Making Nano-Comparisons

Subject Area(s)

Measurement, Number and Operations, Physical Science, Science and Technology, Chemistry, and Physics

Associated Unit

Measurement and Scientific Notation

Associated Lesson

Graphene oxide and Nanotechnology

Activity Title

Making Nano-Comparison

Grade Level

11 (9-12)

Image 1

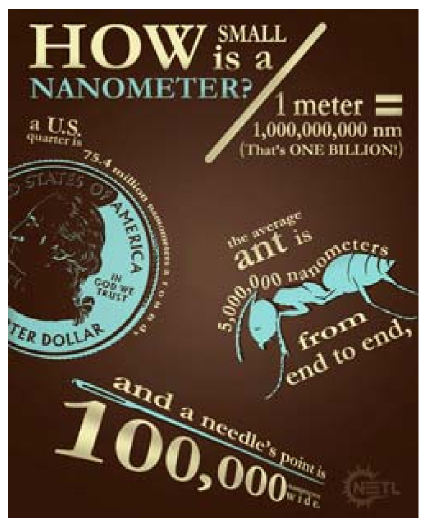
Image file: Nanometer5_sm.jpg

ADA Description: The picture helps students to visualize how small a nanometer is by measuring the length of several objects in nanometers.

Source/Rights: No Copyright:

http://www.netl.doe.gov/newsroom/features/02-2011.html

Caption: How small is a nanometer? This picture describes the size of a nanometer by taking measurements of several objects and converting them into nanometers.



Time Required

30 minutes

Activity Dependency

Group Size

2-3 per group

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Expendable Cost per Group

Expenses will not be per group.

Items to be used are 10 sticky note pads and 10 pieces of graphite.

Cost will depend on the materials available to the teacher.

Summary

Making Nano-Comparisons is an activity designed to relate the emerging field of Nanotechnology to measurement, scientific notation, and unit conversion. This activity is based on Environmental Engineering research using Graphene Oxide, a nano-particle, to remove certain carcinogenic contaminants from water sources. It's designed to enable students to visualize the size of a nano-particle, Graphene Oxide, by comparing it with everyday objects that are measureable with metric rulers or meter sticks. Through the activity students will investigate the structure of Graphene Oxide, learn about the production of this nano-particle, and discuss the units used to measure a material of this size. These comparisons between objects that students can measure and nano-particles will help them to realize the importance of scientific notation and unit conversion in measurement while getting the chance to put these skills into practice.

Engineering Connection

Nanotechnology is an incredibly diverse, fast growing field in which scientists and engineers are working together to understand and put into use new materials which could reshape our future. All fields of engineering are being affected by Nanotechnology because of the wide range of applications for these new nano-materials. This activity focuses on Environmental Engineers using Graphene Oxide to remove contaminants from water sources to help relate engineering and Nanotechnology to measurement, scientific notation, and unit conversion. The activity is meant to draw a connection between science based careers, in this case engineering, and related science curriculum to inspire students to excel in the science classroom.

Engineering Category = #1

Choose the category that best describes this activity's amount/depth of engineering content:
1. Relating science and/or math concept(s) to engineering
2. Engineering analysis or partial design
3. Engineering design process

Keywords

Dimensional Analysis, Measurement, Scientific Notation, Significant Figures, Units, Unit Conversion

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Educational Standards

National and State

Texas Science(Chemistry): 2010-2011, grades 10-12: 3E

3) Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:
(E) describe the connection between chemistry and future careers; and

Texas Science(Environmental Science): 2010-2011, grades 11-12: 3D-E, 5B, 9A-C

(3) Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:
(D) evaluate the impact of research on scientific thought, society, and the environment;
(E) describe the connection between environmental science and future careers

5) Science concepts. The student knows the interrelationships among the resources within the local environmental system. The student is expected to:
B) identify source, use, quality, management, and conservation of water;

(9) Science concepts. The student knows the impact of human activities on the environment. The student is expected to:
(A) identify causes of air, soil, and water pollution, including point and nonpoint sources;
(B) investigate the types of air, soil, and water pollution such as chlorofluorocarbons, carbon dioxide, pH, pesticide runoff, thermal variations, metallic ions, heavy metals, and nuclear waste;
(C) examine the concentrations of air, soil, and water pollutants using appropriate units;

Texas Science(Physics): 2010-2011, grades 9-12: 2H, 3E, 8A-B

2) Scientific processes. The student uses a systematic approach to answer scientific laboratory and field investigative questions. The student is expected to:
(H) make measurements with accuracy and precision and record data using scientific notation and International System (SI) units;

3) Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:
(E) research and describe the connections between physics and future careers

8) Science concepts. The student knows simple examples of atomic, nuclear, and quantum phenomena. The student is expected to:
(A) describe the photoelectric effect and the dual nature of light;
(B) compare and explain the emission spectra produced by various atoms;

Texas Science(Principles of Technology): 2010-2011, grades 10-12: 2H, 4D-F

(2) The student uses a systematic approach to answer scientific laboratory and field investigative questions. The student is expected to:
(H) make measurements with accuracy and precision and record data using scientific notation and International System (SI) units;

4) The student uses the scientific process to investigate physical concepts. The student is expected to:
(D) demonstrate the appropriate use and care of laboratory equipment;
(E) demonstrate accurate measurement techniques using precision instruments;
(F) record data using scientific notation and International System (SI) of units;

ITEEA Educational Standard(s): Grades 9-12

Standard 3. Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

J. Technological progress promotes the advancement of science and mathematics.

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Standard 5. Students will develop an understanding of the effects of technology on the environment.

J. The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment.
K. Humans devise technologies to reduce the negative consequences of other technologies.

Standard 17. Students will develop an understanding of and be able to select and use information and communication technologies.
Q. Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.

Pre-Requisite Knowledge

Collect data and make measurements with accuracy and precision.

Express and manipulate chemical quantities using scientific conventions and mathematical procedures, including dimensional analysis, scientific notation, and significant figures.

Learning Objectives

After this activity, students should be able to:

- Use scientific notation in writing very large or small numbers.
- Convert units of measurement and use scientific notation to write their answers when appropriate.
- Apply basic math skills for precision and accuracy when taking measurements and making conversions.

Materials List

Each group needs:

- 1 stack of sticky notes
- 1 piece of graphite
- Making Nano-Comparisons Guided Notes [See *Attachments*]

To share with the entire class (Teacher):

- PowerPoint – Nanotechnology and Graphene [See *Attachments*]

Introduction / Motivation

Students should be arranged in groups of 2-3 for this activity.

Teacher:

Start with these two question prompts:

Are the activated carbon particles considered nano-particles?

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Convert the activated carbon particle size to meters? Write your answer in scientific notation.

Students:

Students answer the question and convert the particle size in the blank provided in the guided notes.

Teacher:

There is place for the students to record their answers on the guided notes for the Making Nano-Comparisons PowerPoint.

When students complete this activity the teacher reviews how to correctly convert units and write in scientific notation.

(5-8 minutes)

Making Nano-Comparisons PowerPoint [See Attachments] should be displayed.

Start by asking the students:

What were you unable to answer? Do you know what a nanoparticle is?

The PowerPoint contains information on the field of Nanotechnology and explains the concept of a nanometer. This will also lead into the applications of Nanotechnology and the ways in which engineers use nano-materials today.

The PowerPoint focuses on one group of environmental engineers and their research with Graphene Oxide, a nano-particle. It will explain how Graphene Oxide is produced and highlight the size of these Graphene Oxide nano-particles.

Start at slide # 28 on the PowerPoint.

Give each student a sticky note pad and a piece of graphite.

Ask students to pick up the graphite and examine it compared to the molecular structure they see on the Power Point slide.

What do a sticky note pad and a piece of graphite have in common?

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Student Group:

The students make comparisons of their sticky note pad and the graphite and record observations on the lines provided in the guided notes.

Teacher:

Explain that scientists have discovered chemical processes that can seperate one layer from the graphite molecule. The resulting product is called Graphene which is a one atom thick layer of graphite.

Ask students to imagine the sticky note pad as the graphite:

Use the sticky note pad to represent the graphite. How could you model the process of using graphite to make Graphene?

Student Group:

Students peel layers off the stick note pad and place them in separate places around their desk.

Teacher:

After the students remove a few layers from the sticky note pad; stop them, and ask:

What represents the graphite? What represents the graphene? Compare the thickness of the two.

Record your observations in the space provided in the guided notes.

Student Group:

Expected Observations:

The sticky note pad represents the graphite and the single layers represent the Graphene.

The Graphene is much thinner than the graphite.

Teacher:

Advance the PowerPoint to slide # 29.

Explain that Graphene is a nanoparticle, .142 nm or 1 atom thick, which has many unique properties that make it interesting to a diverse group of engineers in a variety of engineering fields. The PowerPoint highlights some of these unique characteristics and potential applications for Graphene.

Advance the PowerPoint to slide # 30.

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The focus of the lesson will be on Graphene Oxide which is produced when Graphene is oxidized. Oxidation of Graphene is done to stabilize Graphene and make it more reactive with molecules around it. Environmental Engineers are attempting to use Graphene Oxide as a medium for adsorption of toxic chemicals in the Houston Ship Channel. The lesson highlights Graphene Oxide because of the close proximity my students have to the Houston Ship Channel and to make them aware of environmental concerns and efforts to find solutions to these problems.

Explain to the students that one of the reasons Graphene Oxide is an excellent candidate for removal of certain contaminants in the Houston Ship Channel is because the particles are so small.

Making the Comparison

Go to PowerPoint Slide #31.

Present this information to the students:

Teacher:

Look at the sticky notes that are modeling Graphene: What would be attached to the sticky notes if you wanted them to model Graphene Oxide?

Students:

The graphene will have oxygen attached to it.

Teacher:

Tell students that Graphene Oxide ranges from .43 nm to 1.23 nm in thickness. Imagine we are dealing with a molecule of Graphene Oxide that is exactly 1 nm thick.

Teacher:

Tell the students the thickness of an individual sticky note is (.07 mm)

Ask them to convert that measurement into meters and record the answer in scientific notation.

Show the students how to multiply and divide numbers in scientific notation.

Ask them to convert the measurement from meters (This measurement will be in scientific notation) to nanometers and record the answer as a whole number. (1 nm = 1×10^{-9} m)

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How does the thickness of a piece of paper compare to the thickness of Graphene Oxide based on your calculations? How many Graphene Oxide molecules would you have to stack together to make the thickness of a piece of paper?

Students:

Students will convert .07 mm into m:

.00007 m = 7×10^{-5} m

Students will convert 7×10^{-5} m into nm:

7 x 104 nm = 70,000 nm

1 sticky note is 70,000 nm thick and a Graphene Oxide molecule is only 1 nm thick. In order to equal the same thickness of a sticky note we would need to stack 70,000 Graphene Oxide molecules on top of each other.

Vocabulary / Definitions

Word	Definition
Dimensional Analysis	Problem solving method that can be used to convert measurements from one unit to another.
Engineer	Problem based innovators that find answers to how things work.
Metric Ruler	Instrument used to measure length.
Millimeter	A metric measurement of length equal to one thousandth of a meter.
Molecule	The smallest part of a substance that retains all the properties of the substance and is composed of two or more atoms.
Nanometer	A metric measurement of length equal to one billionth of a meter.
Nanotechnology	The engineering of materials at the molecular scale.
Oxidation	The interaction between oxygen molecules and all the substances they may come in contact with; The loss of electrons during a reaction.
Scientific Notation	A way of writing numbers which are too large or too small to be conveniently written in standard decimal notation.
Unit	Specific standards for measurement.

Procedure

Background

The activity is designed to inspire interest in engineering and nanotechnology by using relevant research with Graphene Oxide to introduce the topics of measurement, scientific notation, and unit conversion. Using the molecule Graphene Oxide and comparing it to the size of several known objects will help the students to visualize the size of a nano-particle as well as practice measurement techniques, scientific notation, and unit conversions.

Graphene has many impressive properties and seems to have almost unlimited potential in a huge variety of engineering fields. A group of Environmental Engineers have been testing

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Graphene Oxide, Graphene that has been oxidized, for its ability to remove contaminants called polychlorinated biphenyls (PCB's) from the Houston Ship Channel and Galveston Bay area.

Graphene is not naturally a very reactive material but when oxidized it becomes more stable and reactive with other molecules. Graphene oxide is also a nano-sized particle which gives it an extremely high surface area so when it is dispersed in water the chances of the contaminant coming in contact and adsorbing to the Graphene Oxide particle is high. These properties make Graphene Oxide an excellent candidate for removing large amounts of PCB's from our water sources.

Before the Activity

- Gather enough graphite pieces to give each student group 1 piece
- Make ready enough sticky note pads to give each student group 1 pad.
    - To reduce the amount of sticky note pads needed; teacher can separate one full sticky note pad into three smaller pads.
- Ready technology to project the Making Nano-Comparisons PowerPoint.
- Make enough copies of Making Nano-Comparisons guided notes for each student to have their own copy.

With the Students

1. Introduction activity begins on PowerPoint slide # 9. Students will need the guided notes to answer Pre-Assessment questions in the introduction activity.
2. Once the introduction is complete the students will need the graphite and sticky note pad materials. This activity starts on PowerPoint slide # 25.
3. Students will be lead through activity using the sticky note pad, graphite, and guided notes.

Making the Comparison

Taking accurate and precise measurements is important!

Image 2
Image file: MP900399349.JPG
ADA Description: Ruler
Source/Rights:
Caption: Accuracy and precision in measurement is very important with any piece of measurement equipment.

Making Nano-Comparisons

Assessment

Scientific Notation and Measurement Test

Pre-Activity Assessment
Descriptive Title: ___?

Activity Embedded Assessment
Descriptive Title: ___?

Post-Activity Assessment
Descriptive Title: ___?

Contributors

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Supporting Program

University of Houston, National Science Foundation GK-12 and Research Experience for Teachers (RET) Programs

Classroom Testing Information

http://nepis.epa.gov/Exe/ZyNET.exe/2000CIAZ.txt?ZyActionD=ZyDocument&Client=EPA&Index=1976%20Thru%201980&Docs=&Query=%28266%29%20OR%20FNAME%3D"2000CIAZ.txt"%2