

How Acidic are the Things We Drink?
Measuring the pH of Common Drinks
(Teacher's Guide)

OVERVIEW

Students will measure the pH of different kinds of beverages (soda pop, juice, coffee and milk) using the Ward's DataHub pH sensor. The results will then be arranged in order from lowest to highest pH. In conclusion, students should relate the excessive consumption of acidic beverages to physical symptoms that people experience.

MATERIALS NEEDED

Ward's DataHub
USB connector cable*
pH sensor
Tape to mark the beakers
Wash bottle
Distilled Water
Beakers or some other containers
Juice (apple juice, orange juice, or grape juice)
Milk
Coca Cola®
Sprite®
Coffee
Paper towels

* – *The USB connector cable is not needed if you are using a Bluetooth enabled device.*

NUMBER OF USES

This demonstration can be performed repeatedly.

FRAMEWORK FOR K-12 SCIENCE EDUCATION © 2012

* The Dimension I practices listed below are called out as **bold** words throughout the activity.

Dimension 1 Science and Engineering Practices	✓	Asking questions (for science) and defining problems (for engineering)		Use mathematics and computational thinking
	✓	Developing and using models	✓	Constructing explanations (for science) and designing solutions (for engineering)
	✓	Planning and carrying out investigations	✓	Engaging in argument from evidence
	✓	Analyzing and interpreting data	✓	Obtaining, evaluating, and communicating information

Dimension 2 Cross Cutting Concepts	✓	Patterns		Energy and matter: Flows, cycles, and conservation
		Cause and effect: Mechanism and explanation	✓	Structure and function
	✓	Scale, proportion, and quantity		Stability and change
		Systems and system models		

Dimension 3 Core Concepts	Discipline		Core Idea Focus	
	Physical Science		PS1: Matter and Its Interactions	
			PS1.A: Structure and Properties of Matter	

NGSS Standards	Middle School Standards Covered		High School Standards Covered	
	MS.PS-SPM: Structure and Properties of Matter		HS.PS-SPM: Structure and Properties of Matter	

NATIONAL SCIENCE EDUCATION STANDARDS © 2002

Content Standards (K-12)			
✓	Systems, order, and organization	✓	Evolution and equilibrium
✓	Evidence, models, and explanation	✓	Form and Function
✓	Constancy, change, and measurement		

Physical Science Standards Middle School		Physical Science Standards High School	
✓	Properties and Changes of Properties in Matter	✓	Structure of Atoms
	Motion and Forces	✓	Structure and Properties of Matter
	Transfer of Energy		Chemical Reactions
			Motion and Forces
			Conservation of Energy and Increase in Disorder
			Interactions of Energy and Matter

✓ Indicates Standards Covered in Activity

LEARNING OBJECTIVES

Core Objectives (National Standards):

- Develop the ability to refine ill-defined questions and direct to phenomena that can be described, explained, or predicted through scientific means.
- Develop the ability to observe, measure accurately, identify and control variables.
- Decide what evidence can be used to support or refute a hypothesis.
- Gather, store, retrieve, and analyze data.
- Become confident at communicating methods, instructions, observations, and results with others.

Activity Objectives:

The objective of this activity is to compare the pH of carbonated drinks, juices, and other drinks, formulate a hypothesis and proceed to check it using the Ward's DataHub pH sensor.

Time Requirement:

45-60 minutes

VOCABULARY

Alkalies: Chemical compounds that neutralize or effervesce with acids.

Acids: A chemical substance that neutralizes bases. Likewise a molecule or other entity that can donate a proton or accept an electron pair in reactions.

Bases: A substance capable of reacting with an acid to form a salt and water. Likewise, capable of accepting or neutralizing hydrogen ions.

Hydronium Ion: The ion H_3O^+ , consisting of a protonated water molecule and present in all aqueous acids.

Hydroxide Ion: The ion OH^- , denoting a water molecule that has lost a proton.

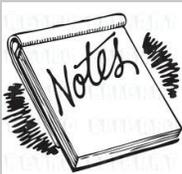
Ions: Atoms or molecules with a net electric charge due to the loss or gain of one or more electrons.

Neutralization: A chemical reaction in which an acid and a base interact with the formation of a salt; with strong acids and bases the essential reaction is the combination of hydrogen ions with hydroxyl ions to form water.

Neutral Solution: Any solution in which the H_3O^+ and OH^- ion concentrations are equal.

pH: A figure expressing the acidity or alkalinity of a solution on a logarithmic scale on which 7 is neutral, lower values are more acidic, and higher values are more alkaline.

pH Scale: A scale from 0 to 14 reflecting the concentration of hydrogen ions in solution; the lower numbers denote acidic conditions and the upper numbers denote basic, or alkaline, conditions.



Teacher Notes

INTRODUCTION

Have you ever felt a burning sensation at the top of your stomach after a large meal, or having a specific food or beverage? It could even happen with something healthy like a seasoned lettuce with lemon juice. This feeling is known as heartburn. Heartburn is caused by excessive consumption of certain substances that can change the normal acidity of our stomach. Do you know exactly what the concept of “acidity” means? In this class, we invite you to discover the true meaning of this word, and to measure how acidic different beverages that we often drink really are.

- **Can you name some popular drinks that people consume on a regular basis? Try to organize them according to their degree of acidity.**
- **Have you ever heard about the term “pH”? What do you think it refers to?**

Carry out the experiment with your class so that at the end students will be able to answer the following question:

- **How acidic are common beverages?**

BACKGROUND

When we talk about acid and alkaline, we are referring to the amount of hydrogen present in a solution. Acid raises the concentration of hydrogen, while an alkali lowers the hydrogen concentration. To know if a substance is acid or alkaline, we measure the pH (potential of hydrogen), with a pH meter and probe. The pH is measured on a scale of 1 to 14. The higher the pH, the more alkaline (or base) the solution, 1 is the most acidic and 14 the most alkaline. If the pH is 7, it is considered neutral, below this value it is considered acidic and above basic. Inside our stomach, we can find a pH 1 (extremely acidic), wine has a pH of 3.5, blood 7.35, sea water 8.5, etc.



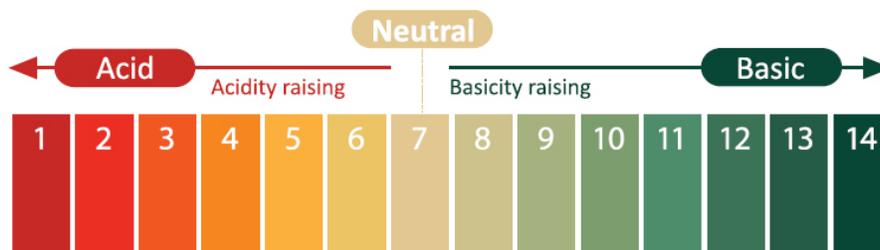
DID YOU KNOW?

Sulfuric acid is a strong mineral acid which is highly corrosive. It is used to produce almost all car batteries. It is also known as oil of vitriol.



Every solution inside or outside the human body is acid, alkali or neutral. This means that blood, gastric juice, wine, coffee and so on each have a specific pH.

Inside the human body under ideal conditions, we should find an acidity degree between 7.35 and 7.45, this means slightly basic.



Inside our organs, it is vital to maintain a certain acid-base balance, because a lot of metabolic reactions that perform fundamental roles inside our body can only happen at precise levels of acidity or basicity. A small change in the pH of the solution can affect the rate of important chemical reactions that our metabolism depends on, so risking the natural processes that occur in our body.

For example, during exercise the acidity of the muscles rises because of the generation of lactic acid. This causes pain and a decrease of voluntary muscle contraction.

At this point, encourage students to formulate a hypothesis to test as part of this activity. Students may find it helpful to formulate their hypothesis as an answer to the following questions:

- **If you have a carbonated drink, juice beverage and glass of milk, do you think there is a difference in their pH? Which one do you expect to be more acidic and which one more basic?**

CONNECTING THE WARD'S DATAHUB TO A COMPUTER

If you are using a Bluetooth communication device:

Right-click on the Bluetooth icon in the lower right corner of the screen and select the Ward's DataHub you are using. The icon will change from gray to blue, as shown at right, indicating that the Ward's DataHub and the computer are now connected via Bluetooth.



If you are using a USB communication device:

In order to use USB communication, connect the Ward's DataHub and the computer with the USB cable supplied. Click on the USB icon at the lower right corner of the screen. This icon will change from gray to blue, as shown at right, indicating that the Ward's DataHub is connected to the computer via USB.



USING THE WARD'S DATAHUB



= Select key



= On/Off and Escape key



= Scroll key

To collect measurements with the Ward's DataHub, it must first be configured as follows:

1. Turn on the Ward's DataHub by pressing the On/Off/Esc key.		8. Press the On/Off/Esc key to return to the setup menu.	
2. Go to setup by using the Scroll key then select Setup by pressing the Select key.	 then 	9. Press the Scroll key to highlight the Number of Samples and then press the Select Key.	 then 
3. Select the Set Sensors option by pressing the Select key.		10. Press the Scroll key until "Manual" is highlighted, then press the Select key.	 then 
4. If any sensor(s) appear on the screen, press the key representing that sensor to deactivate it. Once you have a blank window, press the pH Sensor key once.		11. Press the On/Off/Esc key Three times to return to the main operating screen.	 x 3
5. Press the On/Off/Esc key once to return to the setup menu.		12. Press the Select key to start measuring. (You are collecting data when there is an icon of a Runner in the upper left hand corner of the screen.)	
6. Press the Scroll key to highlight the Sampling Rate and then press the Select Key	 then 	13. Once you have finished measuring, stop the Ward's DataHub by pressing the Select key, followed by the Scroll key.	 then 
7. Press the Scroll key until "Manual" is highlighted, then press the Select key.	 then 		



DID YOU KNOW?

In order to make carbonated beverages fizzy, carbonic acid is added. Carbonic acid (H_2CO_3) decomposes in the drink to form bubbles of carbon dioxide (CO_2).



ACTIVITY

- The pH sensor is very sensitive and must be handled with care. When using the pH sensor, note the following:**
 - After each measurement, the pH probe should be cleaned with distilled water. Always keep the wash bottle and distilled water close at hand. If you don't have a wash bottle, you will need a syringe of at least 10 mL in order to clean the sensor properly.
 - Following each time the sensor is washed, ensure it is dried with absorbent paper, without touching the transparent ball at the tip of the sensor.
 - Whenever the sensor is not used, it must stay inside the buffer solution inside the jar. Ensure the sensor is always cleaned and dried properly before inserting the tip of the sensor into the solution (see notes above).
- Take the five beakers and mark each of them with the name of the liquid you will analyze (e.g., milk).
- Put a small amount of the liquid inside the beaker, about 50 mL (you should be able to completely insert the tip of the sensor into the liquid).
- To start measuring, remove the electrode from the buffer and clean it with plenty of distilled water. Dry it with absorbent paper.
- Measure the pH of the different liquids inside the beakers in the following order: Cola soda, Clear soda, Juice, Coffee, and Milk.
- To collect data, put the electrode inside the liquid without touching the sides of the beaker.
- Press the  button on the Ward's DataHub.
- Observe the pH variation displayed on the Ward's DataHub.
- Wait until the pH value you are measuring stabilizes. It is ready when the second decimal displayed on the screen varies between +/- 0.01.
- Once you have taken the measurement, clean the electrode again with distilled water and dry using the absorbent paper.



DID YOU KNOW?

Vitamin C is actually an acid. It is called ascorbic acid and a lack of this acid in our bodies can lead to a disease called scurvy. Pirates often had scurvy because they did not eat enough food containing ascorbic acid (such as lemons, limes and oranges). They knew they had it when their teeth started falling out, and their skin became very pale.



11. Follow Steps 5 -10 for the remaining liquids.
12. Once you have finished measuring, turn the Ward's DataHub off.
13. Remember to wash the sensor after each measurement with plenty of water, rinsing well the tip of the electrode.
14. Once you have finished, remember to place the sensor back inside the buffer solution.



DID YOU KNOW?

After eating certain foods, your stomach may feel acidic. When this happens, most people take an antacid. This helps to neutralize the acid produced naturally in our stomachs. Antacids are typically made of two bases, aluminum hydroxide or magnesium hydroxide. Both of these help neutralize the hydrochloric acid in our stomachs.

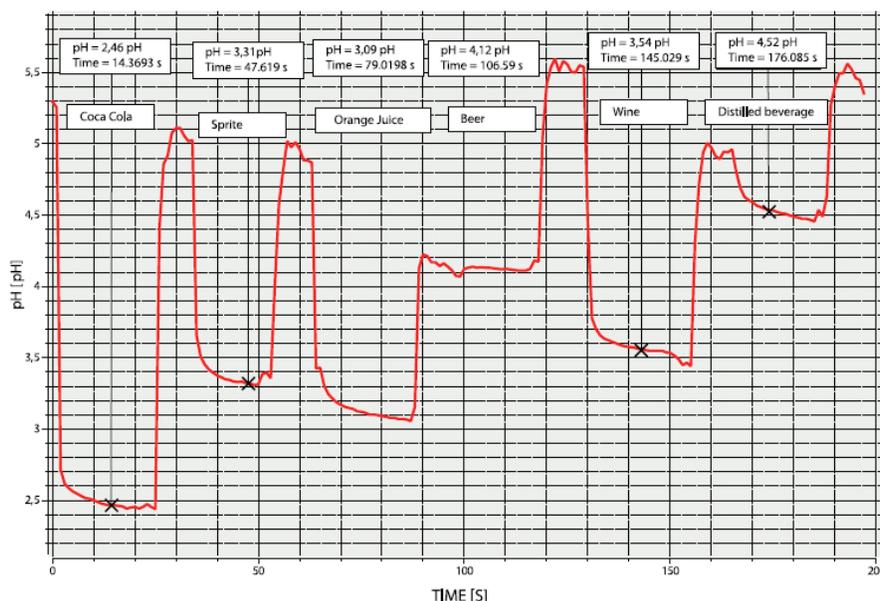


RESULTS AND ANALYSIS

The following steps explain how to analyze the experiment results.

1. Connect the Ward's DataHub to the computer using the Bluetooth wireless communication channel or USB connector.
 2. In the top menu, click on the  button and select the  button.
 3. Select the last experiment on the list.
 4. Observe the graph displayed on the screen.
 5. Press the  button and write notes on the graph, specifying your observations according to the moment you registered the data.
 6. Click the  button and select points on the graph. Pick one representative point for each solution (the representative points are the ones achieved once the measurement reaches a plateau).
- **How did your results relate to your initial hypothesis? Explain.**
 - **Which was the most acidic liquid you analyzed? Which one was the most basic?**
 - **Using the data you collected, locate each liquid you tested on the pH scale.**

The graph below should be similar to the one the students come up with.



CONCLUSIONS AND ASSESSMENTS

1. How does the proton (hydrogen) concentration of cola soda compare to that of milk and coffee? **Explain.**

Students should explain that the proton concentration of the cola soda is higher than that of the coffee and the milk, because it has a lower pH value; therefore, it is more acidic.

2. What are the variations in pH between the soda and the milk? What could be the reason for this difference? **Explain.**

Students should point out that soda is more acidic than the milk and that this is related to the hydroxyl group (OH⁻). The hydroxyl group of the milk substances raises the pH (making the solution more basic).

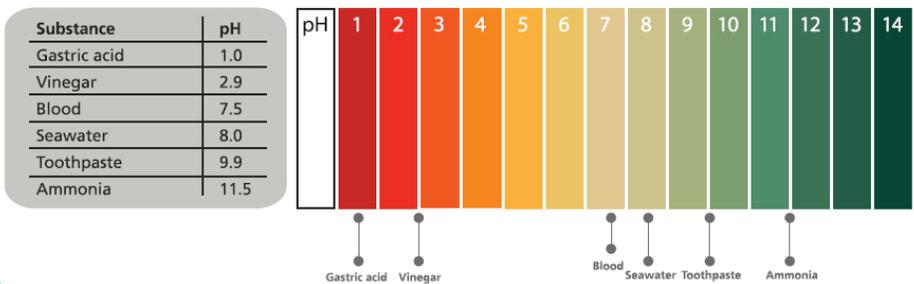
3. Write a concluding paragraph describing what you observed during the experiment.

Students should reach the following conclusions:

Students will be more familiar with carbonated drinks, realizing that despite their sweet flavor this type of drink is more acidic than a glass of milk. The most acidic soda is cola, which means that it has a higher hydrogen concentration than other analyzed substances.

ACTIVITIES FOR FURTHER APPLICATION

The aim of this section is for students to extrapolate the knowledge acquired during this class and apply it to different contexts and situations. Furthermore, it is intended that students question and present possible explanations for the experimentally observed phenomena.



1. Explain the symptomatology we experience when our gastric acid becomes more acidic or basic.

Students should establish the negative effects of an abrupt pH variation in the stomach, knowing it normally is in the range of 1.0 - 2.0. Students should understand that a sudden drop of this value may cause heartburn and a sudden rise may cause a "heavy" feeling in our stomach.

2. How are our teeth affected by excessive consumption of acidic beverages?

Students should establish that excessive consumption of acidic beverages causes dental erosion. This means the tooth enamel (the hard, protective coating of the tooth) is lost because of the acid attack. Sometimes the enamel is worn away and the dentine underneath is exposed. In extreme cases, erosion may even reach the nerve. This can cause tooth decay, together with weakening and demineralization, which causes dental sensibility.

How Acidic are the Things We Drink?
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(*Student Guide*)

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- **Can you name some popular drinks that people consume on a regular basis? Try to organize them according to their degree of acidity.**
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After carrying out this experiment, you should be able to answer the following question:

- **How acidic are common beverages?**

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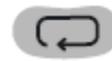
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- Once you have taken the measurement, clean the electrode again with distilled water and dry using the absorbent paper.
- Follow Steps 5-10 above, for the remaining liquids.
- Once you have finished measuring, turn the Ward's DataHub off.
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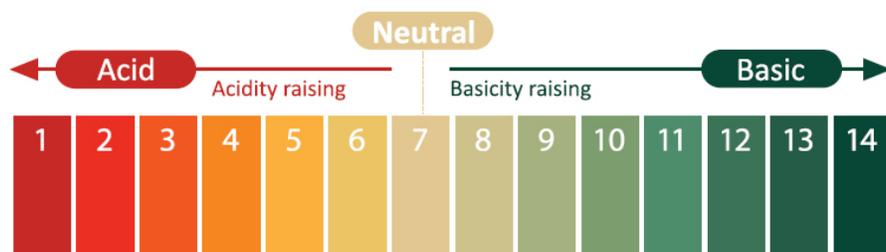
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CONCLUSIONS AND ASSESSMENTS

1. How does the proton (hydrogen) concentration of cola soda compare to that of milk and coffee? **Explain.**

2. What are the variations in pH between the soda and the milk? What could be the reason for this difference? **Explain** your answer in terms of the data gathered.

3. Write a concluding paragraph describing what you observed during the experiment.
