Student directions *pH scale* activity 1: Introduction to pH

http://phet.colorado.edu

**Directions:** Use specific examples to demonstrate each of the following learning goals.

1. Determine if a solution is acidic or basic using
   a. pH
   b. $H_3O^+/OH^-$ ratio (molecular size representation of just the ions in the water equilibrium)
   c. Hydronium/Hydroxide concentration

2. Relate liquid color to pH.

3. Predict if dilution and volume will increase, decrease or not change the pH

4. Organize a list of liquids in terms of acid or base strength in relative order with supporting evidence.

5. Write the water equilibrium expression. Describe how the water equilibrium varies with pH.
PhET Computer Simulation Activity: Acid-Base Solutions

Introduction
1. Take a few minutes to **play** with the sim (http://phet.colorado.edu/en/simulation/acid-base-solutions). Check out both the Introduction and Custom Solution tabs. **Explore** what factors affect pH. **List** the factors you found that affect pH.

Investigating Concentration Changes
2. a. **Create** a strong acid solution in the “Custom Solution” tab.
   b. **Draw** bar graphs for Initial and Equilibrium concentrations.
      **Hints:** No calculator needed – try the ‘Equilibrium Concentration’ view.
      Don’t forget to label your graphs!

      | Initial Concentrations | Equilibrium Concentrations |
      |-------------------------|-----------------------------|
      |                         |                             |

   c. What equilibrium concentrations are affected by changing the initial concentration?

3. a. **Create** a weak acid solution in the “Custom Solution” tab.
   b. **Draw** bar graphs for Initial and Equilibrium concentrations.
      **Hints:** No calculator needed – try the ‘Equilibrium Concentration’ view.
      Don’t forget to label your graphs!

      | Initial Concentrations | Equilibrium Concentrations |
      |-------------------------|-----------------------------|
      |                         |                             |

   c. What equilibrium concentrations are affected by changing the initial concentration?

4. Are your results for the strong and weak acid in questions 2 and 3 consistent with the definition of strong and weak acids?
PhET Computer Simulation Activity: Acid-Base Solutions

Investigating the Effects of Acid Strength and Concentration

5. a. What does the ‘strength’ slider (in the sim) effect?

   b. What does the term ‘strength’ mean? (In your own words)

6. How does strength affect the pH of acids?

7. How does initial concentration affect the pH of acids?

8. a. Is it possible for a solution of weak acid and a solution of strong acid to have the same pH? Design and carry out an experiment using the simulation to answer this question. What are your results?

   b. What was your strategy for testing whether a solution of strong acid and a solution of weak acid can have the same pH?
Acid Base Solutions:
Strength and Concentration
by Trish Loeblein July 2011

Learning goals: Students will be able to
1. Generate or interpret molecular representations (words and/or pictures) for acid or base solutions
2. Provide or use representations of the relative amounts of particles in acid or base solutions to estimate strength and/or concentration
3. Use common tools (pH meter, conductivity, pH paper) of acid or base solutions to estimate strength and/or concentration

Some materials adapted from an activity by Lancaster /Langdon
Icons for Acid Base Solutions

- $H_2O$
- $HA$
- $A^-$
- $H_3O^+$
- $MOH$
- $M^+$
- $B$
- $BH^+$
- $OH^-$
1. Order the solutions from lowest to highest pH.

A. X < Y < Z
B. Y < X < Z
C. Z < Y < X
D. Z < X < Y
E. Y < Z < X
2. Order the solutions from lowest to highest pH.

- A. X < Y < Z
- B. Y < X < Z
- C. Z < Y < X
- D. Z < X < Y
- E. Y < Z < X
3. Which image is from a strong acid?

- A. X
- B. Y
- C. Z
- D. more than one
- E. none
4. Which image is from a weak base?

A. X       B. Y       C. Z

D. more than one   E. none
5. Strong acids have lower pH than weak acids.

A. Always True
B. Always False
C. Sometimes True
5. Strong acids have lower pH than weak acids?

Use pH meter to see that if the acids are the same concentration, then the statement is true, but there are other possibilities.
7. A solution with \([H_3O^+] = .1 \text{ M}\) contains a **stronger** acid than a solution \([H_3O^+] = .001 \text{ M}\).

A. Always True  
B. Always False  
C. Sometimes True
8. A solution with \([H_3O^+] = .1 \text{ M}\) contains a stronger acid than a solution \([H_3O^+] = .001 \text{ M}\)?

Use the Equilibrium concentration View to see that if the acid is weak, then the statement is true, but if the acid is strong, concentration matters.
9. What **ALWAYS** distinguishes a weak acid from a strong acid?

A. A weak acid doesn’t react much in water; strong acids completely react.

B. A weak acid is more dilute than a strong acid.

C. A weak acid has a higher pH than a strong acid.

D. Statements a and c are both characteristics that distinguish weak acids from strong acids.

E. Statements a, b, and c are all characteristics that distinguish weak acids from strong acids.
10. What **ALWAYS** distinguishes a **weak base** from a **strong base**?

A. A weak base doesn’t react much in water; strong bases completely react.

B. A weak base is more dilute than a strong base.

C. A weak base has higher pH than a strong base.

D. Statements a and c are both characteristics that distinguish weak bases from strong bases.

E. Statements a, b, and c are all characteristics that distinguish weak bases from strong bases.
Icons for Acid Base Solutions

Use these icons to write reactions for strong and weak acids and then for strong and weak bases.
Lesson plan for \textit{pH Scale}:

Time for activity 50 minute class

**Learning Goals:**
Students will be able to: Use specific examples to demonstrate each of the following learning goals.

1. Determine if a solution is acidic or basic using
   a. pH
   b. \(H_2O^+/OH^-\) ratio (molecular size representation of just the ions in the water equilibrium)
   c. Hydronium/Hydroxide concentration

2. Relate liquid color to pH.

3. Predict if dilution and volume will increase, decrease or not change the pH

4. Organize a list of liquids in terms of acid or base strength in relative order with supporting evidence.

5. Write the water equilibrium expression. Describe how the water equilibrium varies with pH.

**Background:** This activity was used on the first day of second semester acid-base unit. The students had an introduction to acid-base reactions as part of stoichiometry in semester one. Originally, the learning goal 1b just stated “molecular representation”; many of my students answers demonstrated that they were confusing concentration with ion levels. We had a discussion and I have changed the goals for next year. The next PhET simulation addresses learning goals around strength and concentration directly. My students have done several titrations in labs so they are familiar with indicators.

**pH Scale Introduction:** I did a short demonstration just to peak interest in acid-bases. I put some universal indicator in a large test tube and then added some .1M HCl. Then I used a pipet to add some saturated NaCO\(_3\) solution. The results will be a variation in colors. We discussed briefly that the layers had varying pH.

**Lesson:** My students worked in pairs and most completed the activity in 40 minutes.

Post lesson: Use clicker questions
pH Scale: qualitative learning goals

1. Determine if a solution is acidic or basic using
   a) pH  b) $H_3O^+/OH^-$ ratio molecular size representation  
c) Hydronium/Hydroxide concentration

2. Relate liquid color to pH.

3. Predict if dilution and volume will increase, decrease or not change the pH

4. Organize a list of liquids in terms of acid or base strength in relative order with supporting evidence.

5. Write the water equilibrium expression. Describe how the water equilibrium varies with pH.
1. The color of a solution identifies if it is an acid, base, or neutral solution.

A. True  B. False  C. red is acid & clear is base
2. Which solution is basic?

A. pH: 6.50
B. pH: 7.40
C. pH: 12.06

D. More than one
E. None
3. Which solution is acidic?

A

B

C

D. More than one

E. Difficult to tell
4. Which solution is basic?

A. $1.0 \times 10^{-7}$

B. $1.0 \times 10^{-2}$

C. $8.1 \times 10^{-4}$

D. $1.2 \times 10^{-11}$

E. $4.3 \times 10^{-3}$

F. $2.4 \times 10^{-12}$

D. More than one

E. None
5. Which solution is acidic?

A. $3.01 \times 10^{18}$
B. $9.65 \times 10^{20}$
C. $3.01 \times 10^{10}$
D. More than one
E. None
6. How will adding water effect the pH?

A. Increase the pH
B. Decrease the pH
C. No pH change
A: more water lessens the acidity, so pH goes up
7. How will equal amount of water effect the pH?

A. Increase the pH
B. Decrease the pH
C. The pH will be cut in half
D. No pH change
B: more water lessens the basicity, so pH goes down, from 10 to 9.7, but not by 2 (log scale)
8. What is the order from most acidic to most basic?

A. A B C
B. A C B
C. B A C
D. C B A
E. C A B
9. What is the order from most acidic to most basic?

A. A B C
B. A C B
C. B A C
D. C B A
E. C A B
10. If spit has a pH = 7.4, what does that tell you about the water equilibrium?

$2\text{H}_2\text{O} \rightleftharpoons \text{OH}^- + \text{H}_3\text{O}^+$

A. Something was added that made the equilibrium shift left
B. Something was added that made the equilibrium shift right
C. pH has nothing to do with the water equilibrium
Answer to 10
Since the pH is not 7, then something was added to make the equilibrium shift left. For example, if NaOH was added to water, OH\(^-\) is immediately in the solution and some of it will react with the H\(_3\)O\(^+\), so the pH (which is inversely related to [H\(_3\)O\(^+\)]), goes up.
If something like HCl were added there would be more H\(_3\)O\(^+\), which would also cause a shift left, but there would be less OH\(^-\), (which is directly related to pH), so the pH is less than 7.