

**Teacher’s Guide**

**Bottled Water Wars**

***April 2022***

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Activate students’ prior knowledge and engage them before they read the article.

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These questions are designed to help students read the article (and graphics) carefully. They can help the teacher assess how well students understand the content and help direct the need for follow-up discussions and/or activities. You’ll find the questions ordered in increasing difficulty.

[Graphic Organizer 5](#waterwarsorganizer)

Thishelps students locate and analyze information from the article. Students should use their own words and not copy entire sentences from the article. Encourage the use of bullet points.

[Answers 6](#waterwarsanswers)

Access the answers to reading comprehension questions and a rubric to assess the graphic organizer.

[Additional Resources 9](#waterwarsresources)

Here you will find additional labs, simulations, lessons, and project ideas that you can use with your students alongside this article.

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# Anticipation Guide

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions: *Before reading the article*,** in the first column, write “A” or “D,” indicating your **A**greement or **D**isagreement with each statement. Complete the activity in the box.

As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

|  |  |  |
| --- | --- | --- |
| **Me** | **Text** | **Statement** |
|  |  | 1. Once tooth enamel is eroded by acid, the enamel cannot be repaired. |
|  |  | 1. Carbonated water contains carbon dioxide gas dissolved in water. |
|  |  | 1. Naturally occurring springs add gas to water through biological processes. |
|  |  | 1. The solubility of a gas in a liquid depends on the partial pressure of the gas above the liquid. |
|  |  | 1. Gases dissolve better in liquids at high temperatures. |
|  |  | 1. Carbonated water is slight basic. |
|  |  | 1. Carbonated water has a higher pH than soda and juice. |
|  |  | 1. Alkaline water harms teeth and gums. |
|  |  | 1. The same enzyme that makes carbonated water taste tangy keeps your blood pH between 7.3 and 7.4. |
|  |  | 1. Acidic drinks can cause the main component of tooth enamel to lose calcium ions in solution. |

# Student Reading Comprehension Questions

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions**: Use the article to answer the questions below.

1. According to the World Health Organization, what is the leading cause of death globally?
2. What type of bonding causes water molecules to be attracted to one another?
3. What gas is dissolved into water to make carbonated water?
4. Explain how carbonated water may occur in nature.
5. Why are carbonated beverages pressurized?
6. What is the main component in tooth enamel?
7. Name two health conditions that you may be more at risk for if you consume a high-sugar diet.
8. Drinks that are high in sugar content tend to be acidic. How does this impact teeth?
9. Explain why flavored carbonated water may still lead to tooth decay even though its pH is in a safe range.
10. Name three actions you can take to protect your teeth from acidic beverages.
11. What is an aqueous solution?
12. Explain how Henry’s Law relates to carbonated water.
13. What is the relationship between a solvent and a solute?
14. What is the function of carbonic anhydrase within your circulatory system?
15. Explain Le Chatelier’s Principle.

# Student Reading Comprehension Questions, cont.

**Questions for Further Learning**

***Write your answers on another piece of paper if needed.***

1. Write a paragraph comparing pure water, carbonated water, and alkaline water in terms of pH and health benefits/drawbacks.
2. Look at the pH scale in the article. Identify three appropriate beverages that are not already on the chart. Perform research to determine the pH of each substance and note where each would be placed on the chart.

# Graphic Organizer

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions**: As you read, complete the graphic organizer below to describe the different types of water explained in the article.

|  |  |  |
| --- | --- | --- |
|  | **Carbonated Water** | **Alkaline Water** |
| **How is it made?** Include chemicals involved |  |  |
| **pH** |  |  |
| **Effect on teeth enamel**  Include chemicals involved |  |  |
| **Advantages** |  |  |
| **Disadvantages** |  |  |

**Summary:** On the back of this sheet, write three interesting facts about flavored water you would like to share with a friend.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. According to the World Health Organization, what is the leading cause of death globally?

*The leading cause of death globally is heart disease.*

1. What type of bonding causes water molecules to be attracted to one another?

*Hydrogen bonding causes water molecules to become attracted to one another.*

1. What gas is dissolved into water to make carbonated water?

*CO2 is dissolved in water to produce carbonated water.*

1. Explain how carbonated water may occur in nature.

*Carbonation can be added to water through geological processes, such as volcanic activity.*

1. Why are carbonated beverages pressurized?

*Carbonated beverages are pressurized to prevent soda from going flat.*

1. What is the main component in tooth enamel?

*The primary component in tooth enamel is calcium hydroxyapatite.*

1. Name two health conditions that you may be more at risk for if you consume a high-sugar diet.

*Consuming a high-sugar diet may put you at risk for heart disease and diabetes.*

1. Drinks that are high in sugar content tend to be acidic. How does this impact teeth?

*Drinks that are acidic can dissolve tooth enamel and sugar content can cause tooth decay.*

1. Explain why flavored carbonated water may still lead to tooth decay even though its pH is in a safe range.

*Flavored carbonated water may still lead to tooth decay because it contains sugar.*

1. Name three actions you can take to protect your teeth from acidic beverages.

*You can protect your teeth from acidic beverages by limiting consumption, using a straw, and avoiding acidic drinks before bed.*

1. What is an aqueous solution?

*An aqueous solution is a solution in which a substance is dissolved in water.*

1. Explain how Henry’s Law relates to carbonated water.

*Henry’s Law states that the solubility of a gas is directly proportional to the partial pressure of the gas above the solution. If the partial pressure increases, the gas molecules are forced into the solution, which explains how CO2 is added to water to produce carbonated water.*

1. What is the relationship between a solvent and a solute?

*A solute dissolves in a solvent.*

1. What is the function of carbonic anhydrase within your circulatory system?

*Carbonic anhydrase ensures that your blood pH remains constant.*

1. Explain Le Chatelier’s Principle.

*Le Chatelier’s Principle is the idea that when a system that is at equilibrium is stressed, the system responds by changing direction to relieve the stress.*

**Questions for Further Learning**

***Write your answers on another piece of paper if needed.***

1. Write a paragraph comparing pure water, carbonated water, and alkaline water in terms of pH and health benefits/drawbacks.

*Student answers should note that carbonated water is acidic while alkaline water is a weak base. Health benefits can be that these forms of water (carbonated and alkaline) are less harmful in reacting with tooth enamel, but they contain sugar which can still cause tooth decay.*

1. Look at the pH scale in the article. Identify three appropriate beverages that are not already on the chart. Perform research to determine the pH of each substance and note where each would be placed on the chart.

*Student choices will vary. Some* [*websites*](https://drinksdestroyteeth.org/wp-content/uploads/2012/10/4C_DrinksDestroyTeeth_2013.pdf) *include lists of beverages and their pH and sugar content, which can assist students in generating their chart. Alternately, the instructor could lead students in a lab designed to check the pH of the beverages students select.*

**Graphic Organizer Rubric**

If you use the Graphic Organizer to evaluate student performance, you may want to develop a grading rubric such as the one below.

|  |  |  |
| --- | --- | --- |
| **Score** | **Description** | **Evidence** |
| 4 | Excellent | Complete; details provided; demonstrates deep understanding. |
| 3 | Good | Complete; few details provided; demonstrates some understanding. |
| 2 | Fair | Incomplete; few details provided; some misconceptions evident. |
| 1 | Poor | Very incomplete; no details provided; many misconceptions evident. |
| 0 | Not acceptable | So incomplete that no judgment can be made about student understanding |

# Additional Resources

**Labs and demos**

[Designing a Greener Le Chatelier’s Principle Lab](https://teachchemistry.org/periodical/issues/march-2020/designing-a-greener-le-ch-telier-s-principle-lab) **–** This lab allows students to observe visualizations of equilibrium shifts through color changes by using non-toxic materials.

**Simulations**

[pH Scale](https://phet.colorado.edu/en/simulations/ph-scale) – This PhET simulation allows students to explore pH by manipulating the concentration of various liquids.

[Salts and Solubility](https://phet.colorado.edu/en/simulations/soluble-salts) – In this PhET simulation students explore chemical equilibrium and Le Chatelier’s Principle.

**Lessons and lesson plans**

[Brush Up Eggsperiment](https://www.training.nih.gov/assets/TYCTWD_BrushUp_Eggsperiment.pdf) – In this lesson plan students explore the impact of soda and fluoride on eggshells, which represent tooth enamel.

# Chemistry Concepts, Standards, and Teaching Strategies

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Acids and bases
* pH
* Solutions
* Equilibriums
* Partial pressure
* Hydrogen bonding
* Ions

**Correlations to Next Generation Science Standards**

This article relates to the following performance expectations and dimensions of the NGSS:

|  |
| --- |
| **HS-PS1-3.**  Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. |

**Disciplinary Core Ideas:**

* PS1.B: Chemical reactions
* ETS1C: Optimizing the design solution

**Crosscutting Concepts:**

* Stability and change
* Structure and function

**Science and Engineering Practices:**

* Constructing explanations and designing solutions

**Nature of Science:**

* Scientific knowledge assumes an order and consistency in natural systems.

See how *ChemMatters* correlates to the[**Common Core State Standards** online](https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/teachers-guide.html).

**Teaching Strategies**

Consider the following tips and strategies for incorporating this article into your classroom:

* **Alternative to Anticipation Guide:** Before reading, engage students by asking them if they enjoy drinking flavored water. Also ask if they know the ingredients found in different flavored waters, and how they might affect their teeth and gums. Their initial ideas can be collected electronically via Jamboard, Padlet, or similar technology.
  + As they read, students can find information to confirm or refute their original ideas.
  + After they read, ask students what they learned about flavored waters, and how it will affect their water choices.