Student Worksheet or Guide

The Surface Area-to-Volume Ratio of Nanoparticles: Part I

Introduction

Plants can now be turned into a car fuel based on alcohol, but the exhaust has pollutants, like carbon dioxide. We need your help to make a clean burning fuel cell that combines hydrogen and oxygen to make energy, steam, and nothing else. The fuel cell itself has already been invented, but we still haven't been able to cheaply make a hydrogen source. Many oil refineries use a platinum catalyst to make fuel, but platinum is so rare that it's worth more than gold. We must find a cheaper alternative!

Nickel is for more abundant than platinum, and much cheaper. If we can find a way to use nickel instead of platinum, we might make hydrogen fuel cells affordable for the masses! Nickel, if it is made small enough, can react with air like dynamite. Help us make a device that will make hydrogen using only air, water vapor, and sunflower oil using two nanoparticle catalysts—one based on carbon, and the other based on nickel. What shape should we use for the nickel nanoparticles to make them more explosive?

Materials

- waxed paper sheet
- modeling clay, the size of a walnut (3/student)
- metric ruler
- calipers, with metric markings
- pencil
- calculator
- small rectangular box

Make a Prediction

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Procedure

1. Place the wax paper atop your desk. For each of the steps below, be sure to use all of the clay. Do not remove any clay between measurements.
2. Press the clay into a cube.
3. Use the ruler to measure the size of each side. Write each measurement in the table on the next page.
4. Place the clay into a flat, rectangular box.

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5. Use the ruler to measure the size of each side. Write each measurement in the table on the next page.
6. Roll the clay into a ball.
7. Use the calipers to measure the ball's diameter. Write your measurement in the table on the next page.
8. Roll the clay into a cylinder.
9. Use the calipers to measure the diameter of the cylinder. Write your measurement in the table below.
10. Use the ruler to measure the length of the cylinder. Write your measurement in the table below.

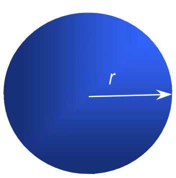
Record Your Observations

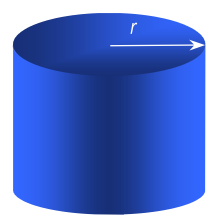
Measurements of Objects

	Diameter (cm)	Length (cm)	Width (cm)	Height (cm)
Cube				
Box				
Ball				
Cylinder				

Analyze the Results

Calculate the volume *(V)* of each shape using the formulae below. Write your answer in the table on the next page.





Volume of a box $length \times width \times height$

Volume of a ball $\frac{4\pi}{3} (radius)^3$

Volume of a cylinder $\pi \times height \times (\text{radius})^2$

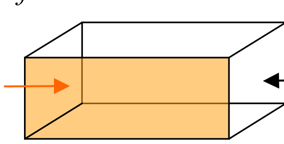
11. Calculate the surface area (A) of each shape using the formulae below. Write your answer in the table on the next page.

Surface area of a cube $length \times width \times number\ of\ sides$

Surface area of a box

$(4 \times length \times width)_{front\ face}$

$+ (2 \times length \times width)_{side\ face}$



Surface Area of a ball $4\pi \times (radius)^2$

Surface Area of cylinder $2\pi (radius)^2 + 2\pi \times radius \times height$

12. For each shape, calculate the ration of surface area to volume by dividing the surface area by the volume and write this ratio in the table.

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	Surface area (cm^2)	Volume (cm^3)	Ratio $\frac{\text{Surface Area}}{\text{Volume}}$
Cube			
Box			
Ball			
Cylinder			

Draw Conclusions

1. Which shape had the smallest surface area-to-volume ratio?______________________

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2. Which shape had the largest surface area-to-volume ratio?______________________

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3. Of the shapes you tested, which shape would you recommend as the most reactive catalyst? Explain.____

4. Why are manufacturers interested in using nanoparticles for catalysts?_____________

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5. Apart from cost, why do you think this company is considering using nickel nanoparticles for fuel cells? **(Hint:** Look at the periodic table of elements.)_________

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