Lesson Plan: Why Drink Gatorade?

FOR THE TEACHER

Summary
In this lesson, students will test different flavors of Gatorade and other liquids to investigate acids and bases. This will take several days unless students already know about acids and bases.

Resource Type
Lesson plan

Grade Level
Middle school

Objectives
By the end of this lesson, students should be able to
- Explain, on the molecular level, that pH is a measure of the concentration of the \( \text{H}_3\text{O}^+ \) ions in water and that adding an acid or a base to water affects the concentration of these ions.
- Design an experiment to classify an unknown liquid either as an acid or a base.
- Identify liquids as either an acid, base, or neutral by its pH or reaction to an indicator.
- Identify variables in an experiment.

Chemistry Topics
This lesson supports students’ understanding of
- Acids & bases
- pH
- Chemical changes
- Solutions
- Conductivity

Time
Teacher Preparation: 1 hour
Lesson: 2 class periods (45 minutes each)

Materials
For each group:
- Depression plates filled with 12 liquids or beakers filled & labeled with liquids (such as rubbing alcohol, dilute sodium hydroxide, vinegar, tap water, distilled water, several flavors of Gatorade, soda pop, lemon juice, liquid soap, dilute sulfuric acid, copper sulfate, table salt solution, baking soda solution, sugar solution, citric acid)
- Conductivity tester
- Indicator such as litmus paper, universal indicator paper and/or pH probes

Safety
- Safety goggles should be worn at all times.
- The conductivity tester should be rinsed between each test. Liquids should not be mixed.
- Citric acid is an eye irritant.
- Liquid Universal indicator is alcohol-based and flammable.
- Read and follow all safety warnings on the label.
• At the end of the lesson, have students pour their used solutions in a waste container. Dispose of this waste down the drain or according to local regulations. Wash hands.

Vocabulary Terms
• Acids
• Bases
• pH
• Electrolytes
• Ions
• Neutral
• Concentration
• Salt

Teacher Notes
• When a solution conducts electricity, the charge is carried by ions moving through the solution. Ions are atoms or small groups of atoms that have an electrical charge. Some ions have a negative charge and some have a positive charge. Pure water contains very few ions, so it does not conduct electricity very well. When table salt is dissolved in water, the solution conducts very well, because the solution contains ions. The ions come from the table salt, whose chemical name is sodium chloride. Sodium chloride contains sodium ions, which have a positive charge, and chloride ions, which have a negative charge. Because sodium chloride has ions and lights up the bulb, it is called an electrolyte. Not all substances are made up of ions. Some are made of uncharged particles called molecules. Sugar is such a substance. When sugar is dissolved in water, the solution does not conduct electricity, because there are no ions in the solution.
• Start with lesson 8 if students need to complete activities to learn about acids & bases
  http://www.middleschoolchemistry.com/lessonplans/chapter6/lesson8
• Great simulation to review pH http://phet.colorado.edu/en/simulation/ph-scale
• Investigate the strength of acids and bases with this simulation
  http://phet.colorado.edu/en/simulation/acid-base-solutions
• Simple interactive pH panel identifies if acids & bases by clicking on the name of the substance
• Use cafeteria trays for students to conduct work & this also an easy way for them to gather their supplies from the front of the room & less likely anything will spill
• A piece of white paper under the depression plate is helpful when identifying the color of the liquids
• Students need to test each liquid by placing the tester gently into each depression or beaker. After each test, place the tester into the reservoir or beaker filled with distilled water. When they are finished testing all the liquids, take a paper towel & soak up ONLY the reservoir or dump the beaker into the sink. The teacher will need to refill the reservoir or beaker with distilled water after each class.
• Students must wear goggles at all times and remain seated while conducting experiment. The lights might need to be turned off so students can see the light bulb brightness on the tester.
• Differentiation: if students are absent or need more guidance, give them a data table with the liquids listed and some information provided. Watch to learn about electrolytes
  https://www.youtube.com/watch?v=u6njronZeCU

FOR THE STUDENT
Lesson

Student Activity Sheet: Why Drink Gatorade?

Engage
Show students a Gatorade commercial. Have them list the vocabulary used to catch their attention. What words do they know? What words are new to them? (Hint: Find a commercial with the word electrolyte mentioned, or do a demo with a salt solution that lights a light bulb [https://www.youtube.com/watch?v=1XWnovm6JLs])

Explore
1. Pass out the Student Activity Sheet: Why Drink Gatorade?
2. Discuss independent & dependent variables. Have students identify what the variables were in the engage activity with a person beside them.
3. Pair up & gather their supplies.
4. Have students predict which liquids are acids, bases or neutral and then taking turns writing or recording on a computer, each pair designs a table to collect information on the different liquids.
5. Use the acid/base indicators to test each liquid. Fill in the color change, pH number & whether the liquid is an acid, base or neutral
6. Test the liquids with the conductivity tester & record the brightness of the bulb (dim, bright, not lit)

Ask the following questions:

Which liquids are acidic? [vinegar, lemon juice, pop, sulfuric acid, Gatorade]
Basic? [sodium hydroxide, tap water, liquid soap, baking soda solution]
neutral? [copper sulfate, table salt solution, distilled water]
Were you surprised by some results? [students often guess the salts are not neutral]

What are the controlled variables in this experiment? [some answers: volume of liquid, bulb in conductivity tester]
Which liquids made the light bulb burn bright? [copper sulfate, sulfuric acid, sodium hydroxide, table salt solution]
Any patterns? [strong electrolytes are strong bases, strong acids or salts]
Did you ever test the reservoir at the end of the experiment? [it will have enough ions from the other liquids to light the bulb]

Explain
Students will share their data as a presentation to the whole class. They choose one
• Sing a song
• Create a poster at smore.com or Power Point
• Design an artistic concept map
• Create signs of strong/weak substances and then allow students to move to act out or stand under the sign for the liquid
• Write a conclusion with given vocabulary = liquids, electrolyte, conductivity, light bulb, ions, solution, acids, bases

- Most materials that have a sour taste contain an acid. Acids are compounds that have one or more hydrogen atoms combined in a certain way with one or more other atoms.
When dissolved in water, acids have a sour taste. They react with metals to liberate hydrogen gas, and they also react very readily with the compounds called bases. Acids produce color changes in certain dyes called indicators. One indicator, litmus paper, changes from a blue color to red in the presence of acid.

- Bases are compounds that have one or more groups of oxygen and hydrogen atoms (OH) combined with one or more other atoms. They are characterized by a bitter taste and a slick, soapy texture. Bases produce color changes in indicators. When an acid and a base react with each other, they form salt and water. The reaction of an acid solution on a basic or alkaline solution is called neutralization because both the acidic and basic properties neutralize each other.

- When a solution conducts electricity, the charge is carried by ions moving through the solution. Ions are atoms or small groups of atoms that have an electrical charge. Some ions have a negative charge and some have a positive charge. Pure water contains very few ions, so it does not conduct electricity very well. When table salt is dissolved in water, the solution conducts very well, because the solution contains ions. The ions come from the table salt, whose chemical name is sodium chloride. Sodium chloride contains sodium ions, which have a positive charge, and chloride ions, which have a negative charge. Because sodium chloride has ions and lights up the bulb, it is called an electrolyte.

- Not all substances are made up of ions. Some are made of uncharged particles called molecules. Sugar is such a substance. When sugar is dissolved in water, the solution does not conduct electricity, because there are no ions in the solution.

**Elaborate**

Students will be given 4 unknown liquids to determine whether the liquids are acids or bases and weak or strong electrolytes. Students design their own experiment to solve this problem (some might use litmus paper while others use universal indicator paper). Suggestions for these 4 unknowns (liquids that do not have an odor nor recognizable color and pH values are different): very dilute sulfuric acid, liquid soap, very dilute sodium hydroxide, solution of baking soda, citric acid . Don’t use liquids that have pH close to 7 unless students have access to pH sensors.

**Evaluate**

Teacher holds up the chemical symbol or the chemical name of a liquid on a card. Students signal whether the item is an acid (1), neutral (2) or a base (3). Students read more about sports drinks. Use simulation at [https://phet.colorado.edu/en/simulation/acid-base-solutions](https://phet.colorado.edu/en/simulation/acid-base-solutions) or [https://phet.colorado.edu/en/simulation/ph-scale](https://phet.colorado.edu/en/simulation/ph-scale)

**Discussion Questions**

- What was a controlled variable in the experiment you designed? [possible answers: volume of liquid, brand of sports drink or flavor of drink]
- Why does Gatorade feel you need to drink their sports drink? [marketing strategy suggesting you lose all the necessary electrolytes when you sweat]
- How are the ions different in distilled water and tap water? [there are no ions present in distilled water. There are only water molecules present since the minerals have been removed]
- On a molecular level, how are acids different than bases? [An acid donates protons to water molecules. This increases the concentration of H3O+ ions in the solution. The H3O+ ions donate protons to the indicator molecules causing the indicator to change color toward red. When a base is added to an indicator solution, it accepts protons from]
the water molecules, creating OH− ions. The H3O+ ions and indicator molecules donate protons to the OH− ions, causing the indicator to change color.]

**Multiple Choice Items**

1. Which liquid has more ions?
   a. Tap water
   b. Distilled water
   c. Gatorade
   d. HCl

2. Looking at the formula, which one of these is a base?
   a. H2O
   b. NaOH
   c. H2CO3
   d. HCl

**Open-Ended Questions**

1. How can you change the concentration of hydronium ions in a liquid? [add an acid or base]
2. Describe two ways you can determine a strong base. [Use universal indicator paper to determine the pH, the higher the number, the stronger the base. Second use a pH sensor or conductivity tester (the brighter the light, the stronger the base). Never accept tasting as an answer]

**Other [Project-based; Performance task]**

- Students could watch videos about the bottle industry. How is a plastic bottle formed? What kind of engineering is necessary?
- How does marketing affect a product’s effect on the public? Are there some products targeted to certain age groups?
- How does the package or label affect consumers influence to buy that product?
- Students could learn more about food safety.

**CONNECTIONS TO STANDARDS**

**Cross-Disciplinary Extensions**

**Connect to Math**
Students use a number line to determine the pH of a liquid. They could also learn about the powers of ten, the math behind pH numbers or create a graph with Excel to share the results.

**Connect to Reading**
Students can read about sports drinks or research comparing water & Gatorade after a workout. What careers are involved in such a study? What other sport drinks are available?

**Connect to Writing**
Students can write a 6 trait paragraph about their results in the unknown lab. The assignment is to present your findings in a scientific paper to prove to your supervisor that you do know what you are talking about and should be paid. This paper must include a title, some background information (an introduction paragraph), a data table, and a conclusion (explain your results). That means four different sections!!! Each paragraph should include at least four sentences. Please take turns writing each section. This paper should make sense to someone that does not know anything about acids or bases.
Connect to Social Studies
How is pH important in farming? Look at the history of advertising...how has it shaped our history? What if the plastic bottle was never invented-how would that changed our current history?

Next Generation Science Standards
This lesson supports the following:

Practices of Science and Engineering
- Asking questions and defining problems
- Developing and Using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Using mathematical and computational thinking
- Obtaining, evaluating, and communicating information

Cross-Cutting Concepts
- Patterns
- Systems and System Models
- Structure and Function
- Stability and Change

Disciplinary Core Ideas, Grades 6-8

Physical science
- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2),(MS-PS1-3)
- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2),(MS-PS1-3),(MS-PS1-5)
- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. The total number of each type of atom is conserved, and thus the mass does not change. Some chemical reactions release energy, others store energy. (MS-PS1-2)

Life Science
- Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy. (MS-LS1-7)
Engineering Design

- The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)

- Models of all kinds are important for testing solutions. (MS-ETS1-4)

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)