# Connected Chemistry
## Acids & Bases Unit
### Lesson 4: Introduction to the pH Scale

## Student's Lesson at a Glance

### Lesson Summary

This lesson contains three activities that briefly introduce students to the pH scale. The purpose of this unit is to create real-world connections to pH and the study of acids and bases. This lesson contains the first wet lab in the unit.

### SWBAT (Students Will Be Able To)

- Know pH is a scale to measure the acidity of a solution based on the relative concentration of $OH^-$ ions and/or $H_3O^+$ ions

### 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

- 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 $H_3O^+$.
- Depending on the textbooks being used in your class, the term "basic" may also be referred to as "alkaline."
- Remember that molar concentration is represented by enclosing the substance in square brackets. For example: $[OH^-]$ refers to the molar concentration of $OH^-$ ions.

## Notes

## Homework

## Upcoming Quizzes/Tests

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## Activity 1: Connecting

1. Draw a submicroscopic picture of how you think acids and bases look. *Describe your answer.*

| Draw a submicroscopic picture of an acid. | Draw a submicroscopic picture of a base |
|---|---|
| | |
| **Description of your answer:** | **Description of your answer:** |

### pH Scale

pH = **0** acidic

pH = **7** neutral

pH = **14** basic

This lesson explores the pH scale and its relationship to acids and bases. You may have heard of the pH scale in other science classes. In 1909, a Danish scientist named S.P.L. Sørensen proposed the use of a logarithmic pH scale to express the concentration of **hydrogen ions** ($H^+$) and **hydroxide ions** ($OH^-$) in aqueous solutions. Scientists later discovered that hydrogen ions only exist for a brief time because they react almost instantly with water to form **hydronium ions** ($H_3O^+$).

$$H^+ (aq) + H_2O (l) \rightleftharpoons H_3O^+ (aq)$$

Thus, scientists today use the concentration of hydronium ions instead of the hydrogen ions originally proposed by Sørensen to determine pH. The pH scale was developed from the measurement of the concentration of hydroxide and hydronium ions. The figure above shows an example of a pH scale. **Acidic** substances have a pH value less than 7 on the scale. **Basic**

substances have a pH greater than 7 on the scale. Basic substances can also be called **alkaline substances**. **Neutral** substances have a pH of exactly 7, which is the midpoint of the pH scale.

Many of the substances that you come into contact with at home represent a wide range of pH values. Acids, such as hydrochloric acid, phosphoric acid, and citric acid are used in industry to make stain removers, toilet bowl cleaners, and rust removers. Bases, such as sodium hydroxide, potassium hydroxide, and ammonium hydroxide, are used to make soaps, oven cleaners, and drain openers. Even the foods you eat and drink, like fruits, may be acidic or basic!

2. What other food items do you think may be acidic?

3. Do you think bases have more hydroxide or hydronium ions? Why?

4. Do you think acids have more hydroxide or hydronium ions? Why?

## Activity 2: pH Wet Lab

Students use an inquiry-based approach to design procedures, create hypotheses, and develop data collection methods for determining the pH of household items.

## Activity 3: Teacher Facilitated Discussion

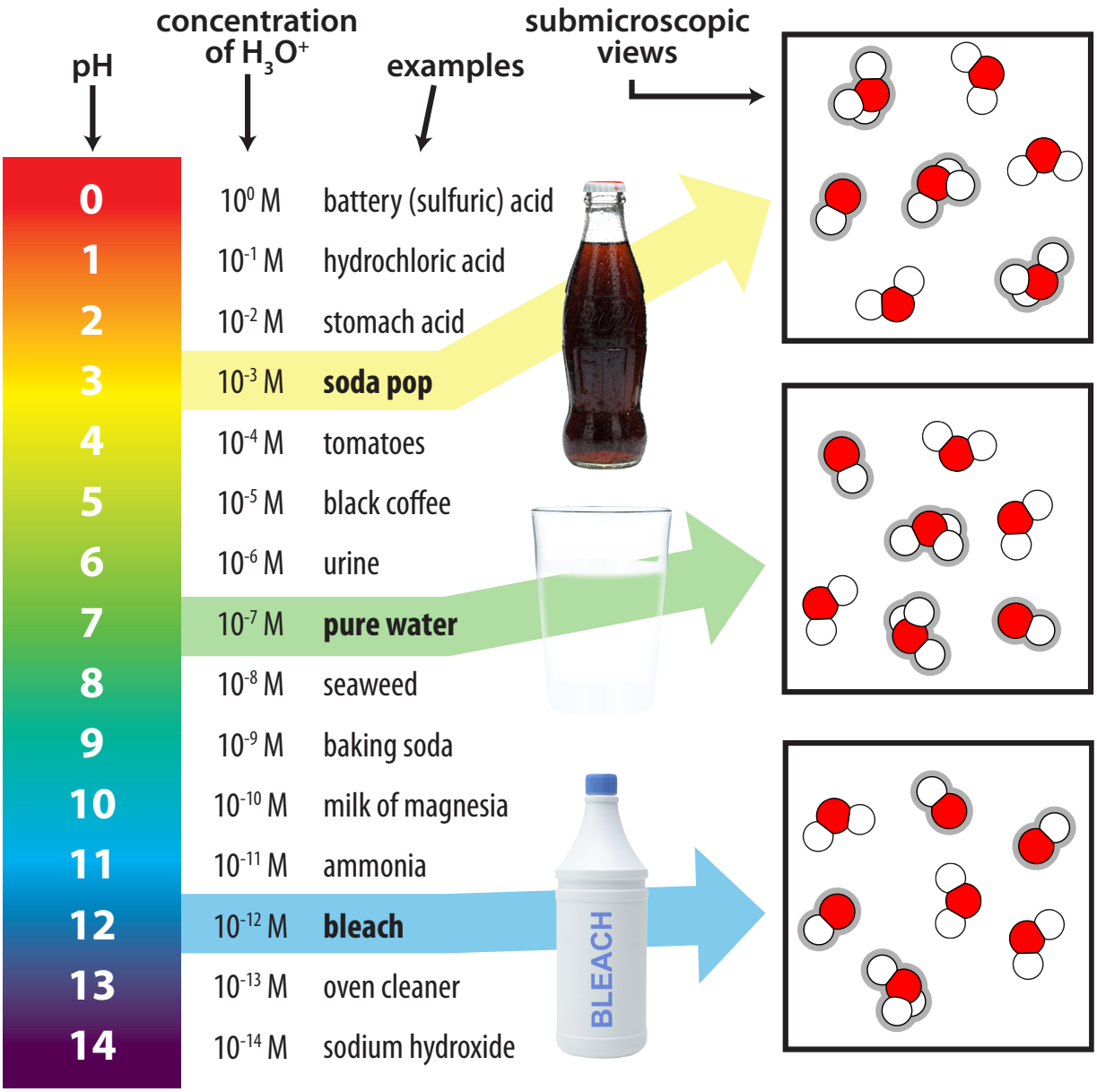
*Read the following paragraph as a class.*

The pH scale has many real-world applications. Understanding how pH is measured is important to the work of many professionals, such as doctors, hair dressers, and chefs. Eating foods with certain pH levels can have effects on the internal functions of your body. For example, eating foods that have high concentrations of acid (low pH) can cause damage over time to the enamel on your teeth and irritate ulcers in your digestive system.

| pH | $[H_3O^+]$ |
|---|---|
| **0** | $10^0 = 1\ M$ |
| **1** | $10^{-1} = 0.1\ M$ |
| **2** | $10^{-2} = 0.01\ M$ |
| **3** | $10^{-3} = 0.001\ M$ |

The pH scale is based on a **logarithmic base-10 scale.** This means that a change of one pH unit indicates that the hydronium ion concentration changes by a factor of ten. For example, take a look at the table above for hydrochloric acid.

A pH of 0 has 10 times more hydrogen ion concentration than a solution with pH of 1. A pH of 0 also has 100 times more hydrogen ion concentration than a solution with pH of 2. As the pH increases by 1 unit, the change in concentration changes by a factor of 10. The hydronium concentration on the pH scale varies over fifteen **powers of 10** on a pH scale that ranges from 0-14.




The picture above gives you a look at pH from the macroscopic view all the way down to the submicroscopic view of a few of the substances listed on the pH scale. It also tells you the concentration of $H_3O^+$ for each pH. *As a small group, answer the following questions and be ready to discuss your ideas with the whole class. Make sure you take notes so you can discuss the ideas generated by your group.*

5. What is the relationship between the concentration of $H_3O^+$ ions and how it is classified on the pH scale? Be as specific as possible.

6. Using the picture above, what is the difference between the soda, water, and bleach from the submicroscopic view? Be as specific as possible.

7. Based on your answers for questions 5 and 6, define an acid in your own words.

8. Based on your answers for number 5 and 6, define a base in your own words.

9. How much greater is the concentration of hydronium ions in soda than in water?

The role of acids and bases can also be observed in the natural world. Some plants and flowers change color based on the pH of the soil in which they grow. Hydrangea flowers planted in acidic soils produce blue flowers. In comparison, hydrangea flowers planted in neutral soils produce very pale, cream-colored petals and basic soils produce pink or purple flowers.

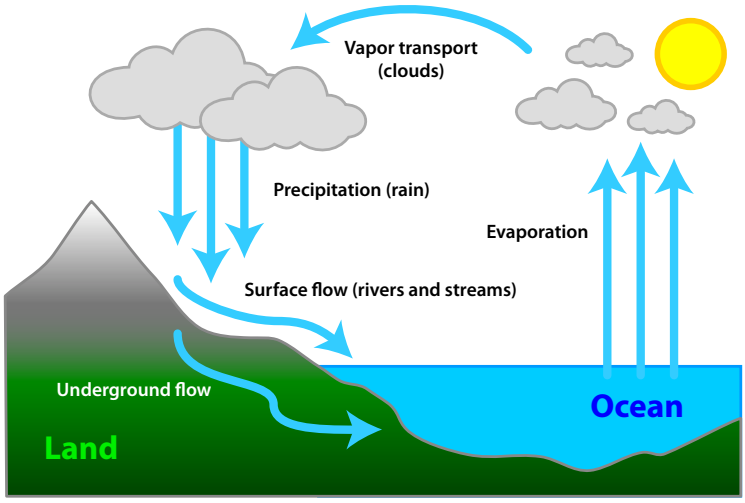
The pH level of the human body is also very important because the speed of the body's biochemical reactions, including those utilizing enzymes, are dependent on pH. Enzymes will only properly function within a specific pH range. If the environment changes out of that range, the enzymes will no longer help to speed up biochemical reactions, which can lead to poor health.

10. Blood has a pH of 7.4. Why do you think that blood has an almost neutral pH?

11. What do you think happens if your blood becomes too acidic or basic?

12. What could be the result of eating foods with a high concentration of $H_3O^+$?

Acid rain is an environmental threat caused by the combination of industrial air pollution and the water cycle. Your teacher may have discussed with you some safety concerns while working with acids and bases.




## Lesson Reflection Question

13. Using the water cycle diagram above, what can you infer about the effects of acid rain on the environment? *Be specific when discussing what living and nonliving things could be impacted.*