



**Reading Supports**

**Teacher’s Guide:**

**“Clean & Green”**

*February/March 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 (page 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:

**Clean &Green**

* Before reading, ask students how chemists try to reduce our impact on the environment.
* As they read, students should add to their original list.
* **Graphic Organizer (page 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 (page 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. Dry ice is solid carbon dioxide. |
|  |  | 1. Most professional chemists receive training in toxicology. |
|  |  | 1. Waste can be a resource. |
|  |  | 1. Green chemistry is an approach to designing chemicals that avoids harming the environment and human health. |
|  |  | 1. Essential oils are found in nature and they evaporate easily. |
|  |  | 1. Traditional methods of obtaining essential oils from plants require a lot of energy. |
|  |  | 1. Many companies value green chemistry. |
|  |  | 1. Supercritical fluids have properties of both liquids and gases. |
|  |  | 1. Carbon dioxide is a liquid at low temperatures and pressure. |
|  |  | 1. Lesson plans have been developed to help elementary students learn about green chemistry. |

## Graphic Organizer

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

**Directions:** As you read the article, complete the graphic organizer below to analyze green chemistry principles.

|  |  |
| --- | --- |
|  | ***Essential Oil Extraction*** |
| **Uses of essential oils** |  |
| ***Green process, including advantages*** |  |
| **Traditional process and drawbacks** |  |
| ***What do green chemists do? Give at least three examples.*** | |

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

## Student Reading Comprehension Questions

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

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

* 1. What do students learn about molecules in a toxicology class that is different than what those students would learn about the same molecules in a typical chemistry class?
  2. What is the approach of green chemistry?
  3. In Kiara and Keirsi’s experiment, what caused the carbon dioxide gas to change to liquid?
  4. How were the essential oils extracted in the experiment?
  5. Why are essential oils fragrant?
  6. Why does the industrial process to obtain essential oils require a lot of energy?

**Student Reading Comprehension Questions, cont.**

* 1. (a) What was the initial focus of green chemistry, and (b) how did this eventually shift?
  2. Estimate from the graph the temperature at which solid CO2 would sublime if its pressure were reduced to 0.1 atmospheres.
  3. Give three criteria used for the materials produced for industry by green chemistry methods, as provided by the article.
  4. How is Beyond Benign advancing green chemistry education in K-12 classrooms?

**Critical-Thinking Question**

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

Considering the last three “wet” laboratory activities that you performed in class, suggest two ways that you could have “greened” any of the chemistry that you used.

## Answers to Reading Comprehension Questions

1. **What do students learn about molecules in a toxicology class that is different than what those students would learn about the same molecules in a typical chemistry class?**

Toxicology classes teach students about what happens when molecules interact with the environment and with our bodies, rather than just learning what molecules can do and how to make them.

1. **What is the approach of green chemistry?**

The approach of green chemistry is to design chemicals, chemical processes, and consumer products in ways to avoid harm to the environment and human health.

1. **In Kiara and Keirsi’s experiment, what caused the carbon dioxide gas to change to liquid?**

In Kiara and Keirsi’s experiment, the warm water caused the dry ice to sublime (change directly from solid to gas); as the gas pressure increased in the centrifuge tube, the extra pressure turned the carbon dioxide gas to liquid.

1. **How were the essential oils extracted in the experiment?**

The essential oils were extracted by the liquid CO2, which penetrates the zest and brings the essential oils out.

1. **Why are essential oils fragrant?**

Essential oils are fragrant because of their chemical makeup. They are complex mixtures that contain some volatile compounds that evaporate easily, releasing odors.

1. **Why does the industrial process to obtain essential oils require a lot of energy?**

The industrial process to obtain essential oils from plant material uses steam distillation at high temperatures, which requires a lot of energy.

1. **(a) What was the initial focus of green chemistry, and (b) how did this eventually shift?**

a. The initial focus of green chemistry was to clean up pollution after it had already been released.

b. The focus shifted to creating products that will degrade harmlessly rather than accumulate in the environment. (Accept this student answer: “… products that will degrade in water and sunlight, not accumulate in oceans”).

1. **Estimate from the graph the temperature at which solid CO2 would sublime if its pressure were reduced to 0.1 atmospheres.**

Solid CO2 will sublime at a temperature of –100 oC when its pressure is reduced to   
0.1 atmospheres.

1. **Give three criteria used for the materials produced for industry by green chemistry methods, as provided by the article.**

According to the article, three criteria used for the materials produced for industry by green chemistry methods are

1. cost,
2. safety, and
3. performance.
4. **How is Beyond Benign advancing green chemistry education in K-12 classrooms?**

Beyond Benign is advancing green chemistry education by creating free, online lesson plans for K-12 classrooms.

**Critical-Thinking Question**

**Considering the last three “wet” laboratory activities that you performed in your chemistry lab, suggest two ways that you could have “greened” any of the chemistry that you used.**

Student suggestions could include:

* Reduce the energy required by
* reducing the hot-plate temperature as soon as the required boiling temperature has been reached.
* considering the use of a solar oven for the experiment.
* Reduce pollution by
* following suggested procedures from the teacher for safely neutralizing acid or base waste by-products.
* drying waste solutions to reduce volume.
* properly disposing of residual solids.
* placing environmental contaminants into specially labeled containers for professional disposal.
* Reduce chemical use by
* carefully measuring supplies.
* checking to see if distilled water is required or if tap water will work as well.

If student answers to the question above are discussed in class, the teacher might add to the discussion the following question: “In terms of green chemistry, what would be the advantages of *me* [the teacher] doing this lab activity as a class demonstration rather than *you* doing it in individual lab groups?”

Answers might include:

* Far fewer chemicals and smaller quantities of them might be needed—only one experiment instead of perhaps 10–12  
  (but the teacher might need a slightly larger amount than one student lab group’s amount to make it visible to the whole class).
* Less energy required for only that one reaction than for many.
* Safer because the teacher is in control of the reaction, flame, etc.
* Less waste after the reaction due to a smaller amount of chemicals used and produced.

It is *strongly recommended* that this follow-up question, for class discussion, be included.

“Ignoring green chemistry, what are some advantages of *you* [the students] doing the lab individually or in lab groups, rather than having *me* [the teacher] doing the lab as a demonstration?”

Student answers might include:

* Being able to *do* experiments myself is one of the main reasons I chose to take chemistry.
* Student-run experiments provide individual experiences for the student.
* I learn so much more from my handling the chemicals and equipment.
* The chemistry of the substances becomes so much more real to me when I actually *see* the reaction happening because I am the one doing it.
* I can’t see the reaction as clearly when you do it as a demonstration up front.

[Note: The student answers above are *critical* to the task of maintaining a student lab program when administrators so frequently—and adamantly—try to minimize that aspect of the chemistry curriculum.]