Space Shuttle Tiles STEM Activity - Porous Silicon

3 Days (90 Minute Classes)

Authors

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Materials

- NASA Article on Space Shuttle Tiles
- Flinn Density Inquiry Kit

SUBJECT/GRADE LEVEL

Subject Areas: Science - Chemistry
Math - Algebra 1
STEM

Grade Level: Middle School

STANDARDS

Next Generation Science Standards

- MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.
- MS-PS1-1 Each pure substance has characteristic physical properties (for any bulk quantity under given conditions) that can be used to identify it.
- MS-PS1-3 Students calculate the density of eight different cubes, all with the same volume but different masses. Students use illustrations of the atoms and molecules that make up the different cube materials to begin to understand how the atoms and molecules of a substance determine its characteristic properties, including density, and can be used to identify it.

Mathematics Standards | Common Core State Standards

- CCSS.Math.Content.HSA-SSE.A.1 - Interpret expressions that represent a quantity in terms of its context.
- CCSS.Math.Content.HSA-SSE.A.2 - Use the structure of an expression to identify ways to rewrite it.
- CCSS.Math.Content.HSA-REI.A.1 - Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.

Space Shuttle Tiles and Density

LESSON OBJECTIVE(S)

Students will understand the concept of density and its importance in space exploration, specifically in the context of using porous silicon in Space Shuttle tiles. They will learn to calculate density and analyze data to determine the suitability of materials for specific applications, such as protecting the Space Shuttle during re-entry.

- Describe how material densities affect a space shuttle launch.
- Generate data to determine the identity of unknown substances based on density.
- Apply an understanding of density.

CAREER CONNECTION(S)

Mentor Background: **Dr. Erin Gawron-Hyla, Chemist**



Erin earned her B.S. in chemistry and mathematics from Rose-Hulman Institute of Technology (Terre Haute, IN) in 1999. Her work focused on conducting polymer/noble metal composites for catalysis. She followed that with a postdoctoral appointment at the University of Calgary (Calgary, Alberta, Canada), researching polymer/nanoparticle composite films. While there, her team's work led to a start-up company, SenSyn, Inc., which makes sensors to detect oil pipeline leaks, and Erin serves as a co-founder and Chief Technical Officer. She now works as a research chemist at the U.S. Army Research Laboratory (DEVCOM ARL) in Adelphi, MD, where her current work focuses on porous silicon nanoenergetic reactions, including researching new oxidizers, printable formulations, and reliability studies.

STEM Careers: Army engineer (and other army technical fields), Electrical Engineer, Data Analyst, and computer scientist.

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ENGAGEMENT

Brief Description: Discover how material densities affect a Space Shuttle launch.

Launch Lesson - Space Shuttle Re-entry:
Begin the lesson with a short video or presentation showcasing the Space Shuttle re-entry into Earth's atmosphere and the role of Space Shuttle tiles in protecting the spacecraft. Video Link

- Ask students what they know about the Space Shuttle and how it safely re-enters the atmosphere. Prompt them to think about the challenges of re-entry and the importance of heat protection.
- Introduce the concept of density and its significance in space exploration and engineering. Discuss how materials with specific densities are selected for various components of spacecraft, including Space Shuttle tiles.

Lesson Procedures - Introduction to Density:
Begin the lesson by using a tennis ball and baseball to engage students in a conversation about properties of different materials.

a. Discuss how you would find the densities of the balls (i.e. mass/volume). They both have the same approximate volume, but because the baseball has more mass and thus more weight, it is more dense.
b. Explain that engineers must consider many factors when designing and choosing materials for various purposes. Show the students the picture of the space shuttle orbiter. Point out the tiles and ask the students to infer the function of the tiles.
    i. To protect the shuttle and the shuttle occupants from heat that is produced from friction as the shuttle moves through the atmosphere.
    ii. What would be some characteristics of materials that engineers would find desirable for a shuttle tile? As students name characteristics, write these on the board or on chart paper. (Sample Responses: Low cost, safe, durable, high thermal insulating ability, low density.)
    iii. Now, go back to the analogy with the tennis ball and baseball – Why would good material for a space shuttle tile be low density? (Sample Response: Less weight takes less energy and less cost to launch into space.)

EXPLORATION

Brief Description: Explore how material densities affect a Space Shuttle launch.

Procedures:

A. Have students review the document "NASA's Space Shuttle Tiles: Protecting Against Extreme Heat."
B. Ask students to note any observations or questions they have regarding the space shuttle tiles.

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C. In small groups (2-3 students), instruct the groups to create a shared list of properties and characteristics of the space shuttle tiles mentioned in the document.

D. Display the group documents, guide students through the article highlighting the challenges faced by spacecraft during re-entry and the role of the shuttle tiles in protecting against extreme heat.

E. Lead groups to discuss their findings and compile a collective class list of properties.

EXPLANATION

Brief Description: Explain how to calculate the density of different materials and use that property to determine identity.

Procedures:

A. Remind students how the density of the object helps lower energy and cost, as well as discuss how to determine the density of substances.

B. Explain to the students that they will be working in groups to determine the identity of unknown plastics based on the density they calculate.

C. Have students complete the Measurement Challenge Experiment #1 and #2 to calculate the density of different substances in order to determine their identity.

D. Display the Density Comparison Table. Compare the density of a shuttle tile with the density of other materials.

- Discuss how the units from the lab activity are different from those in the table.
- Guide students to convert the units of one of their samples from the lab activity into the units in the comparison table.
- Was the space shuttle tile more or less dense than their samples from the lab?

ELABORATION

Brief Description: Students explore heat transfer prevention.

Procedures:

A. Remind students how the density of the object helps lower energy and cost, as well as discuss how to determine the density of substances.

B. Divide the class into pairs. Provide each pair with a small heat source (i.e. candle or Bunsen burner), a thermometer, a piece of aluminum foil, and a small piece of Styrofoam.

C. Instruct the pairs to place the heat source at a fixed distance and measure the temperature change using the thermometer.

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D. Direct one pair to wrap the heat source with aluminum foil and the other pair to wrap it with Styrofoam.

E. Allow the pairs to conduct their experiments and record their observations.

F. Facilitate a class discussion to compare the temperature changes between the two pairs, highlighting the role of insulation in preventing heat transfer.

All students use the same block.

EVALUATION

Brief Description: Reflection and evaluate students' understanding of density calculations.

Procedures:

A. Ask students to individually write a short reflection on the following questions:

- Why is it important for spacecraft to have thermal protection systems?
- How does insulation help in preventing heat transfer?

B. Collect the reflections for assessment and feedback.

Give unknown to calculate density.

A. Final Measurement Challenge - You are given an “object” of unknown measures. You are tasked with finding all of the measurements for the object.

- Measure the mass, length, width, and height. Calculate the volume.

REFERENCES

- NASA Lesson on Space Shuttle Tiles
- Flinn Measurement Challenge
- Graphing Density Activity