the reaction.

8. Calculate the pH of the solution after the reaction.

9. Is LiOH a strong acid, weak acid, strong base, or weak base? *Support your claim with two pieces of evidence.*

Set 3: *Use Simulation 4, **Set 3***

	Before Reaction				After Reaction			
Submicroscopic Sketch								
Data	$[CH_3NH_2]$		$[H_3O^+]$		$[CH_3NH_2]$		$[H_3O^+]$	
	$[OH^-]$		$[CH_3NH_3^+]$		$[OH^-]$		$[CH_3NH_3^+]$	
	K_{eq}				K_{eq}			

Chemical Formula

CH_3NH_2 (l) + H_2O (l) → ____________________________

Observations

Key

10. Is CH_3NH_2 a strong acid, weak acid, strong base, or weak base? *Support your claim with two pieces of evidence.*

11. Calculate the pOH given that the pKb of CH_3NH_2 is 3.19:

12. Calculate the pH of CH_3NH_2.

Set 4: *Use Simulation 4,* ***Set 4***

	Before Reaction				After Reaction			
Submicroscopic Sketch								
Data	**[$HC_2H_3O_2$]**		[H_3O^+]		**[$HC_2H_3O_2$]**		[H_3O^+]	
	[OH^-]		[$C_2H_3O_2^-$]		[OH^-]		[$C_2H_3O_2^-$]	
	K_{eq}				K_{eq}			

Chemical Formula

$HC_2H_3O_2$ (aq) + H_2O (l) → ____________________

Observations

Key

13. Is $HC_2H_3O_2$ a strong acid, weak acid, strong base, or weak base? *Support your claim with two pieces of evidence.*

14. Calculate the pH for CH_3COOH given that the pKa is 4.75.

15. Calculate the pOH for CH_3COOH.

Activity 3: Teacher Facilitated Discussion

Substance	Classification	Concentration	pH
HCl	Strong Acid	0.10 M	1.00
$HC_2H_3O_2$	Weak Acid	0.10 M	2.90
HF	Strong Acid	0.008 M	3.10

16. Based on the data above, what is relationship between pH and whether a substance is classified as strong or weak? *Support your claim with evidence.*

Lesson Reflection Questions

You are provided with two solutions. One is a weak acid and one is a strong acid. When a pH probe is put into both solutions, the meter indicates that both of them have a pH of 2.0. The pH probe is not malfunctioning .

17. What does the scenario above imply about pH?

18. How is it possible that the weak acid solution and the strong acid solution have the same pH?

19. Consider the three acid-base theories from previous lessons. Would you be able to calculate the pH of a solution using all of them? *Describe your answer.*