

Name _____

pH Scale

You're probably familiar with the sour taste of acidic lemon juice and the slippery feel of alkaline (basic) soap. In fact, these characteristics were used to identify acids from bases long ago. Today, we understand much more about acidity and alkalinity, far beyond taste and feel.

Acids are most simply defined as **proton donors**. They are substances that react with water to **produce H_3O^+ (hydronium) ions** (after all, $\text{H}_2\text{O} + \text{one proton} \rightarrow \text{H}_3\text{O}^+$). When you add an acid to water, the water acts as a base, accepting protons from the acid.

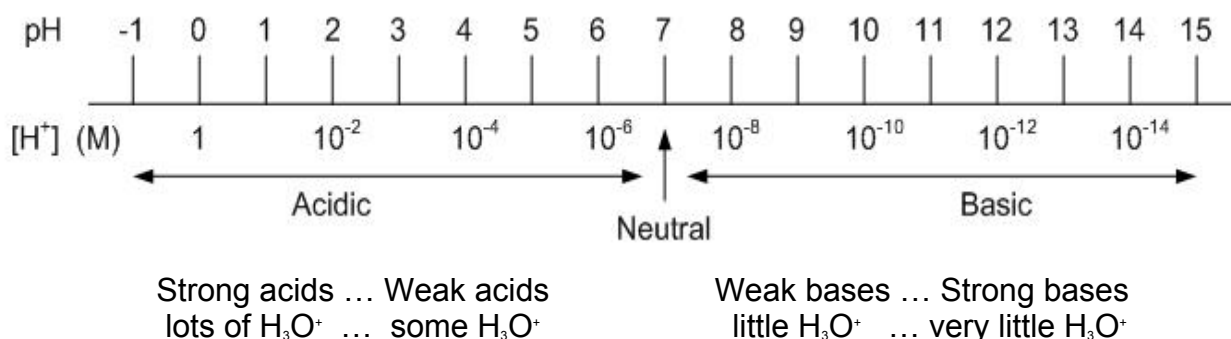


Bases are most simply defined as **proton acceptors**. They react with water to **produce OH^- (hydroxide) ions** ($\text{H}_2\text{O} - \text{one proton} \rightarrow \text{OH}^-$). When you add a base to water, the water acts as an acid, donating protons to the base.



Some acids and bases ionize only partially in water, while others ionize almost entirely. To quantify how many molecules of an acid or base ionize in water (which we call the strength of the solution), we use the pH scale. A solution's place on the pH scale illustrates how many hydronium (H_3O^+) ions are present in that solution. The pH scale is centered around 7, because water contains 1×10^{-7} moles of H_3O^+ ions per liter. A solution with 100x more H_3O^+ ions than water has 1×10^{-5} moles of H_3O^+ per liter, which gives it a pH of 5. This would be considered a weak acid. A solution with 1,000,000x more H_3O^+ than water has 1×10^{-1} moles of H_3O^+ ions per liter. Any such substance has a pH of 1 and is considered a strong acid. On the other side, a solution with 1/100 the H_3O^+ ion concentration of water has 1×10^{-9} moles of H_3O^+ ions per liter. This solution has a pH of 9 and is considered a weak base.

This complicated logarithmic calculation gives us a simple 0-14 pH scale:



Procedure:

- A. Go to phet.colorado.edu.
- B. Click on the *Chemistry* tab.
- C. Choose the *pH Scale* simulation.
- D. Click on *Run in HTML5*, then choose the *Micro* tab.
- E. Add battery acid, then use the bottom faucet to drain the tank until 0.1 L remains.

1) Record the pH of the solution:

2) How many moles of H_3O^+ (hydronium) ions are present in each liter of the solution?

***Answer in scientific notation and decimal form.

Recall how pH relates to the exponent of the concentration of H_3O^+ ions.

3) How many moles of H_3O^+ ions are present in 0.1 L of the solution (the volume in the cup)?

F. Add water until there is 1 L of solution in the container. *Compared to the H_3O^+ in the battery acid, the H_3O^+ in the water is negligible.* So, we can consider the **amount of H_3O^+** in the diluted solution to be **unchanged** by the added water.

4) Since the amount of hydronium is essentially unchanged, how many moles of H_3O^+ ions are present in the liter of diluted solution?

5) What is the new concentration of H_3O^+ ions, in moles per liter?

6) What is the pH of the new diluted solution?

7) Explain why diluting the battery acid increased the pH by 1.

G. Drain the 10% battery acid solution until 0.1 L remains. Be careful not to drain too much of the solution. If you drain too much, you will have to restart the experiment from the beginning.

H. Pour water into the container until the volume again reaches 1 liter. Be careful not to pour too much water into the solution.

8) After again increasing the volume by a factor of 10, what is the new concentration of H_3O^+ ions?

9) What is the pH of the new solution?

I. Drain the 1% battery acid solution until 0.1 L remains.

J. Pour water into the container until the volume again reaches 1 liter.

10) After again increasing the volume by a factor of 10, what is the new concentration of H_3O^+ ions?

11) What is the pH of the new solution?

K. Drain the 0.1% battery acid solution until 0.1 L remains.

L. Pour water into the container until the volume again reaches 1 liter.

12) After again increasing the volume by a factor of 10, what is the new concentration of H_3O^+ ions?

13) What is the pH of the new solution?

M. Drain the 0.01% battery acid solution until 0.1 L remains.

N. Pour water into the container until the volume again reaches 1 liter.

14) After again increasing the volume by a factor of 10, what is the new concentration of H_3O^+ ions?

15) What is the pH of the new solution?

O. Drain the 0.001% battery acid solution until 0.1 L remains.

P. Pour water into the container until the volume again reaches 1 liter.

16) After again increasing the volume by a factor of 10, what is the new concentration of H_3O^+ ions?

17) What is the pH of the new solution?

18) Why did the pH increase by a lesser amount than previous dilutions? *Is the italicized statement in step F still true? What happens to the difference between the solution's H_3O^+ ion concentration and water's H_3O^+ ion concentration each time you dilute the solution?*

Q. Use the *Custom* tab at the bottom to answer the following questions. Manipulate the amount of hydronium and hydroxide in the custom solution.

19) As the H_3O^+ ion concentration decreases, the pH _____.

20) The product of a solution's H_3O^+ concentration and its OH^- concentration must always be 1×10^{-14} . So, if a solution's H_3O^+ concentration goes down, the solution's OH^- concentration must go _____. In other words, if we have **less hydronium**, we must have _____ **hydroxide**.