

**Teacher’s Guide**

 **Is Cold Brew Really Different from Iced Coffee?**

***February 2021***

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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](#_Graphic_Organizer)

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.

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

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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. Cold brew coffee takes much longer to make than iced coffee.
 |
|  |  | 1. The fruit from coffee beans contains only one seed.
 |
|  |  | 1. Caffeine content increases as coffee is roasted.
 |
|  |  | 1. Water can dissolve polar coffee molecules.
 |
|  |  | 1. Making cold brew requires far more coffee grounds than making hot coffee.
 |
|  |  | 1. As cold brew coffee sits in contact with coffee grounds, more compounds dissolve.
 |
|  |  | 1. When coffee is roasted, different chemical processes occur at different temperatures.
 |
|  |  | 1. Light roast coffee beans are heated to a higher temperature than dark roast coffee beans.
 |
|  |  | 1. Cold brew coffee is more acidic than hot brewed coffee.
 |
|  |  | 1. Cold brew coffee is made at room temperature or colder.
 |

# Student ReadingComprehension Questions

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

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

1. Explain the difference between iced coffee and cold brew coffee.
2. What environmental factors influence the character of the coffee you drink?
3. Compare and contrast the two most economically important varieties of coffee.
4. Cold brew coffee is becoming increasingly popular and some say tastes better than its hot brew coffee and iced coffee counterparts. Explain some the reasons for the unique flavor of cold brew.
5. In general, the solubility of a compound in water (or any solvent) increases with increasing temperature. Explain the reason for this chemical phenomenon on the molecular level.
6. Water is known as the universal solvent because of its ability to dissolve many compounds based on its polar nature. Define polarity and explain, using electronegativity, why water has partial positive and negative charges as part of its structure.
7. Based on your knowledge of chemical principles, explain why coffee beans are grinded into grounds before brewing opposed to using the full coffee beans in the brewing process.

**Student Reading Comprehension Questions, cont.**

**Questions for Further Learning**

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

1. Create a diagram (hand drawn or digitally) illustrating and explaining the coffee bean roasting process. The diagram must include a discussion of the Maillard reaction, caramelization, first crack, pyrolysis, and second crack. Include the temperature at which each part of the process occurs, what happens at each phase, and the result.
2. An important draw to coffee, aside from taste, is the energy boost it provides from the caffeine. Research and explain how caffeine boosts energy and alertness inside the body. Draw the structure of caffeine with the point of the pentagonal portion at the top. You will notice the structure looks surprisingly similar to a person with the pentagonal ring being the head and the hexagonal ring being the body. Use your structure of caffeine to create a mascot for your theoretical chemistry themed coffee shop!
3. Create your own cold brew coffee or tea! The process of making cold brew coffee or tea is surprisingly easy. Create a great tasting cold brew coffee or tea is a bit more complicated. There are many cold brew recipes that can be found online that can serve as a foundation for your new brew flavor. Select your favorite coffee blend or tea and try adding some flavors (fruits, nuts, etc.) to create a brand-new brew. Who knows, you may just invent your new favorite drink!

# Graphic Organizer

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

**Directions**: As you read, complete the graphic organizer below to describe the chemistry concepts related to brewing coffee.

|  |  |  |
| --- | --- | --- |
|  | **Describe in your own words** | **Effect on taste of coffee** |
| **VOCs** |  |  |
| **Polarity** |  |  |
| **Surface area** |  |  |
| **Maillard reaction** |  |  |
| **Water vaporization** |  |  |
| **Solubility** |  |  |

**Summary:** Write a tweet (280 characters or less) describing what you learned about the chemistry of cold brew coffee.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. **Explain the difference between iced coffee and cold brew coffee.**

*Iced coffee is brewed using hot water then added to ice to cool. Cold brew coffee is made using cold water and takes longer to make.*

1. **What environmental factors influence the character of the coffee you drink?**

*The variety of the plant, the soil, climate, altitude, and how the beans are processed.*

1. **Compare and contrast the two most economically important varieties of coffee.**

*Coffee beans are produced by species of waxy leaved trees. The trees produce a fruit called “cherries” and their seeds contain coffee beans.*

*Coffea arabica: produces more expensive, mild, lower caffeinated arabica coffee*

*Coffea Canephora: Produces more harsh tasting, higher caffeinated robusta coffee*

1. **Cold brew coffee is becoming increasingly popular and some say tastes better than its hot brew coffee and iced coffee counterparts. Explain some the reasons for the unique flavor of cold brew.**

*Temperature affects the solubility of compounds in water. Solubility increases with increasing temperature and some compounds that dissolve in water at higher temperatures will not dissolve in the colder water used in cold brew. Therefore, the different chemical composition of the brews results in a different state. Also, cold brew requires significantly more coffee grounds and results in a more concentrated coffee brew.*

1. **In general, the solubility of a compound in water (or any solvent) increases with increasing temperature. Explain the reason for this chemical phenomenon on the molecular level.**

*Molecular motion increases with increasing temperature. The increased speed and motion of the molecules allows solvent molecules to more effectively break apart solute molecules, which is required for a substance to dissolve.*

1. **Water is known as the universal solvent because of its ability to dissolve many compounds based on its polar nature. Define polarity and explain, using electronegativity, why water has partial positive and negative charges as part of its structure.**

*Polarity is the property of having poles. In chemistry, we look at poles as having positive and negative portion of the molecule. Electronegativity is an elements attraction towards shared electrons in a covalent bond. Oxygen, due to its increased effective number charge (7 more proton in its nucleus compared to hydrogen) and higher number of valence electrons, has a significantly higher electronegativity compared to hydrogen. This causes the electron density in the covalent bond between oxygen and hydrogen to shift towards oxygen creating a partial negative charge on oxygen, and a partial positive charge on the hydrogen. The polarity of water allows ionic compounds and polar covalent molecules to dissolve in water due to an electrostatic attraction between the water and solute molecules (opposite charges attract).*

1. **Based on your knowledge of chemical principles, explain why coffee beans are grinded into grounds before brewing opposed to using the full coffee beans in the brewing process.**

*Grinding coffee beans into grounds increases the surface area of the coffee beans and allows the chemical compounds that are responsible for the taste and aroma of coffee to dissolve in water more effectively. The increased surface area allows more of the coffee molecules to be exposed to water and increases the solubility in water. According to the principles of collision theory, an increase in surface area will increase the rate of a reaction. Similar to the way small sticks and a tinder bundle is more effective in starting a fire compared to a large log.*

**Questions for Further Learning**

1. **Create a diagram (hand drawn or digitally) illustrating and explaining the coffee bean roasting process. The diagram must include a discussion of the Maillard reaction, caramelization, first crack, pyrolysis, and second crack. Include the temperature at which each part of the process occurs, what happens at each phase, and the result.**

*Answers will vary but must include all expectations outlined in the question.*

1. **An important draw to coffee, aside from taste, is the energy boost it provides from the caffeine. Research and explain how caffeine boosts energy and alertness inside the body. Draw the structure of caffeine with the point of the pentagonal portion at the top. You will notice the structure looks surprisingly similar to a person with the pentagonal ring being the head and the hexagonal ring being the body. Use your structure of caffeine to create a mascot for your theoretical chemistry themed coffee shop!**

*Caffeine has many interacts inside body but in short, caffeine acts as a nervous system stimulant which can affect brain activity, muscle activity, and your heart. All of which will result in the side effect of more alertness and energy. Caffeine mascots and ads will vary.*

1. **Create your own cold brew coffee or tea. The process of making cold brew coffee or tea is surprisingly easy. Create a great tasting cold brew coffee or tea is a bit more complicated. There are many cold brew recipes that can be found online that can serve as a foundation for your new brew flavor. Select your favorite coffee blend or tea and try adding some flavors (fruits, nuts, etc.) to create a brand-new brew. Who knows, you may just invent your new favorite drink!**

*This part of the assignment can be optional. Warn students not to attempt to make cold brew coffee or tea without teacher or parent permission. Students should also be mindful of food allergies if they are making a coffee or tea they are going to share.*

**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

**Lessons and lesson plans**

**Polarity Activity:** In this activity, students will kinesthetically demonstrate the use of electronegativity in determining covalent bond types. <https://teachchemistry.org/periodical/issues/may-2019/modeling-polarity>

**Simulations and animations**

**Solubility Animation:** In an animation, students will have an opportunity to visualize on the particulate level how solubility works. Examples of ionic compounds and a polar covalent compound show how when water is attracted to charged parts, they dissolve, and when they're not attracted to charged parts they stay solid. <https://teachchemistry.org/classroom-resources/solubility-animation>

**Reaction Rate:** Theprocess of dissolving is physical, not chemical. But this simulation does a nice job letting students adjust factors that relate to the speed of how a process can progress.

<https://teachchemistry.org/classroom-resources/reaction-rates-simulation>

Related lesson: <https://teachchemistry.org/classroom-resources/simulation-activity-investigating-reaction-rates>

**Labs and demos**

**Solubility & Compound Type:** In this lesson, students determine whether unknown substances are polar, nonpolar, or ionic by testing their solubilities. <https://teachchemistry.org/classroom-resources/solubility-and-compound-type>

**Other Resources**

**Open for Discussion: Caffeine:** Have students learn more about the effects of caffeine on their body. <https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/past-issues/archive-2013-2014/caffeine.html>

**3D rendering:** This model allows students to get a better idea of what the structure of caffeine looks like.

<https://www.acs.org/content/acs/en/education/resources/undergraduate/chemistryincontext/interactives/brewing-and-chewing/3d-model-caffeine.html>

**Compound Chemistry Infographic**: Coffee Chemistry: Arabica vs. Robusta: <https://www.compoundchem.com/2018/09/30/arabica-robusta/>

**Video:** Using chemistry to unlock the difference between cold- and hot-brew coffee. <https://www.youtube.com/watch?v=FebLfB4P8jQ&feature=emb_title>

**Video:** ACS Reactions explore the chemistry of caffeine. <https://www.acs.org/content/acs/en/pressroom/reactions/videos/2014/the-science-of-caffeine-the-worlds-most-popular-drug.html>

**Video:** ACS Reactions explains how coffee is made. <https://www.acs.org/content/acs/en/pressroom/reactions/videos/2017/the-universe-in-a-cup-of-coffee.html>

**Video:** ACS Reactions explains the Maillard reaction. <https://www.acs.org/content/acs/en/pressroom/reactions/videos/2016/maillard-the-most-delicious-chemical-reaction-in-the-world.html>

# Chemistry Concepts, Standards, and Teaching Strategies

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Gases
* Molecules & Bonding: Polarity
* Organic Chemistry: Functional groups; molecular structure
* Solutions

**Correlations to Next Generation Science Standards**

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

**HS-PS1-5**

Apply scientific principles and evidence to provide an explanation bout the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

**HS-ETS1-3**

Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraint, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

**Disciplinary Core Ideas:**

* PS1.A: Structure and Properties of Matter
* ETS1.C: Optimizing the Design Solution

**Crosscutting Concepts:**

* Cause and effect: Mechanism and explanation
* Structure and Function

**Science and Engineering Practices:**

* Planning and carrying out investigations

**Nature of Science:**

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

**Correlations to Common Core State Standards**

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

**Teaching Strategies**

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

* **Alternative to Anticipation Guide:** Before reading, if they enjoy cold brew coffee, or if they know what it is. Also ask them where coffee comes from and how roasting affects the flavor of coffee.
	+ As they read, students can find information to confirm or refute their original ideas.
	+ After they read, ask students what they learned about roasting coffee beans and making cold brew.
* Students may find this ACS Reactions Video about roasting coffee beans interesting and fun: Coffee Roasting Chemistry Showdown: <https://youtu.be/4Wey8GSglkw>
* Try the *Coffee GC-MS* puzzle with your students! You can find a on the next page and online at [www.acs.org/chemmatters](http://www.acs.org/chemmatters).

Coffee GC-MS Puzzle

Many compounds in coffee are identified using a technique called gas chromatography/mass spectroscopy (GC/MS). In the GC part, the compounds are vaporized and separated into their gaseous forms. The gases feed directly to the MS. Inside the MS, an ion beam knocks an electron off the sample molecule, then sends the ion down into a charged chamber. The distance the ion travels down the chamber is used to calculate the mass to charge (m/z) ratio of the ion, giving the molecular mass of the compound. Because the ions are generally unstable, they also fall apart, usually in pretty predictable patterns. Scientists use the mass of the original ion and the masses of its pieces to identify the compound.

Similarly, the names of the following compounds found in coffee have been broken apart into smaller pieces. Use your smarts (and maybe some help from the coffee article) to reassemble the compounds. An example has been provided.

|  |  |  |
| --- | --- | --- |
|  | **GC/MS result** | **Answer** |
| *Example:* | *LIFT 2 FUR HOURLY* | *2-FURFURYLTHIOL* |
|  |  |  |
|  | ER WAT |  |
|  | COS SURE |  |
|  | CAFE FINE |  |
|  | FIB OR ANVIL |  |
|  | I CAN IN |  |
|  | DECAL HEAD YET |  |
|  | CLAY TIDE |  |

Coffee GC-MS Puzzle – Answer Key

Many compounds in coffee are identified using a technique called gas chromatography/mass spectroscopy (GC/MS). In the GC part, the compounds are vaporized and separated into their gaseous forms. The gases feed directly to the MS. Inside the MS, an ion beam knocks an electron off the sample molecule, then sends the ion down into a charged chamber. The distance the ion travels down the chamber is used to calculate the mass to charge (m/z) ratio of the ion, giving the molecular mass of the compound. Because the ions are generally unstable, they also fall apart, usually in pretty predictable patterns. Scientists use the mass of the original ion and the masses of its pieces to identify the compound.

Similarly, the names of the following compounds found in coffee have been broken apart into smaller pieces. Use your smarts (and maybe some help from the coffee article) to reassemble the compounds. An example has been provided.

|  |  |  |
| --- | --- | --- |
|  | **GC/MS result** | **Answer** |
| *Example:* | *LIFT 2 FUR HOURLY* | *2-FURFURYLTHIOL* |
|  |  |  |
|  | ER WAT | *WATER* |
|  | COS SURE | *SUCROSE*  |
|  | CAFE FINE | *CAFFEINE*  |
|  | FIB OR ANVIL | *RIBOFLAVIN*  |
|  | I CAN IN | *NIACIN* |
|  | DECAL HEAD YET | *ACETALDEHYDE* |
|  | CLAY TIDE | *DIACETYL* |