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NANOlympics: Investigations into Nano Concepts and Challenges

Teacher Lesson Plan

Overview: In this lesson, students will learn about the concepts and challenges associated with nanotechnology. Students will compete in groups with five different challenges. Students will have eight minutes at each of the 5 stations to complete the challenge. The extra class time will be preparation, switching, cleanup and an ending class discussion.	**Classroom time:** 52 minutes
Objectives: ● Explore the basic concepts and challenges related to nanotechnology. ● Engage in hands-on activities to simulate nanotechnology equipment.	
Related Next Generation Science Standards (NGSS): ● HS-PS1-3. Plan and conduct and investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. ● HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.	**Materials:** ● marbles ● tape ● pennies ● water ● rubbing alcohol ● mystery objects ● disposable pipettes ● student handouts
Related North Carolina Standards: ● Phy.1.3 Analyze the motion of objects based on the principles of conservation of momentum, conservation of energy and impulse.	**Safety:** Students should wash hands after the lab.
Lesson Preparation: Make sure you have all the listed materials. Be sure to prepare the taped objects in black bags before the activity. Be sure to have an accurate timing device. The time may need to be altered depending on the age of the students and the course of study.	

Teacher Instructions:

NANOlympics

1. Be sure to have all lab stations set up ahead of time with proper materials
2. Group students and remind them they will have 8 minutes per station
3. Be sure to accurately time each round

Assessment:

The assessment for this activity is the attached lab handout.

Extensions:

There are numerous extensions that could be conducted to further explore nanotechnology concepts and equipment or a discussion on the ethics and concerns with nanotechnology.

Resources:

Jones, Taylor, Falvo (2009). Extreme Science From Nano to Galactic. NSTA press.

Jones, Falvo, Taylor, Broadwell (2007) Nanoscale Science Activities for Grades 6-12. NSTA press.

Bodner Research Web. Unit Cells. Retrieved from http://chemed.chem.purdue.edu/genchem//topicreview/bp/ch13/unitcell.php [Accessed July 13, 2019]

Names:_____ Date:_____

NANOlympics Lab

Introduction:

The NANOlympics is a cooperative and competitive activity. It is designed to be a fun way to explore nanotechnology concepts and challenges. Each group rotates among five different events. Each event will take place at a different lab table and the surrounding area. Each group member must have a specific duty.

Materials:

pennies, water, rubbing alcohol, disposable pipettes, marbles, tape, mystery objects in black bags

Rules and Roles:

Rules: Broken Rules result in penalties and/or disqualifications.

1. NO communication BETWEEN groups.
2. Predictions for ALL team members MUST BE recorded before any actual measurements are made by any team member.
3. Use time wisely – You only have eight minutes at each station. Only work on information for your current station. This will ensure that all teams have the same amount of time for each event.

Roles Needed:

Leader:	Settles disputes, makes final decisions, and sets the order of her/his group.
Mathematician:	Ensures all data is recorded properly and **verifies** all calculations.
Measurer:	Ensures all measurements are properly made.
Materials Manager:	Ensures all material is properly handled and maintained, including clean-up before group moves on to next event.
Timer:	Each group has a maximum of 8 minutes for all participants to complete the station.

Procedure:

1. Find a lab partner/s. Your teacher may assign you a group or you may be allowed to choose your own lab partners. A lab group cannot be larger than four students. Give your team a creative name that relates to nanotechnology. You can use a calculator when appropriate.
2. Decide who will be the leader, mathematician, measurer, materials manager, and/or timer.
3. Your teacher will assign your team their first event / station. Once you complete this station, go to the next higher numerical station. (e.g. If you start at station #3, go to station #4 next.)
4. Your team will have no more than 8 minutes to complete each event.
5. When required, everyone must record their predictions before any group member makes their actual calculations or measurements.
6. Record all of your data on the provided handout. Remember to be neat! Use a pencil in case you make a mistake.
7. Make sure all stations look identical to when you arrived and rotate to the next event when your teacher calls time.
8. When all events are completed, turn in your handout. Make sure all group members' names are included and everything is complete.

Any questions? Let the games begin…

Station#1 - Nano Calculations

Nanotechnology is a branch of technology that deals with particles less than or equal to 100 nanometers. At these extremely small sizes, many classical physical models and properties of materials do not apply to these materials. At this station you will make some predictions and calculations about the size of various objects.

1. Rank the following objects in size from smallest to largest: diameter of a red blood cell, car, diameter of a proton, diameter of a human hair, virus, atom, bacteria. Circle any that are nanoparticles.

Objects ranked from smallest to largest: _____

_____

2. A human hair is on average 75 micrometers (also called microns) in diameter. Calculate how many nanometers it would be and show your work below.

3. A grain of sand is 1 mm on average. How many nanometers would that grain of sand be? Show your calculation and answer below.

Station #2 – Special Forces

Attractive forces are very important at the nanoscale. Examples of important attractive forces include van der Waals forces, hydrogen bonding, and hydrophobic bonding. These forces are much more important than gravity since nanoparticles are so small.

1. Test how many drops of water can stay on top of a penny before it spills over the side. _____ drops

2. Now do the same test with rubbing alcohol and record the drops held _____ drops.

3. Explain (in complete sentences) why there was a difference in the number of drops for the two tests. Be sure to include an explanation of the intermolecular forces present in both tests.

Station #3 – Nano Vision

One challenge when working with nanomaterials is that they are too small to see with the human eye or optical microscopes. In this station you will use other senses than sight to try to identify various objects. Scientists could use a scanning electron microscope (SEM) or transmission electron microscope (TEM) to see the nanomaterial.

You can do anything that you want to determine which materials are in the black bag except open the bags. Your team does have to come to a consensus about what each material is. Write your hypotheses below.

The object labeled #1 is a _____

The object labeled #2 is a _____

The object labeled #3 is a _____

The object labeled #4 is a _____

Station #4 – Nano Simulations

The way many tools used to visualize and analyze nanoparticles work are by sending x-rays or electrons at a sample. These tools have detectors to analyze the x-rays, electrons or ions that are reflected or emitted by the sample to determine various characteristics about the sample. These characteristics include crystal structure, elemental analysis, or a visual image of the sample.

In this simulation, you are going to put 15 marbles randomly inside the taped circle on the ground. You are going to try to roll marbles outside the circle toward the marbles on the inside to see how many marbles you can knock outside of the circle. You must release your marble (shooter) before it crosses the taped circle. This represents the x-rays and electrons that come in contact with a sample in the nanotechnology tools like scanning electron microscope.

1. How many marbles were you able to knock outside the circle in the given time? _____

2. If you use a larger marble (shooter) to collide with a smaller marble, what should happen to the velocity of the smaller marble and why?

Station #5 – Nano Proportions

In this station, you will predict and then calculate what you think will happen to the ratio of surface area to volume of spheres as the radius of the sphere decreases. This is an important trend in nanotechnology because the radius of the particles is so small. It results in particles looking "bumpy" and having different properties than larger samples of the same material.

1. What do you think will happen to the ratio of surface area to volume as the radius of the particle size decreases? Will it increase or decrease? (circle one)

2. Let's find out. Fill in the below chart. Show all calculations in the space provided under the chart.

Particle size	Surface Area ($4\pi r^2$)	Volume ($4/3\pi r^3$)	Surface Area / Volume
1 m			
1mm (1×10^{-3} m)			
1 mm (1×10^{-6} m)			

Room for calculations:

3. What happened to the ratio of surface area to volume as the particle size decreased?

4. How does this ratio relate to the properties of nanoparticles?

5. Extra Credit (if time permits): Combine the equations for surface area and volume of a sphere to derive one equation to calculate the surface area to volume ratio.