pH Activity

Overview
In this activity, students will learn how to calculate hydrogen ion concentration from pH and vice versa. Students will work with pOH and hydroxide ion concentrations as well. Students will also investigate the relationship between pH and pOH with solutions at room temperature. The pH virtual instrument, VI, will be used in performing and checking calculations as well as building a conceptual understanding of the concept of pH.

Objectives
Students will be able to:

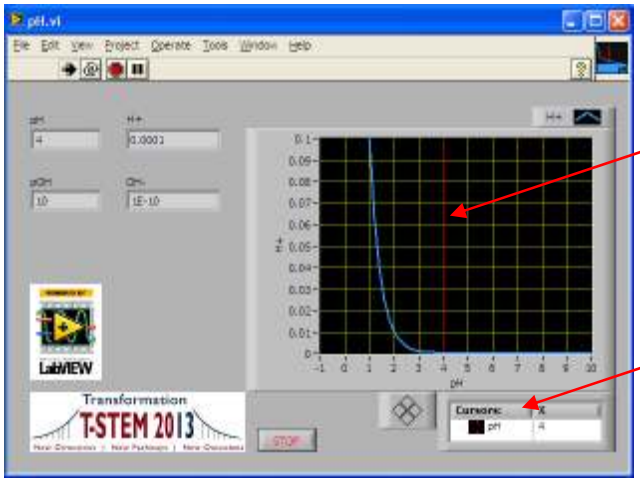
- Calculate pH, pOH, and the H^+ or OH^- ion concentrations

Standards (TEKS)
IPC 9B

Activity
pH as a measure of the concentration of hydrogen ions, H^+. pH is the negative logarithm of H^+, i.e. $pH = -\log(H^+)$.

1) Open and run the pH virtual instrument, VI.

The pH VI has a graph of hydrogen ion concentrations, H^+, as a function of pH. In the graph, there is a red vertical line on the graph called a cursor. You can click and drag on the vertical line of the cursor to select a particular value for pH.



A particular value of pH can be set using the cursor legend below the graph. Simply double-click on the number displayed and set it to the desired amount of time.

The VI also has indicators to show the selected pH and the calculated values of H^+, pOH, and the concentration of hydroxide ions, OH^-.

Let's focus on the relationship between pH and hydrogen ion concentration to start.

2) Click and drag the vertical red line of the cursor to the right.
    a) Notice the pH increases.
    b) What happens with **H^+** as pH increases?
    c) What will happen to **H^+** if pH was to decrease?

Since pH is a measure of H^+ ion concentration, these questions are a bit backward. The relationship between the two values is what is important to notice.

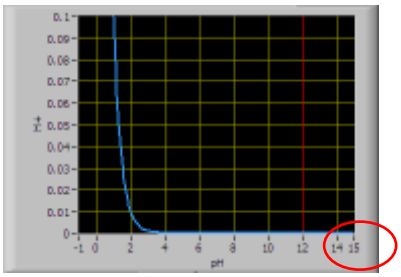
3) If H^+ increases, what happens to pH?
4) If H^+ decreases, what happens to pH?
5) Which solution has a higher concentration of hydrogen ions?
    a) Solution A has a pH of 7
    b) Solution B has a pH of 4

Like a calculator, the VI uses E in scientific notation to mean "times ten to the". That is, 1E-8 = 1 x 10^{-8}, which of course equals 0.00000001.

6) Use the VI to check your answer.
    a) Use the cursor to set the pH to 7. What is the **H^+** ion concentration?
    b) Now, set the pH to 4. What is the **H^+** ion concentration?
    c) Which solution has the higher concentration of hydrogen?

Remember, $pH = -\log(H^+)$. With a scientific or graphing calculator and this formula, you can calculate the pH of a solution if you know the hydrogen ion concentration, H^+.

7) Use the formula to calculate pH for the following H^+ ion concentrations.
    a) 0.001 M
    b) 0.0000000001 M
    c) 1 x 10^{-7} M
    d) 1 x 10^{-12} M
8) Check your work with VI.
    a) Set the pH to each of your answers.
    b) The limits on the graph can be set as needed.
    c) Does the hydrogen ion concentration match?



By now, you may have noticed a direct relationship between the exponent on the 10 and pH when H^+ is given in scientific notation. If not, you will after this next set of questions.

9) Calculate pH of a solution with each of the following H^+ values.
   a) 1×10^{-6} M
   b) 1×10^{-3} M
   c) 1×10^{-8} M
   d) 1×10^{-11} M
10) Do you see the pattern? What is the pH of a solution with a hydrogen ion concentration of 1×10^{-n} M?
11) What is the hydrogen ion concentration of a solution with a pH of 4?

pOH is similar in concept to pH. pOH is a measure of the hydroxide ion concentration, OH^-. pOH is the negative logarithm of OH^-. That is, $pOH = -\log(OH^-)$

At room temperature, the sum of the pOH and pH of a solution is about 14. Said another way, $pOH + pH = 14$. If we solve that formula for pOH, we have a formula for pOH when the pH is known. That formula is $pOH = 14 - pH$.

12) For each of the pH values, calculate the pOH.
   a) 2
   b) 4
   c) 7
   d) 0
13) What happens to pH as pOH:
   a) Increases?
   b) Decreases?
14) Check this out with the VI.
   a) Click and drag the vertical red line of the cursor to the right.
   b) Click and drag the vertical red line of the cursor to the left.
   c) Make note of what happens to pOH as pH changes.

Calculating pOH with the formula, $pOH = -\log(OH^-)$, is much like calculating pH from H^+.

15) Calculate pOH for the following hydroxide ion concentrations.
   a) 0.0001 M
   b) 0.0000001 M
   c) 1×10^{-4} M
   d) 1×10^{-2} M

Using $pOH + pH = 14$ as a bridge, it is possible to know pH, pOH, and the H^+ or OH^- ion concentrations as long as you know one of the values.

16) If H+ ion concentration is 0.000001 M, find pH, pOH, and OH^- ion concentration.
17) If the hydrogen ion concentration of a solution is 1×10^{-9} M, find the hydroxide ion concentration.
18) What is the H_3O^+ ion concentration of a solution of a solution with OH^- ion concentration of 1×10^{-3} M?
19) Check your answers to the last couple of questions with the VI.
20) Stop the VI. You are done.