

**Teacher’s Guide**

 **What’s in Marshmallows?**

***February 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](#_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.

[Answers 6](#_Answers_to_Reading)

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

[Additional Resources 10](#_Additional_Resources_1)

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. Gelatin is an important ingredient in marshmallows.
 |
|  |  | 1. Gelatin comes from animal tissues.
 |
|  |  | 1. Gelatin’s form (liquid or gel) depends on the temperature.
 |
|  |  | 1. Gelatin melts at about 50 °C (120 °F).
 |
|  |  | 1. Marshmallows and gummy bears have the same ingredients.
 |
|  |  | 1. The sweeteners sugar and corn syrup are the same.
 |
|  |  | 1. The ratio of sugar to corn syrup determines the texture of the marshmallow.
 |
|  |  | 1. Microwaved Peeps inflate as they are heated because the air bubbles expand.
 |
|  |  | 1. Microwaving Peeps makes them softer.
 |
|  |  | 1. Peeps can be used to demonstrate the ideal gas law.
 |

# Student ReadingComprehension Questions

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

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

**Reading Comprehension**

1. What are the common ingredients in marshmallows?

2. Define the term collagen and describe the structure and composition of a collagen.

3. Explain how gelatin is made from collagen.

4. Discuss how temperature and the amount of gelatin impacts the texture of foods containing gelatin.

5. Explain how the texture of a marshmallow containing treat can be altered and adjusted.

**Connecting Concepts**

6. Use your knowledge of chemistry to explain what happens to marshmallows when placed inside a microwave oven.

7. Explain why marshmallows that were placed inside a microwave or subjected to heat often have a crunchy texture.

8. According to Charles’ Law, the volume of a gas sample is directly proportional to the temperature of a gas sample (when pressure is constant). If the internal temperature of a marshmallow increased from 25 ℃ to 100 ℃ would you expect the air inside the marshmallow to also expand by a factor of 4? Explain your answer.

9. If the internal temperature inside a marshmallow increased from 25 ℃ to 100 ℃ , by what factor would the volume of the air inside the marshmallow increase? (Hint on number 8, the volume does not increase by a factor of 4)

10. The phrase “Ideal Gas Law” is mentioned in the article. What assumptions are made about gases in order from them to behave “Ideally”.

11. Why do marshmallows get stickier as they are heated? Use chemistry to explain your answer.

**Questions for Further Understanding and Exploration**

12. Create a “Chemistry of Marshmallows” infographic highlighting the main points of the article and demonstrating your new understanding of the popular sugary treat!

# Graphic Organizer

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

**Directions**: As you read, complete the graphic organizer below to describe each term related to marshmallows. Include formulas where appropriate.

|  |  |
| --- | --- |
| **Collagen** | **Sugar** |
| **Corn syrup** | **Peeps** |

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

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

**Reading Comprehension**

1. What are the common ingredients in marshmallows?

The common ingredients in marshmallows are sugar, corn syrup, gelatin, and air.

2. Define the term collagen and describe the structure and composition of a collagen.

A collagen is a protein made up of 3 polypeptide chains (in a triple helix structure) composed of amino acids.

3. Explain how gelatin is made from collagen.

Collagen is treated with acids or bases which partially break down the triple helical structure into individual strands.

4. Discuss how temperature and the amount of gelatin impacts the texture of foods containing gelatin.

Higher temperatures break down the bonds holding the helices polypeptide chains which can reset and recoil when cooled. This gives marshmallows the ability to melt and mold into different shapes. Warm temperatures inside a person’s mouth allow marshmallows to “melt in your mouth” for easy consumption. The amount of gelatin can also influence the firmness of a marshmallow containing treat.

5. Explain how the texture of a marshmallow containing treat can be altered and adjusted.

Manufacturers can alter the type of corn syrup and the ratio of sugar to corn syrup.

High levels of sugar will cause a more firm product such as circus peanuts and less sugar will create a softer, fluffier product such as an original marshmallow.

**Connecting Concepts**

6. Use your knowledge of chemistry to explain what happens to marshmallows when placed inside a microwave oven.

The high energy waves cause water molecules inside the marshmallow to vibrate which heat and soften the sugar matrix inside the marshmallow. The weakened sugar matrix allows air bubbles within the marshmallow to expand rapidly and the marshmallow puffs up.

7. Explain why marshmallows that were placed inside a microwave or subjected to heat often have a crunchy texture.

As the marshmallow cools the air bubbles shrink and the sugar matrix hardens. Combine that with the decreased amount of water lost during the heating results in a hard, crunch texture.

8. According to Charles’ Law, the volume of a gas sample is directly proportional to the temperature of a gas sample (when pressure is constant). If the internal temperature of a marshmallow increased from 25 ℃ to 100 ℃ would you expect the air inside the marshmallow to also expand by a factor of 4? Explain your answer.

No, gas law relationships are dependent on the absolute temperature. Therefore, the temperature must be in Kelvin when comparing values. Since the 4 fold increase in temperature was in the celsius scale, which would not be the case on the Kelvin scale, a 4 fold increase would not occur.

9. If the internal temperature inside a marshmallow increased from 25 ℃ to 100 ℃, by what factor would the volume of the air inside the marshmallow increase? (Hint on number 8, the volume does not increase by a factor of 4)

25 ℃ = 298 K

100 ℃ = 373 K

373 K / 298 K = 1.25

Since there was 1.25 fold increase in temperature, the volume of air would increase by a factor of 1.25 as well because temperature and volume are directly proportional (when pressure is constant)

10. The phrase “Ideal Gas Law” is mentioned in the article. What assumptions are made about gases in order from them to behave “Ideally”.

Ideal gases are assumed to be in constant random motion. Collisions between gas molecules are considered to be completely elastic, meaning energy is conserved. The gas are assumed to not have any attractive or repulsive forces between gas molecules and the volume of the gas molecules themselves is considered negligible.

11. Why do marshmallows get stickier as they are heated? Use chemistry to explain your answer.

The air bubbles and sugar matrix help contain the gelatin inside the marshmallow. When heat or moisture is added to the marshmallow the air bubbles collapse allowing the gelatin to move freely. Gelatin is a large polymer with strong London dispersion forces which attract to your hand or anything else a marshmallow comes in contact with.

**Questions for Further Understanding and Exploration**

12. Create a “Chemistry of Marshmallows” infographic highlighting the main points of the article and demonstrating your new understanding of the popular sugary treat!

Students' responses will vary.

**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

Marshmallow Lab connected to Gas Chemistry

<https://teachchemistry.org/classroom-resources/three-station-gas-lab>

Kinetic Molecular Theory Activity

<https://teachchemistry.org/classroom-resources/mega-marshmallows>

Stoichiometry Practice with Marshmallows

<https://teachchemistry.org/classroom-resources/smore-stoichiometry>

Related Article on Collagens

<https://teachchemistry.org/pdf/2020/08/27/15/17/10/b59a8c65-d078-4ff8-988f-8b324b07013f/2011_Dec.pdf>

# Chemistry Concepts, Standards, and Teaching Strategies

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Physical properties
* Gas laws
* Mixtures

**Correlations to Next Generation Science Standards**

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

|  |
| --- |
| **HS-PS1-3.**  Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.  |

**Disciplinary Core Ideas:**

* PS1.A: Structure and properties of matter
* 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 eating marshmallows. Also ask if they know the ingredients, and how each is important to the final product. Ask if they have ever microwaved a Peep, and what happened. 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 marshmallows.
* You may want to show one of these short Peep Jousting videos: <https://youtu.be/qWQe0WLsDUw> (Arizona Science Center) and <https://youtu.be/RdMvJqIykhA> (Smithsonian)