

**Teacher’s Guide**

**The Great Molasses Flood**

***December 2019***

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

[***Reading Comprehension Questions***](#_heading=h.3znysh7) ***3***

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***](#_heading=h.2et92p0)

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***](#_heading=h.lnxbz9)

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

[***Additional Resources 9***](#_heading=h.tyjcwt)

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

[***Chemistry Concepts, Standards, and Teaching Strategies***](#_Chemistry_Concepts,_Standards,) [***10***](#_heading=h.17dp8vu)

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

# Anticipation Guide

**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. Molasses comes from sugar cane. |
|  |  | 1. Molasses is less than 50% sugar. |
|  |  | 1. Glucose and fructose have the same molecular formula but different structures. |
|  |  | 1. The fermentation process requires oxygen. |
|  |  | 1. Molasses has much greater intermolecular forces than water. |
|  |  | 1. Sugar molecules are polar, with partial positive and negative charges. |
|  |  | 1. Molasses is less dense than water. |
|  |  | 1. Molasses becomes more viscous as shear stress increases. |
|  |  | 1. The pressure of liquids is greater at the bottom of the container. |
|  |  | 1. Substances vaporize more readily at higher temperatures. |

# Student Reading Comprehension Questions

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

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

1. Briefly describe how molasses is manufactured.
2. Define and give an example of isomers.
3. Define viscosity and rank three liquids of your choice in order of increasing viscosity.
4. Explain the term catalyst. How does a catalyst affect the fermentation process?
5. What factors contributed to the failure of the molasses tank causing a tragic sticky flood?
6. It is highly recommended to use diet soda instead of regular soda when conducting the now famous Mentos in soda experiment. Using concepts discussed in the article, why is diet soda the beverage of choice when conducting this demonstration?
7. Hydrogen bonding, dipole-dipole, and London dispersion forces are the three types of intermolecular forces (IMFs) discussed in chemistry courses. Briefly explain each force, rank the forces from strongest to weakest, and explain your ranking using your knowledge and understanding of chemistry.
8. Compare and contrast Newtonian fluids and non-Newtonian fluids, and give an example of each type.
9. Suppose you were assigned the task of designing a new molasses tank for the Purity Distilling Company. What materials/safety mechanisms would you implement in your tank to prevent a future disaster?
10. Research the chemical structures of three artificial sweeteners. Do you notice any similarities between the structure of sugar and artificial sweeteners? Would you predict the artificial sweeteners to be as sticky or less sticky compared to sugar? Explain your reasoning.

**Student Reading Comprehension Questions, cont.**

**Questions for Further Learning**

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

Oobleck is a mystery substance used in science classes around the world. It is composed of cornstarch and water. Obtain a sample of Oobleck from your teacher and answer the following questions:

1. Make three observations about the mystery substance.
2. How would you classify the mystery substance: a solid, liquid, or gas? Newtonian fluid or non-Newtonian fluid? Explain your reasoning.
3. Compare and contrast Oobleck to quicksand. Would you expect to escape from Oobleck and quicksand using similar methods or would you utilize a different approach? Explain.

# Graphic Organizer

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

**Directions**: As you read, complete the graphic organizer below to describe the properties of molasses.

|  |  |
| --- | --- |
|  | **Properties of Molasses**  Provide chemical explanation examples. Include formulas and equations when appropriate |
| **Chemical composition** |  |
| **Use in fermentation** |  |
| **Viscosity** |  |
| **Adhesion to surfaces** |  |
| **Non-Newtonian fluid** |  |

**Summary:** In the space below, or on the back of this paper, write a tweet (280 characters or less) describing what caused the tank to rupture, releasing molasses.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. **Briefly describe how molasses is manufactured.**

*When sugar cane is crushed during the process of making sugar, juice is released. The juice is then boiled until the sugar crystallizes, at which point it is removed. The leftover syrup from this process is molasses.*

1. **Define and give an example of isomers.**

*Isomers are compounds with the same chemical formula but different structures. An example of isomers are glucose and fructose, both have the same chemical formula (C6H12O6) but have different structures (see pg. 16).*

1. **Define viscosity and rank three liquids of your choice in order of increasing viscosity.**

*Viscosity is a liquid’s resistance to flow. Students’ rankings and liquid choice may vary but an example of a correct solution: Water, Cooking oil, Honey.*

1. **Explain the term catalyst. How does a catalyst affect the fermentation process?**

*A catalyst is a substance that speeds up a chemical reaction by providing an alternate mechanism for the reaction with a lower activation energy. A catalyst is not consumed during the reaction. The catalyst, Zymase, speeds up the process of glucose decomposing into ethanol and carbon dioxide.*

1. **What factors contributed to the failure of the molasses tank causing a tragic sticky flood?**

*The wall thickness was inadequate for the tank’s load. The walls were also deficient in manganese, making it brittle and subject to fatigue. A buildup of carbon dioxide gas due to warming of the molasses was another contributing factor. Lastly, cyclical loading (filling and emptying) applied additional stress to the tank and contributed to its failure.*

1. **It is highly recommended to use diet soda instead of regular soda when conducting the now famous Mentos in soda experiment. Using concepts discussed in the article, why is diet soda the beverage of choice when conducting this demonstration?**

*Diet soda works the best because artificial sweetener results in lower surface tension than sugar- or corn syrup-containing solutions. The relatively strong IMFs in sugar do not allow as much carbonation to be released compared to diet soda, which contains no sugar. Using sugarless diet soda also makes clean-up much easier due to the lack of sticky sugar.*

1. **Hydrogen bonding, dipole-dipole, and London dispersion forces are the three types of intermolecular forces (IMFs) discussed in chemistry courses. Briefly explain each force, rank the forces from strongest to weakest, and explain your ranking using your knowledge and understanding of chemistry.**

*The forces are listed from strongest to weakest below:*

*H-bonding: A covalent molecule containing hydrogen bonded to another highly electronegative element (N, O, F). The relatively high difference in electronegativity values results in a permanent net dipole in the molecule. The permanent net dipole causes a strong electrostatic attraction between adjacent molecules.*

*Dipole-Dipole: A covalent molecule containing two elements with significant electronegativity differences resulting in a permanent net dipole. The permanent net dipole causes an electrostatic attraction between adjacent molecules.*

*London Dispersion Forces: A temporary dipole caused by the polarization of electrons in adjacent atoms based on the position of the electrons. LDFs are present in all molecules and the strength of the LDFs is dependent on the number of protons and electrons (polarizability) and the surface area of the molecule.*

*Hydrogen bonding is the strongest IMF due to the relatively large electronegativity difference between H and N, O, or F (the most electronegative elements). This results in a strong dipole and strong electrostatic attraction between molecules. Also, hydrogen has a small atomic radius, which causes a strong attraction. Dipole-dipole forces are stronger than LDFs due the permanent dipole compared to the temporary dipole present in LDFs.*

1. **Compare and contrast Newtonian fluids and non-Newtonian fluids, and give an example of each type.**

*A Newtonian fluid’s viscosity will not be affected by a stress (stirring, movement) while a non-Newtonian fluid’s viscosity will change due to a shear stress. An example of a Newtonian fluid is water, an example of a non-Newtonian fluid is ketchup.*

1. **Suppose you were assigned the task of designing a new molasses tank for the Purity Distilling Company. What materials/safety mechanisms would you implement in your tank to prevent a future disaster?**

*Student answers will vary. Some ideas could include safety pressure release, reinforced steel, level monitoring, and temperature control.*

1. **Research the chemical structures of two artificial sweeteners. Do you notice any similarities between the structure of sugar and artificial sweeteners? Would you predict the artificial sweeteners to be as sticky or less sticky compared to sugar? Explain your reasoning.**

*Student answers will vary but may include any artificial sweetener (aspartame, saccharin, etc.). Student may comment on any similarities they notice. Students may predict the artificial sweeteners to be less sticky due to experiences with “diet” and sugar-free drinks.*

**Questions for Further Learning**

To make Oobleck mix two parts cornstarch and one part water in a bucket or similar container. Give each student or group a sample in a bowl or plate.

1. **Make three observations about the mystery substance.**

*Student answers will vary but should include three observations*

1. **How would you classify the mystery substance: a solid, liquid, or gas? Newtonian fluid or non-Newtonian fluid? Explain your reasoning.**

*Oobleck is classified as a non-Newtonian fluid due to a change in viscosity when a stress is applied.*

1. **Compare and contrast Oobleck to quicksand. Would you expect to escape from Oobleck and quicksand using similar methods or would you utilize a different approach? Explain.**

*The viscosity of quicksand decreases with movement; individuals stuck in quicksand are told not to move and call for help. Oobleck becomes more viscous with movement and an individual may be able to climb out if they move fast enough and cause the fluid to become more rigid.*

**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**

IMFs and Physical Properties – In this demonstration, students observe and compare the properties of surface tension, beading, evaporation, and miscibility for water and acetone. <https://teachchemistry.org/classroom-resources/intermolecular-forces-and-physical-properties>

Demo: What Causes Yeast to Ferment? In this lesson, students will observe and verify molasses sugar content as a result of its ability to ferment yeast. They will compare how molasses allows yeast to ferment with other sugar solutions as well as a sugar-free solution. <https://teachchemistry.org/classroom-resources/what-causes-yeast-to-ferment>

**Simulation**

Solubility – In this 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>

**Lesson**

Structure Matters – In this project, students will develop a presentation to explain how and why a specific material can solve a problem. The explanation will involve researching the properties of the material and how its properties are suited for solving a specific problem. <https://teachchemistry.org/classroom-resources/problem-solving-with-materials>

**Projects and extension activities**

What is Paint? In this activity, students watch a video and answer related questions about the composition of paint. During the video, students will learn about the differences between three common paint types, water colors, oil-based and acrylic paint as well as the chemistry of each. <https://teachchemistry.org/classroom-resources/what-is-paint-video-questions>

**Articles**

*Chemical & Engineering News* (ACS’s weekly news magazine) recently published an article about sugar and sugar substitutes as a result of FDA requiring added sugar content to be included on nutrition labels. <https://cen.acs.org/business/specialty-chemicals/sugar-wars-change-food-label/97/i41>

C&EN also has an article about the chemistry of artificial sweeteners. It’s dated, but still accurate. https://pubsapp.acs.org/cen/whatstuff/stuff/8225sweeteners.html

# Chemistry Concepts, Standards, and Teaching Strategies

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Chemistry basics - Fermentation
* Gases – Pressure
* Kinetics – Catalysts
* Molecules & Bonding
  + Intermolecular forces
  + Polarity
  + Isomers
  + Molecular structure
* Solutions

**Correlations to Next Generation Science Standards**

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

**HS-PS2-6**. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

**HS-ETS1-3.** Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, 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:**

* Analyzing and interpreting data
* Constructing explanations (for science) and designing solutions (for engineering)

**Nature of Science:**

* Scientific knowledge is based on empirical evidence.
* 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) at www.acs.org/chemmatters.

**Teaching Strategies**

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

* Alternative to the Anticipation Guide: Before reading, ask students if they know what molasses is, and what it is used for. Ask them how they think storing molasses could cause a steel tank to rupture. As they read, students should record information they find interesting and look for answers to their questions.
* Show the 26-second animated video (no sound) at [www.bit.ly/ChemMattersJetStream](http://www.bit.ly/ChemMattersJetStream) to students visualize the movement of the jet stream.
* Ask students what they found most interesting from reading article.