Big Idea: Size-Dependent Properties[1]

(1)- The Big Ideas of Nanoscale Science & Engineering: A Guidebook for Secondary Teachers. S.Y. Stevens, L.M. Sutherland, & J.S. Krajcik, NSTA Press, 2009.

The properties of matter can change with scale. In particular, during the transition between the bulk material and individual atoms or molecules, a material often exhibits unexpected properties that lead to new functionality. This transition generally occurs at the nanoscale

Learning Goals [1]

1. The surface area-to-volume ratio increases as the size of an object becomes smaller. As a result, as the size of an object approaches the nanoscale, the fraction of the atoms on the surface increases dramatically, and surface-related properties become more important.

2. Some of the characteristic properties of matter change with size, particularly as the length scale of the sample decreases and approaches the nanoscale.

3. The shape of nanoscale structures can lead to unique properties. [1]

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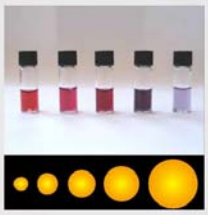
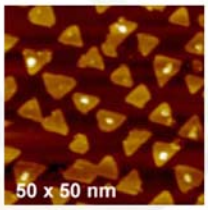


Pictured: Gold Nanoparticles.

Image Wikipedia - wikipedia.org/wiki/Colloidal_gold#/media/File:Gold255.jpg; Aleksandar Kondinski - kondinski.webs.com CC BY-SA 4.0

Examples

Colloidal suspensions of gold nanoparticles exhibit different colors depending on particle size. This is how medieval glass makers created such beautiful stained glass colors ,although they did not know why. In addition, the melting point of gold decreases dramatically when the diameter falls below 100nm. Magnetic properties can also be size-dependent. For example, in its bulk form, aluminum is not magnetic. However, aluminum nanoparticles with a diameter of approximately 0.8nm are magnetic.



Pictured: Iron-oxide nano particles.

Image courtesy Omicron-instruments .com/results/formation_of_iron_nanoparticles_and_thin_films_on_au_111

Cutting-Edge Application

Magnetic susceptibility, the degree of magnetization that a substance exhibits in response to an applied magnetic field, is also dependent on size. This size-dependent property is being explored to use iron oxide nanoparticles for water purification processes. Iron oxide nanoparticles are non-toxic, low cost, and corrosion resistant. They are able to bind with arsenic, cyanides, and radionuclides. Once bound to the nanoparticles, the toxins can be removed using magnets.

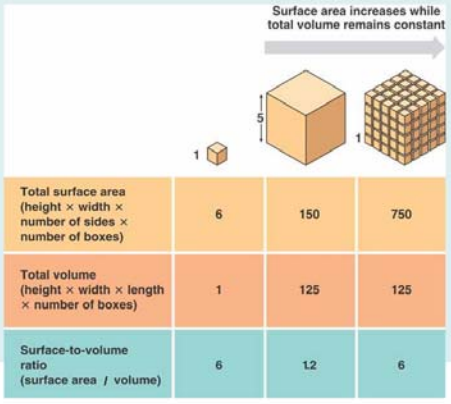
Questions to Ponder

During a chemical reaction, is the physical transformation occurring at the molecular or atomic level?

Why does an increase in surface area change the way materials interact?

How does the size of a material affect its optical properties?

Why is there a limit to the use of magnetic materials for data storage?



Total surface area (height × width × number of sides × number of boxes)	6	150	750
Total volume (height × width × length × number of boxes)	1	125	125
Surface-to-volume ratio (surface area / volume)	6	1.2	6

Image is associated with numerous websites including Quroa.com; bio1151b.nicerweb.com/ among others