2.0 Nanotechnology and Surface Area to Volume Ratio

At a Glance

Essential Question: How does surface area and volume ratio impact the way that materials react to their environment based on size?

Standards

NGSS Science Standards Gr. 5

5-PS1-1. Develop a model to describe that matter is made of particles too small to be seen.

5-PS1-2 Measurement and graphing

Mathematics

5.NF(number and operations-fraction),
5.MD(Measurement and Data)

Materials

- Paper cube cutouts (1 large, 2 medium, 4 small sized)
- Alka-Seltzer (2 pills (1 package) per activity)
- Cups (2 per activity)
- Measuring cups
- Water
- Stopwatches

Overview

This section of the course will discuss about the effects of the change in materials due to variations in surface area and volume. The main goal of this section is to provide understanding of how chemical reactions occur faster when a larger surface area of the material is covered.

Major Concepts

- Calculating Surface Area of a cube
- Calculating Volume of a cube
- Ratio of volumes between two different cubes
- Surface area to volume ratio
- Limits to infinity and zero

Objectives

Students will:

- be able to calculate surface area to volume ratio, and should understand the underlying concepts behind it such as the fact that if the same shape of material gets smaller, the ratio increases.
- Explain a chemical reaction and how they can change how fast chemical reactions occur due to manipulating the surface area of reactants.

Lesson Preparation

Preparation

- Print cube cards or present students with two different sizes of cubes. Examples might be dice and children's blocks or math manipulatives.
- Student Observation Sheet

Procedure

Activity 1: Introduction and review surface area and volume of shapes

The goal of this activity is to review how to calculate surface area and volume of cubes.

Procedure:

Note to Teacher: If you are having the students construct their own shapes, they will need to cut out and assemble the cubes to use with this activity. If you are using dice or blocks, pass out the blocks.

Review Volume

Create a definition of Volume- Have the students discuss volume. What is it and why do we need to know volume.

Volume is the amount of space a 3D object takes up. It is measured in cubic units.

Review the Formula for Volume:
Volume=length x width x height.

- Pass out the cubes
- Measure the length of the edges of each cube
- Calculate the volumes and surface area.
- Check students understand
- Discuss the calculations

It is vital they know how to do this in order to understand the next activities.

Review Calculating Ratios and Fractions

For a Great lesson, use Surface Area to Volume Ratios in Nano Science
http://www.community.nsee.us/lessons/Apples_to_Atoms/AtoAch5.pdf

Activity 2: Introduction to surface area/volume ratio

Goal: to teach them how surface area to volume ratio increases as the length of cubes decreases.

Procedure:

- To show how this works, we use the cube cutouts that they made in the first activity. The cutout will consist of 3 sets of cubes.
    - The first set will have 1 really large cube, the second will consist of 2 medium sized cubes, and the 3rd will be the 4 smallest cubes.
    - Have the students find the volume and surface area of the large cube and then calculate the ratio between the two.
    - Next, have the students measure the volume and surface area of both medium cubes. The students will then add the two volumes and the two surface areas together, and then calculate the ratio of the combined surface area to volume ratio.
    - Repeat this process for the four smallest cubes.
    - Have the students compare these ratios to see as one large box is divided into sections the amount of surface area becomes larger while the volume remains the same.

Activity 3: Comparing the Chemical reaction of Alka-Seltzer based on surface area

(Warning: Alka-Seltzer contains the active ingredient Aspirin)

In this activity we shall apply the concept of limits to infinity and zero towards surface area/volume ratio in a real life experiment.

Procedure

Using Seltzer, which fizz when touching water, we shall have the students take 2 Seltzer tables and 2 clear plastic cups.

- First of all ask the students to leave the first Seltzer tablet intact
- Crush the second Seltzer tablet. A suggestion is keeping the second tablet in the foil packet after taking out the first and having the students crush the table with their shoe.
- Measure ½ cup of water and pour the water into each of the two cups.
- Make sure that the students have their observation sheets ready to record
- Make sure that you have each member of the team assigned a job for the experiment.

Discussion:

- Which one they think will dissolve the fastest and which tablet will fizz the most?
- Have them write down their predictions

Dissolving of the full tablet of Seltzer

- Have the students fill the container with ½ cup of water
- have the students drop the tablet into the cup
- The students will time how long it takes the table to dissolve.
- Write the observation on the student sheet

Dissolving of the crushed seltzer table

- fill the second container with ½ cup of water
- Add the powder into the cup.
- Time how long it takes the second container of seltzer to dissolve.

- Write down their Observe.

Discussion

How fast did the second container dissolve compare to the first container?

Note To teacher: They should observe the quick and vigorous fizz versus the slow fizz of the complete tablet. Even though it's the same amount of Seltzer, the powder from the crushed tablet has a larger surface area to volume ratio, and since the surface area is larger, it has a faster reaction time than the complete tablet.

Activity 3: *Wrap Up*

- Ask the students how to calculate Area, Volume, and Surface Area. Feel free to ask a student to demonstrate if they would like.
- Have the students complete the Question Worksheet.
- Questions on the worksheet will include:
  - As a particle gets smaller, what happens to its surface area to volume ratio?
  - What would happen if you took an Alka-Seltzer tablet and continued to break it into smaller pieces? How would the reaction with water change as the pieces got smaller and smaller?
  - How would you describe infinity?
  - Why is the surface area/volume ratio important in nanotechnology?

Resources:

1. United States Nanotechnology Initiative. "What's So Special about the Nanoscale?" Nano.gov. 3/9/2015. http://www.nano.gov/nanotech-101/special
2. Nanoscale Science Education. "Scale and Scaling." North Carolina State University. 3/9/2015. http://www.ncsu.edu/project/scienceEd/scale.html
3. ***http://www.community.nsee.us/lessons/Apples_to_Atoms/AtoAch5.pdf***