Lab: Mega Marshmallows

FOR THE TEACHER

Summary
In this lab, students will investigate the Kinetic Molecular Theory and particle motion while experimenting with a marshmallow. Students will observe how an increase in kinetic energy will cause particles to increase in motion. This concept will be extended into a discussion about additional real world thermal expansion examples.

Grade Level
Middle and High School

NGSS Standards
- MS-PS1-4: Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

Objectives
By the end of this lab, students should be able to
- Describe the relationship between particle motion and temperature change.
- Be able to recognize and describe real world applications of thermal expansion joints.
- Explain why increased temperature leads to expansion of a marshmallow.

Chemistry Topics
This lab supports students' understanding of
- Gases
- Kinetic Molecular Theory
- Energy
- Heat
- Thermal Expansion

Time
Teacher Preparation: 15 minutes
Lesson: 50-60 minutes

Materials
- 1-2 bags of large marshmallows (2 per student group is needed)
- Small paper plates (1 per student group is needed)
- Standard power microwaves (2 or more is recommended)

Safety
- Do not consume lab materials, even if they’re otherwise edible products.
- Students should wash their hands.

Teacher Notes
- I suggest spending 10 minutes having a pre-lab discussion with the students so they understand the objective as well as lab rules. It then takes approximately 20 minutes to complete the lab with two microwaves. I then allow 10-15 minutes for students to answer the laboratory questions.
- During the pre-lab discussion the teacher should discuss how microwaves heat items and how energy is transferred to the particles. Teacher may also discuss diffusion and temperature as a way to examine the Kinetic Molecular Theory.
• When setting up the lab, I suggest placing one microwave in the front of the room and the other in the back of the room. Then, evenly divide your class of student into 2 groups, to use each microwave. If you have access to more than 2 microwaves, that would make the lab portion faster.

• Students should be placed in lab partners/small groups. Each group will take turns using the assigned microwave. This will cause some wait time for students.

• When it is a group’s turn to use the microwave, the students will need to watch through the window of the microwave. After about 20 seconds, the marshmallows will start to expand. They’ll grow to about four times their original size!

• At your discretion, you can allow students to consume the marshmallows after they have completed their observations. Please note that normally lab materials should not be consumed. Ensure that proper safety is enforced, counters are cleaned, hands are washed, etc. Also warn students that the marshmallows will be hot after they are removed from the microwave.

• *Explanation of lab observations:* Marshmallows are mostly a matrix of sugar and water puffed around air bubbles. Cut a marshmallow open and you will see microscopic bubbles under a microscope or hand lens. When you cook marshmallows in your microwave oven, several things happen. The microwave makes the water molecules vibrate very quickly as they gain more and more energy. The moisture within the marshmallows heats up and vaporizes into steam. The hot steam also warms the sugar, which softens a little. In addition, the steam also warms the air bubbles and causes them to expand. When air in a closed container is warmed, the gas molecules move around faster and push harder against the walls of the container, causing the pressure inside that container to increase. As the air in the bubbles in a marshmallow warm up, they bounce around faster and faster. Since the marshmallow is flexible and soft, the bubbles expand, and the marshmallow puffs up. If it puffs up too much, some air bubbles burst, and the marshmallow deflates. When you take the marshmallow out of the microwave and it cools off, the bubbles will shrink and the sugar hardens again. When the microwaved marshmallow cools, it’s dry and crunchy, similar to a puff sugar cookie. If you cook your marshmallow for too long, it turns brown or black inside. This happens when the sugar gets so hot that it starts to burn and caramelize.

**FOR THE STUDENT**

*Lesson*

**Mega Marshmallows**

**Purpose**

You will observe a marshmallow as the kinetic energy of the particles change.

**Materials**

- 2 Marshmallows
- Paper plate
- Microwave

**Procedure**

1. Put two marshmallows on a paper plate.
2. Put the plate in the microwave. Set the timer for 30 seconds.
3. Stand back and watch through the window of the microwave. Record your observations in the data table below.
4. When the microwave turns off, take the plate out and put it on the counter. Wait a few seconds, and then pick up one marshmallow. Caution! It will be very warm!
5. Pull the warm marshmallow apart. Record your observations in the space provided in the table below.
6. Allow the second marshmallow on the plate to cool for several minutes and then examine it. You will record your observations in the space provided, after it shrinks.
back to its original size. Pick it up, feel it, reshape it, move it around and pull it apart.

**Data**

<table>
<thead>
<tr>
<th>What happened to the marshmallows while they were in the microwave?</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe the <strong>warm</strong> marshmallow when it was pulled apart.</td>
<td></td>
</tr>
<tr>
<td>• Is it hollow?</td>
<td></td>
</tr>
<tr>
<td>• Texture?</td>
<td></td>
</tr>
<tr>
<td>• Color?</td>
<td></td>
</tr>
<tr>
<td>Describe the <strong>cool</strong> marshmallow when it was pulled apart.</td>
<td></td>
</tr>
<tr>
<td>• Is it hollow?</td>
<td></td>
</tr>
<tr>
<td>• Texture?</td>
<td></td>
</tr>
<tr>
<td>• Color?</td>
<td></td>
</tr>
</tbody>
</table>

**Analysis**

1. Describe the main differences between the warm and cool marshmallows.

2. How does each marshmallow differ from how it was before cooking? What has happened that makes each of them different?

3. Explain what happens to the marshmallow when it **warms and expands** while referencing the Kinetic Molecular Theory.

4. Explain what happens to the marshmallow when it **cools and contracts** while referencing the Kinetic Molecular Theory.

**Extension**

Thermal expansion is something that happens as particles gain energy and vibrate more quickly. This can be seen in expansion joints on bridges and highways or in the corkboard on a sidewalk. Photos are shown below for reference. Use your knowledge of the Kinetic Molecular Theory to explain the reason for using these types of joints.

![Thermal expansion on a sidewalk](image1)
![Thermal expansion on a sidewalk](image2)