**Title:** Surface area to Volume activity

**Description:** This activity demonstrates the relationship between sphere surface area and volume using ping pong balls, tennis balls, containers, calipers, and data tables made in Microsoft Excel. The effects of the surface area to volume ratio on filling space and reactivity are also discussed.

**Audience:** Grades 7-12, chemistry or physical sciences class

Background information: Formulas for sphere surface area and volume, familiarity with Microsoft Excel, unit conversions, and general understanding of reaction dynamics of surface-solvent chemistry

**Concepts Taught:** As sphere radius decreases, the surface area to volume ratio increases. Because chemical reactions between a solid and a liquid occur only at the surface of the solid, reactivity of materials increases as particle size decreases.

**Vocabulary:**

Surface area is a measure of how much exposed area a solid object has, measured in squared units.

Volume is the quantity of 3-dimensional space enclosed by a shape.

Chemical reactivity of a substance in a chemical reaction depends on my factors, including particle size.

**Materials:**

50 ping pong balls

15 tennis balls

Calipers

Plastic containers, lids

Microsoft Excel

**Conclusion:** This activity reinforces concepts of unit conversion, the ratio of sphere surface area to volume, chemical reactivity of a solid in a liquid, particle space-filling, and data calculation and plotting using computer spreadsheet software.

**Sphere Surface Area and Volume Exercise - October 25, 2011**

It may come as a surprise to find that a sphere’s surface area-to-volume ratio does not remain constant as the size of the sphere changes. Today, we will investigate this trend as sphere radius is varied using two different approaches:

1) Direct measurement and comparison of different size spheres.

2) Excel plots of parameters with varying sphere radius.

Here are the formulas for sphere surface area and volume, where r is radius:

$S.A.\_{sphere}=4πr^{2}$ $V\_{sphere}=\frac{4}{3}πr^{3}$

**SA/V Activity Part 1:**

**Step 1:**

1. Record the volume of the plastic container in cm3.

**Volume:\_\_\_\_\_cm3**

**Step 2:**

1. Fill the container with as many tennis balls as you can without any of the tennis balls sticking out of the top of the box.
2. Measure the diameter of one of the tennis balls.
3. Calculate the surface area and volume of the tennis ball and multiply by the total number of tennis balls in the container.
4. Calculate the SA:V by dividing the total surface area by the total volume.
5. Calculate the “wasted” volume by subtracting the total volume from the volume of the plastic container that was calculated in step 1.

**Diameter:\_\_\_\_\_cm Surface Area:\_\_\_\_\_cm2 Volume:\_\_\_\_\_cm3**

**# of Tennis Balls:\_\_\_\_\_ Total Surface Area:\_\_\_\_\_cm2 Total Volume:\_\_\_\_\_cm3**

**SA:V\_\_\_\_\_ Wasted Volume:\_\_\_\_\_cm3**

**Step 3:**

Repeat the procedure in step 2 using ping pong balls instead of tennis balls. Record all calculations and measurements below:

**Diameter:\_\_\_\_\_cm Surface Area:\_\_\_\_\_cm2 Volume:\_\_\_\_\_cm3**

**# of Ping Pong Balls:\_\_\_\_\_ Total Surface Area:\_\_\_\_\_cm2 Total Volume:\_\_\_\_\_cm3**

**SA/V\_\_\_\_\_ Wasted Volume:\_\_\_\_\_cm3**

**SA/V Activity Part 2:**

1.1) Using the equations for sphere volume and surface area, fill in the table below. Plot sphere volume vs. radius and sphere surface area vs. radius. Plot both data sets on one graph for easy comparison.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 1.1) | **Sphere Radius (m)** | **Surface Area (m2)** | **Volume (m3)** | 1.2) | **SA/Vol. (m-1)** |
|  | 1.000E-09 |   |   |  |   |
|  | 1.000E-08 |   |   |  |   |
|  | 1.000E-07 |   |   |  |   |
|  | 1.000E-06 |   |   |  |   |
|  | 1.000E-05 |   |   |  |   |
|  | 1.000E-04 |   |   |  |   |
|  | 1.000E-03 |   |   |  |   |
|  | 1.000E-02 |   |   |  |   |
|  | 1.000E-01 |   |   |  |   |
|  | 1.000E+00 |   |   |  |   |
|  | 1.000E+01 |   |   |  |   |
|  | 1.000E+02 |   |   |  |   |
|  | 1.000E+03 |   |   |  |   |
|  | 1.000E+04 |   |   |  |   |
|  | 1.000E+05 |   |   |  |   |
|  | 1.000E+06 |   |   |  |   |
|  | 1.000E+07 |   |   |  |   |
|  | 1.000E+08 |   |   |  |   |
|  | 1.000E+09 |   |   |  |   |

1.2) Calculate and record the surface area to volume ratio (SA/V) for each of the data points. Plot SA/V vs. radius.

1.3) Explain the trends you observe in the surface area and volume with respect to sphere size.

2) What radius (m) of sphere has a surface area to volume ratio equal to 1? (HINT: try setting the two equations equal to one another)

3) A colloidal solution contains 5.00\*1013 gold nanoparticles per mL. The nanoparticles have a diameter of 50.0 nm.

a) What is the total volume (m3) of gold in 3 mL of solution?

b) What is the total weight (g) of gold in 3 mL of solution? (HINT: density of gold = 19.30 g/cm3)

c) What is the total surface area (m2) in 3 mL of solution?