



**Reading Supports**

**Teacher’s Guide:**

**“What are   
Pool Chemicals?”**

*April/May 2019*

<http://www.acs.org/chemmatters>



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# Reading Supports

The pages that follow include reading supports in the form of an Anticipation Guide, a Graphic Organizer, and Student Reading Comprehension Questions. These resources are designed to help students prepare to read the article and then locate and analyze information from the article.

* **Anticipation Guide (p. 5):** The Anticipation Guide helps to engage students by activating prior knowledge and stimulating student interest before reading. If class time permits, discuss students’ responses to each statement before reading each article. As they read, students should look for evidence supporting or refuting their initial responses.

**Or** consider the following ideas to engage your students in reading:

**What Are Pool Chemicals?**

* Before reading, ask students what chemicals are used to keep pools clean, and why they are needed.
* As they read, students should record information they find interesting, as well as answers to their questions.
* **Graphic Organizer (p. 6):** The Graphic Organizer is provided to help students locate and analyze information from the article. Student understanding will be enhanced when they explore and evaluate the information themselves, with input from the teacher, if students are struggling. Encourage students to use their own words and avoid copying entire sentences from the article. The use of bullets helps them do this.

If you use the aforementioned organizers 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 |

* **Student Reading Comprehension Questions (p. 7):** The Student Reading Comprehension Questions are designed to encourage students to read the article (and graphics) for comprehension and attention to detail, to provide the teacher with a mechanism for assessing how well students understand the article and/or whether they have read the assignment, and, possibly, to help direct follow-up, in-class discussion, or additional, deeper assignments.

Some of the articles in this issue provide opportunities, references, and suggestions for students to do further research on their own about topics that interest them.

To help students engage with the text, ask students which article **engaged** them most and why, or what **questions** they still have about the articles. The “Web Resources for More Information” section of the Teacher’s Guide: Tools and Resources provides sources for additional information that might help you answer these questions.

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

## Anticipation Guide

**Directions: *Before reading the article*,** in the first column, write “A” or “D,” indicating your agreement or disagreement with each statement. 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. Free chlorine is used to disinfect commercial pools. |
|  |  | 1. Trichlor contains the same elements as trichloramine. |
|  |  | 1. Bromine compounds are often used to disinfect hot tubs. |
|  |  | 1. Chlorine compounds kill all common pathogens. |
|  |  | 1. UV radiation to control microbes in pool water is done prior to releasing water into a pool. |
|  |  | 1. The “chlorine” smell associated with indoor pools comes from chlorine reacting with compounds found in urine and sweat. |
|  |  | 1. Pool chemicals work best when the pH is between 8 and 9 (basic). |
|  |  | 1. No one is sure why the diving pool at the 2016 Summer Olympics turned emerald green. |
|  |  | 1. Because the chemical reactions in a pool are in equilibrium, an understanding of LeChatelier’s principle helps pool operators know how to adjust the pH. |
|  |  | 1. Green hair from swimming is caused by compounds containing copper. |

## Graphic Organizer

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

**Directions:** As you read the article, complete the graphic organizer below to analyze how pool chemicals protect swimmers.

|  |  |  |
| --- | --- | --- |
|  | ***Structure or formula*** | ***What does it do?*** |
| **Hypochlorous acid** |  |  |
| **Trichlor** |  |  |
| **Chemicals to balance pH** |  |  |
| **Green color in a pool or your hair** |  |  |

**Summary**: On the bottom or back of this paper, write a tweet (280 characters or less) about the chemistry of pool water, based on what you learned from reading the article.

## Student Reading Comprehension Questions

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

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

* 1. (a) Give three reasons why people complain about chlorine-based compounds in pool water. (b) So, then, why *is* chlorine added to pools?
  2. Why is chlorine (Cl) added to pool water as a part of more complex molecules?
  3. List three reasons why residential pool owners usually use trichlor for disinfecting their home pools.
  4. Why is maintaining the proper concentration of the disinfectant important?
  5. Why is a stabilizer added to pool water?
  6. (a) How do bromine-containing compounds work as disinfectants, and (b) why are they a better choice than chlorine for hot tubs?

**Student Reading Comprehension Questions, cont.**

* 1. (a) Why is the intestinal parasite *Cryptosporidium* resistant to chlorine? (b) How does UV radiation destroy this organism?
  2. How are swimmers protected from UV radiation used to disinfect swimming pool water?
  3. Why are people asked to urinate and shower before entering a swimming pool?
  4. List three sources of copper that can turn swimmers’ hair greenish.
  5. According to Le Châtelier’s principle, (a) if the pool pH is too high (too basic), how will this affect the concentration of hypochlorous acid and the safety of the water, and (b) what is the problem if the pH is too low (too acidic)?

**Critical-Thinking Question**

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

1. List the advantages and disadvantages of using the various methods listed in the article to disinfect municipal pool water.
2. Based on your analysis of these factors, describe how you would safeguard the water in your school’s pool and explain the rationale for your plan. (Note: If your school doesn’t have a swimming pool, consider this to be your plan for a possible future pool at your school.)

## Answers to Reading Comprehension Questions

1. **(a) Give three reasons why people complain about chlorine-based compounds in pool water.   
   (b) So, then, why *is* chlorine added to pools?**
2. People complain about chlorine-based compounds in pool water because they can
3. dry out skin.
4. turn eyes red.
5. produce the familiar, pungent pool smell.
6. Chlorine is added to pools to keep the water free of microbes, such as *Escherichia coli*, that can cause digestive troubles.
7. **Why is chlorine (Cl) added to pool water as a part of more complex molecules?**

Chlorine is added to pool water as part of more complex molecules because when these compounds are added to water, they spontaneously form hypochlorous acid (HClO), which is the disinfecting agent misleadingly called “free chlorine”.

1. **List three reasons why residential pool owners usually use trichlor for disinfecting their home pools.**

Residential pool owners usually use an isocyanurate known as trichlor to disinfect their home pools because it

dissolves slowly,

has high chlorine content, and

is easy to use.

1. **Why is maintaining the proper concentration of the disinfectant important?**

Maintaining the proper concentration of the disinfectant is important because it must be high enough so that some disinfectant is always in the water and also low enough to be comfortable for swimmers.

1. **Why is a stabilizer added to pool water?**

A stabilizer is added to pool water to help protect the hypochlorous acid from breaking down in sunlight.

1. **(a) How do bromine-containing compounds work as disinfectants? (b) Why are they a better choice than chlorine for hot tubs?**

Bromine-containing compounds can also be used to kill pathogens.

Bromine is a better choice than chlorine for hot tubs because it is more stable than chlorine at warm temperatures.

1. **(a) Why is the intestinal parasite *Cryptosporidium* resistant to chlorine? (b) How does UV radiation destroy this organism?**
2. *Cryptosporidium* has a protective coat that makes it hard to destroy with chlorine.
3. The UV light penetrates the organisms’ cell walls and damages their DNA.
4. **How are swimmers protected from UV radiation used to disinfect swimming pool water?**

Swimmers are protected from UV radiation used to disinfect pool water because the UV treatment takes place in a chamber away from swimmers, before water is released into the pool.

1. **Why are people asked to urinate and shower before entering a swimming pool?**

People are asked to urinate and shower before entering swimming pools to remove body sweat and urine that contain urea and other products that react with chlorine to form trichloramine (pool smell) that may also be linked to asthma in swimmers.

1. **List three sources of copper that can turn swimmers’ hair greenish.**

Swimmers’ green hair can be caused by copper introduced to the pool water from

1. copper-containing compounds added to water to kill algae.
2. copper already present in the water used to fill the pool.
3. copper from corroded plumbing.
4. **According to Le Châtelier’s principle, (a) if the pool pH is too high (too basic), how will this affect the concentration of hypochlorous acid and the safety of the water, and (b) what is the problem if the pH is too low (too acidic)?**

If the pool pH is too high, the reaction will favor the products (shift to the right) reducing the concentration of HClO and its ability to disinfect the water.

If the pH is too low (too acidic) the equilibrium will shift toward the reactants, and too much HClO (hypochlorous acid) could burn swimmers’ eyes.

**Critical-Thinking Questions**

1. **List the advantages and disadvantages of using the various methods listed in the article to disinfect municipal pool water.**
2. **Based on your analysis of these factors, describe how *you* would safeguard the water in your school’s pool. Explain the rationale for your plan. (Note: If your school does not have a swimming pool, consider this to be your plan for a possible future pool at your school.)**

Accept student answers that demonstrate their understanding of the material in the article or, if assigned as homework, the students should demonstrate their understanding of aspects beyond those stated in the article.

1. **Advantages and disadvantages**

**Advantages**

**Chlorine- and bromine-containing compounds**

* Molecules include hypochlorite (ClO–) ions that form hypochlorous acid (HClO) when added to water.
* HClO kills most pathogens in pool water.
* Trichlor dissolves slowly and has a high chlorine content.
* Bromine-containing compounds kill pathogens and are more stable in hot water.

**UV radiation**

* UV radiation can kill *Cryptosporidium* by destroying its protective coat.
* UV radiation kills other harmful microbes.
* UV radiation can degrade trichloramine (NCl3), the potent “chlorine” smell in pools that might be linked to asthma in swimmers.
* The effects of UV radiation are not dependent upon the pH of the pool water.

**Disadvantages**

**Chlorine- and bromine-containing compounds**

* HClO breaks down in sunlight so requires a stabilizer for protection.
* Microbes with protective coats are hard to destroy with chlorine.
* Chlorine reacts with compounds such as urea (CO(NH3)2) in urine and sweat to produce trichloramine (NCl3) causing pool smell.
* Other by-products of chlorine reactions may be linked to asthma in swimmers.

**UV radiation**

* UV radiation can damage the skin.
* Pool water must be exposed to UV light before it enters the pool to avoid human exposure to the UV light.
* UV radiation does not continue to disinfect the water after it leaves the UV chamber.
* UV light does not destroy microbes that enter the water from people’s clothing and bodies.

If this Critical-Thinking Question is assigned as a mini-research project, you might want to direct students to these sites:

“Swimming Pools: Alternatives to Chlorine” discusses and gives pros and cons for disinfection procedures, including bromine. (<https://www.houselogic.com/by-room/yard-patio/swimming-pools-alternatives-chlorine/>)

The Pros and Cons of Using UV Rays for Water Treatment” lists some of the advantages and disadvantages of using UV radiation as part of the water treatment process. (<https://www.skillingsandsons.com/blog/the-pros-and-cons-of-using-ultraviolet-rays-for-water-treatment>)

**b. Possible student analysis**

I live in a rural area where it’s cold and it snows, so an outside pool would not be practical. Our school pool is indoors and much of our water supply comes from wells.

* Our school’s pool will definitely need a disinfecting agent such as trichlor, because it dissolves slowly in water and has a high chlorine content to destroy pathogens.
* Since our pool is indoors, we won’t have to worry about sunlight breaking down the microbe-destroying hypochlorous acid, a product of trichlor.
* We will encourage students to use bathrooms and require that students use the shower before entering the pool, to prevent the formation of chloramines, the products of chlorine reacting with urine and sweat.
* We do not have a hot spa, so chlorine-producing compounds will be more effective against pathogens than those of bromine.
* Since we fill our pool primarily with well water, we need to treat the water with UV radiation before it enters the pool, in order to kill chlorine-resistant pathogens like *Cryptosporidia*.
* UV radiation also degrades trichloramine present in the well water. This is important for me since I am already an asthmatic.
* The UV disinfectant chamber must be sealed so that water is disinfected before it enters the pool, and swimmers aren’t affected by direct exposure to a high concentration of UV radiation.
* Although the pH of our well water fluctuates, this is not a huge problem because, despite the changes in HOCl concentration and its ability to kill pathogens due to changes in pH, UV disinfection will still be effective because UV radiation’s ability to kill pathogens is independent of the pH of the water.