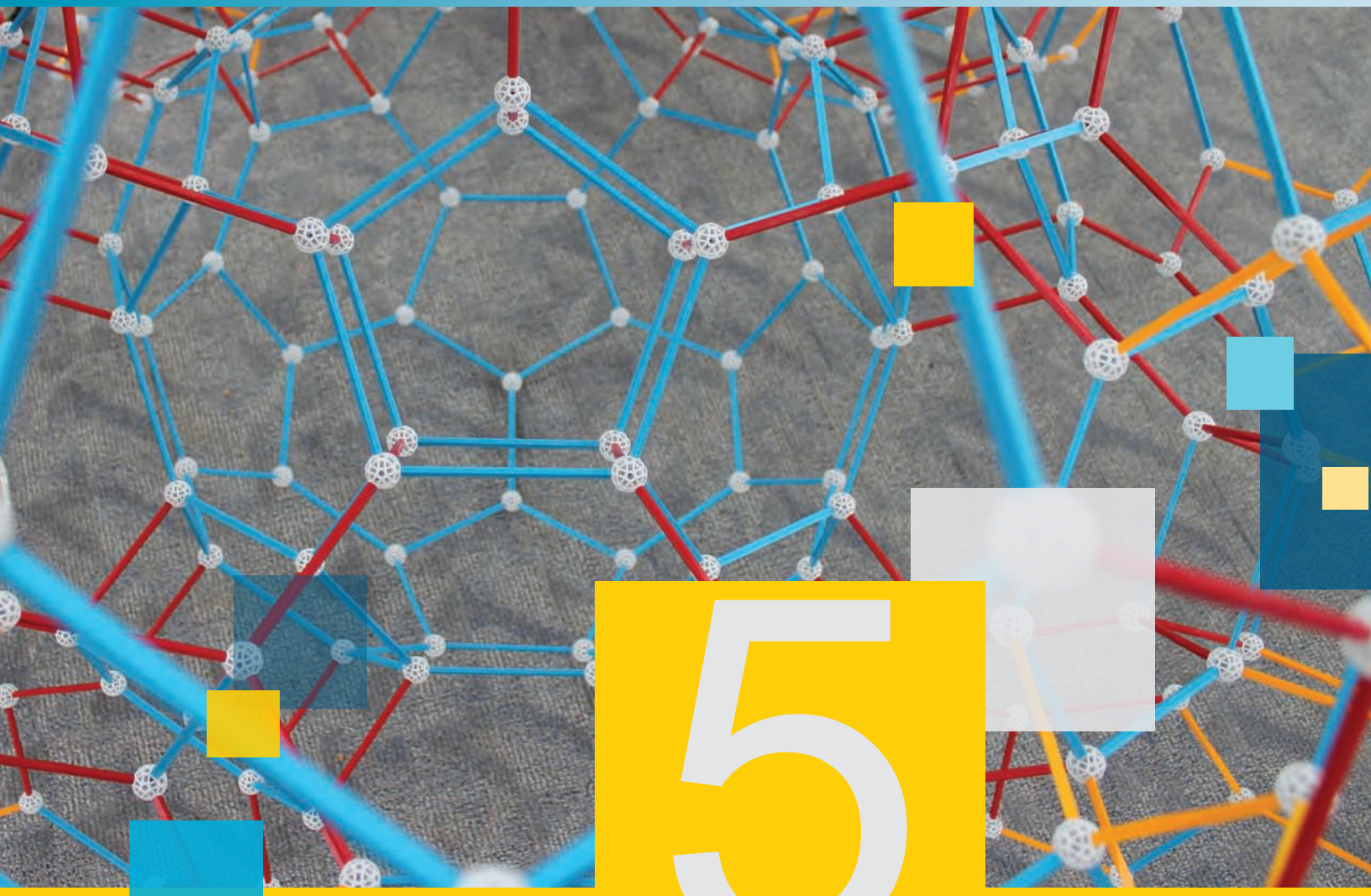
NANOTECHNOLOGY

LESSON PLAN FOR GRADE 5 - SMALL IS DIFFERENT



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Science Teachers,

This lesson plan was designed for grade 5 and meets Alberta Education curriculum learning outcomes for science (see the following page for program of studies reference). The plans are easy to understand and implement without any specialized training, additional work or study. Best of all, they make this interesting subject matter engaging to teach.

The lesson plans were focus tested in seven schools throughout Alberta, incorporating teacher's feedback, and received great reviews. These plans provide the tools necessary to guide students through interactive experiences with nanotechnology that will help them understand this aspect of science. Included in the lesson plans are:

- a short explanation on what is nanotechnology,
- an activity description,
- time requirements,
- materials,
- an assessment rubric, and
- an in-depth teacher's background for reference.

Each lesson was designed in a way that allows you to quickly adapt it to your specific class needs and/or level of knowledge. If you wish to go deeper into the material, you can use the links provided under References or Bibliography. These lesson plans are complemented by a Nano Resource DVD for additional resources such as comic strips, videos, photos and more information related to teaching and understanding nanotechnology. These resources are also available for downloading at **nanolessonplans.alberta.ca**.

Did You Know?

The University of Alberta, the University of Calgary, and the Northern Alberta Institute of Technology all offer nanotechnology programs to train the next generation of curious and bright minds.

As you can see, the subject of nanotechnology is rich with opportunities for learning. We hope you will find the lesson plans worth implementing and include this fascinating area of science in your science program for the year.

If you require more information on additional nanotechnology learning experiences, or have any questions about the information provided, please contact nanoAlberta at 780-450-5111 or email nano@albertainnovates.ca. For grades 7 to 12 check out our travelling Scanning Electron Microscope (SEM) program and book it for your school today. This free program supplies the Microscope for a week and an Alberta certified science teacher will come and work with you and your class or school. A great complement to the nano lesson plans.
Visit **nanolessonplans.alberta.ca** for more information on the SEM program.

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These lesson plans are available to view online and can be downloaded free at **nanolessonplans.alberta.ca**

Limited additional copies are available for ordering from the Learning Resource Centre at **lrc.education.gov.ab.ca**

For information, including reproduction for commercial purposes, please contact:
Alberta Innovates - Technology Futures
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Phone: 780-450-5111
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Program of Studies Reference:

Grade 5 Science – Classroom Chemistry

SLE

- Distinguish reversible from irreversible changes of materials, and give examples of each
- Recognize and describe evidence of a chemical reaction. Explain how the products of a reaction differ from the original substances.
- Use an indicator to identify a solution as being acidic or basic.

Skills

- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Attitudes

- Scientific inquiry
- Collaboration

Check out these other great Nanotechnology Lesson Plans

Nanotechnology: Lesson Plan for Grade 4 Science
Slippery Leaves

Nanotechnology: Lesson Plan for Grade 6 Science
Forestry Nano Superheroes–Trees and Forests

Nanotechnology: Lesson Plan for Grade 7 Science
Nanotechnology and the Environment – Smart Dust

Nanotechnology: Lesson Plan for Grade 8 Science
Nanovision–Light and Optical Systems

Nanotechnology: Lesson Plan for Grade 9 Science
Carbon's Nanocaper–Matter and Chemical Change

Nanotechnology: Lesson Plan for Science 10
"BRANE" Work–Cycling of Matter in Living Systems

Nanotechnology: Lesson Plan for Chemistry 20
Putting it Together-Self Assembly
–The Diversity of Matter and Chemical Bonding

Nanotechnology: Lesson Plan for Biology 30
Medical Applications of Nanotechnology
–Cell Division, Genetics, and Molecular Biology

Did You Know?

Nanotechnology opens students to a wide variety of occupations in an even wider variety of industry sectors. Consider that nanotechnology may be encountered and used in some way by:

- Applications Technician
- Bio Material Engineer
- Cancer Researcher
- Characterization Scientist
- Chemical Technologist/Engineer
- Chemist
- Coating Scientist
- Computational Physicist
- Contact Metallization Process Engineer
- Electron Microscopy Technician
- Materials/Nanotechnology Scientist
- Materials/Metallurgical Engineer
- Mechanical Engineering
- Molecular Biologist
- Molecular Imaging Technologists
- Nanobiologist
- Nanoparticle Development Scientist
- Nanotechnology Business Manager
- Nanotechnology Laboratory Technician
- Nanotoxicologist
- Optical Engineer
- Pharmacologist
- Process Quality Engineer
- Product Marketing Manager
- Tissue Engineer
- Wafer Fabrication Development/Process Engineer

ACTIVITY DESCRIPTION

These lessons are best presented after students have been taught about physical changes. In the first lesson, students experience a chemical reaction that exhibits many of the common signs of a chemical change. They test different sizes of particles during the reaction to show how the overall reaction time is affected by surface area (smaller particle size=increased surface area).

In the second lesson, students investigate the relationship between surface area and particle size. A paper-cutting activity helps students to understand how small a nanometre is. The lessons are then linked to nanotechnology with an examination of nano-based sunscreens and gold nanoparticles. These demonstrations illustrate how the physical properties of a material (such as colour) can change as the particles get smaller.

TIME REQUIRED

Part 1: Chemical Change–40 minutes
Part 2: Surface Area and Nanotech–40 minutes

KEY CONCEPTS

- surface area increases as particle size decreases
- indicator
- surface area and particle size affect overall reaction time (smaller particles react faster)
- nanotechnology

MATERIALS: Part 1

- safety goggles for students who don't wear eyeglasses
- small resealable freezer bags (approximately 16.5 cm x 14.9 cm)
- baking soda ($NaHCO_3$)
- calcium chloride ($CaCl_2$) driveway de-icer pellets
- phenol red (swimming pool chemical)*
- small paper ketchup cups
- plastic spoons (to measure chemicals)
- plastic or foam plates to hold the bags during the reaction
- thermometer

MATERIALS: Part 2

- 1 package frozen cookie dough (or 2, if you want to bake some afterward)
- spherical coloured cake decorating sprinkles
- cookie sheets
- copy paper (from the recycling box)
- 2 types of sunscreen with the same SPF rating (one that goes on clear and one that goes on white)
- newspaper
- scissors
- resealable plastic sandwich bags (same as part 1)

* Teachers' Note

If you are concerned about using a chemical like phenol red which is an acid base indicator, you can prepare a red cabbage solution that works as well. The cabbage indicator starts out blue and changes to lavender during the reaction. The colour change is not as colourful as phenol red which changes from red to orange to yellow but the cabbage juice does produce a definite colour change.

The following link gives information on how to prepare the red cabbage solution:
http://video.about.com/chemistry/Cabbage-pH-Indicator.htm

Teacher background

Adapted from the following sources:

The Lotus Leaf Effect program
(developed for the NISE Network with funding from the National Science Foundation under Award Number 0532536).
http://www.nisenet.org/catalog/programs/lotus-leaf-effect

GLOSSARY

- chemical change
- reactant
- product
- surface area
- nanotechnology
- nanoparticles
- physical change
- wafting

NANOTECHNOLOGY

Nano is the scientific term meaning one-billionth (1/1,000,000,000). It comes from the Greek word meaning “dwarf”.

A **nanometre** is one one-billionth of a metre. One centimetre equals 10 million nanometres (nm). A sheet of paper is about 100,000 nm thick. A human hair measures roughly 50,000-100,000 nm across. A fingernail grows at a rate of one nm per second.

Nanoscale refers to measurements of 1-100 nm. A virus is about 70 nm long. A cell membrane is about 9 nm thick. Ten hydrogen atoms are about 1 nm.

At the nanoscale, unusual properties show up in many common materials. These properties can include remarkably lower resistance to electricity and faster chemical reactions. The same element (i.e. gold) can also exhibit different colours, depending upon the particle size.

Nanotechnology is the manipulation of material at the nanoscale to take advantage of these unusual properties. Technology focuses on developing solutions that involve devices and systems that meet a given need within the constraints of the problem. In nanotechnology, this often means manipulation of individual molecules.

PHYSICAL AND CHEMICAL CHANGES

All matter is made up of atoms, which then form molecules. An atom is the smallest particle of an element that still retains the chemical properties of that element. Matter can go through both physical and chemical changes. A physical change occurs when a substance changes size, shape, or state (i.e. changing from solid to liquid to gas). Note that the substance’s chemical composition (the number, kind, and combination of atoms in a substance) does not change–only its physical form.

In the case of a chemical change, the atoms and molecules rearrange themselves in such a way that new chemicals are formed. The products of the change no longer have the same chemical properties that they did before the reaction took place. There are a number of signs that will indicate that a chemical reaction has taken place.

These are:

1. colour change;
2. temperature change;
3. gas production;
4. odour production.

The kinetic molecular theory tells us that the molecules in a substance are in constant motion. How fast they move depends on whether the substances are solids, liquids, or gases. As well, raising the temperature of a substance also means that the molecules are moving more quickly. The size of the particles (and the corresponding increase in surface area) involved in a reaction will also influence the duration of the reaction.

Given a particular amount of a substance, a chemical reaction will happen more quickly if the substance is broken into smaller bits. The smaller pieces have a greater surface area than the original large pieces, therefore providing more collision sites where a reaction can take place. Two of the factors influencing the time a reaction takes to occur are:

1. temperature of the reactants, and
2. surface area or particle size

Chemical reactions involve the breaking of the bonds that hold together the reactants and the formation of new bonds when products are created. Energy is required for both these activities.

If the amount of energy required to break the bonds is less than what is required to make new bonds, the excess energy is given off in the form of heat. This is an exothermic reaction. Conversely, if more energy is required to break and remake the bonds than is present in the system, the reaction absorbs energy—with a resulting drop in the temperature of the products. This is called an endothermic reaction.

CLASS PREPARATION - PART 1

Chemical Change

20 minutes

Teachers' Note

This activity is an excellent illustration of the signs of a chemical change because it features colour and temperature changes, as well as odour and gas production. The plastic bags can be rinsed and recycled and the plates reused. The paper cups are best discarded, but they are biodegradable. It is safe to dispose of the products of the reaction down the sink.

Particle size and reaction times can be demonstrated more quickly by adding water to antacid tablets (whole and crushed). But this shorter version does not exhibit as many of the signs of chemical change as the activity below does.

You'll need to crush the $CaCl_2$ pellets for the students. We find that a hammer works well for this. You'll need to crush some to the size of small peas, and some to the size of kosher salt.

You will also need to dilute the phenol red to a ratio of at least 10:1 (add 10 ml of phenol red to 90 ml of distilled water).

INTRODUCTION

5 minutes

1. Begin with a reminder about what a physical change is (a change in form, but not chemical structure). Examples include ice melting and refreezing, and sprinkles dissolving and then re-crystallizing.

2. Students can work in groups of four. It can be helpful to put chemicals in small reusable plastic containers (one for each group). Placing all items into a large resealable bag makes distribution and clean up easier.

3. Students work in pairs within their group to perform the reaction. One pair in the group can use whole $CaCl_2$ pellets and the other pair can use the crushed pellets. The reaction should occur more quickly with the crushed pellets than the whole pellets.

4. Discussion: "What are some of the reasons why this reaction happens faster?"

PART 2: SURFACE AREA AND PARTICLE SIZE

Dragonfly TV - Demonstration adapted from:
http://pbskids.org/dragonflytv//show/surfacearea.html

5 minutes

1. This can be a teacher demonstration or a student activity. It shows (using refrigerated cookie dough and decorative sprinkles) how surface area increases as particles get smaller.

2 Dough is cut into two equal parts. One part is made into a single ball, while the other is made into several small balls.

3 You need to use the same amount of sprinkles to coat each of the dough halves. Measuring out an amount that you think will cover the large ball, test to see if it will cover it (1.5 tablespoons (22 ml) of chocolate sprinkles should cover half a package of No Name chocolate chip cookie dough) Once the correct amount is determined, roll the small balls in the same amount of sprinkles.

4 Students should discover that there are not enough sprinkles to cover the small balls, because smaller particle size results in a larger surface area.

5 An extra package of dough can be baked for the students to eat after the lesson.

HOW SMALL IS A NANOMETRE, ANYWAY?

1 Remind students of the results of the chemical change activity. The reaction occurred faster with smaller particles. Talk about nanotechnology and ask what will happen with chemical changes involving particles that are thousands of times smaller than a human hair.

2 Students do the paper cutting activity to get a feel for just how small a nanometre is (see Student Sheets).

NANO SUNSCREEN DEMONSTRATION

Nanotechnology Applications: Teacher Sunscreen Demonstration (Dragonfly TV)

Teacher background:

The purpose of this demonstration is to highlight an everyday application of nanotechnology that students are already familiar with–sunscreen. The demonstration illustrates how reducing the size of zinc or titanium particles in sunscreen changes the colour (or light-reflective property) of the compound. The nano sunscreen goes on clear, while the regular sunscreen goes on white. As well, because the nanoparticles scatter more light, they are a more effective sunscreen.

This should be illustrated by showing that the newspaper treated with the white sunscreen will turn yellow before the one treated with the nano-sized zinc oxide. More of the sunshine gets through the white sunscreen, turning the paper yellow sooner.

HOW SUNSCREEN WORKS:
http://chemistry.about.com/od/howthingsworkfaqs/f/sunscreen.htm

- Sunscreen scatters light, preventing it from reaching the skin.
- Zinc oxide or titanium oxide are the substances that scatter the light. Smaller particles form a larger surface area, giving better coverage and protection.
- The older zinc oxide sunblocks went on white.
- Newer versions that contain nano-sized (between 1-100 nm) zinc oxide and titanium dioxide go on more clearly.
- Zinc oxide and titanium dioxide are more effective at blocking both UVA and UVB rays when they are nano-sized: www.scientificamerican.com/article.cfm?id=do-nanoparticles-and-sunscreen-mix&page=2

DIRECTIONS FOR DEMONSTRATION:

STEP 1 - Cut three strips of newspaper the same size and place them inside three resealable plastic bags.

STEP 2 - Leave one alone.

STEP 3 - Put regular sunscreen on the second (the kind that leaves big white streaks).

STEP 4 - Put sunscreen with nanoparticles on the third (the kind that goes on clear).

STEP 5 - Make sure to use sunscreen with the same SPF to ensure that it is a fair test.

STEP 6 - Place the bags in the bright sun for several days. Check them every day.

EXTENSION

Sunscreen Safety

1. Discussion of the safety issues around nano sunscreen and penetration of particles into the skin. Internet searches turn up a lively discussion, especially in Australia, where skin cancer is a huge problem. One source promoting nano sunscreen is:
   www.sciencebase.com/science-blog/just-say-no-to-sunscreen-nanophobia.html
2. This government of Australia site looks like it offers a credible balanced view on the topic:
   http://www.tga.gov.au/safety/alerts-medicine-sunscreens-051202.htm
3. The Scientific American article "Do Nanoparticles and Sunscreen Mix?" also gives a balanced view:
   www.scientificamerican.com/article.cfm?id=do-nanoparticles-and-sunscreen-mix
4. Nanoparticles and sunscreen safety:
   www.nanowerk.com/spotlight/spotid=714.php

More Chemical Reactions

Ask students to see what happens if they keep the baking soda and calcium chloride from mixing (keep each in a separate corner of the plastic bag) while you add the phenol red. This should illustrate exothermic (calcium chloride) reactions and endothermic (baking soda) reactions. They can use the thermometer to record the change in the temperature of the reactants in each corner of the bag.

Gold and Stained Glass

Finish up by showing the Dragonfly TV Episode noted below:
http://pbskids.org/dragonflytv//show/stainedglass.html

ASSESSMENT

These rubrics for assessing science skills are kindly shared by Julie Arsenault BSc., MSc., Avonmore School (Nellie McClung program).

SCIENCE LAB PORTFOLIO - COMMUNICATION AND TEAMWORK

CRITERIA	4 ▪ WOW!	3 ▪ YES!	2 ▪ YES, but...	1 ▪ NOT QUITE
CLARIFIES AND SHAPES IDEAS IN A GROUP	Clarifies and shapes understanding through effective and extensive collaboration with others	Clarifies and shapes understanding through collaboration with others	Shares understanding with others	Shares little or no understanding with others
PARTICIPATES IN AND CONTRIBUTES TO GROUP WORK	Contributes enthusiastically and invites suggestions from other group members throughout task	Contributes to group and accepts others' ideas throughout task	Contributes to group throughout portions of task	Participates only when encouraged during the task
TASK DISTRIBUTION	Completes her share of the work and encourages each member to have the opportunity to do what they would like	Completes her share of the work and allows each member the opportunity to do what they would like	Completes some of her share of the work, but does not always allow all members the opportunity to do what they would like	Completes little work and participates only when encouraged
COMMUNICATION THROUGHOUT LAB	Communicates clearly with group members regarding instructions, resulting in a seamlessly performed lab	Communicates well with group members regarding instructions, and the lab is performed well	Communicates with members of the groups regarding instructions, and the lab is completed	Communication with group members is lacking, and lab execution suffers as a result

SCIENCE LAB PORTFOLIO - ANALYZING AND INTERPRETING

CRITERIA	4 ▪ WOW!	3 ▪ YES!	2 ▪ YES, but...	1 ▪ NOT QUITE
PRESENTS DATA	Uses technology to effectively display data that is organized and easy to interpret	Uses technology to display data that is accurate and clear	Uses technology to display compiled data, but presentation may contain errors or be unclear	Uses technology to present incomplete data that does little to assist in solving the problem
CONCLUSIONS	Uses data to provide convincing support for conclusions	Uses data to support conclusions	Uses data to provide partial support for conclusions	Draws conclusions that are not related to data
IDENTIFIES ALTERNATIVES AND EVALUATES EFFECTS	Uses data and observations to provide a clear and logical explanation of which design characteristic led to peak performance	Uses data and observations to provide a reasonable explanation of which design characteristic led to peak performance	Uses data and observations to provide some support for their choice of design characteristic that led to peak performance	Choice of design characteristics are not based on data or observations
GRAPH CONSTRUCTION AND MECHANICS	Graph is thoroughly complete, neat and accurate, including a detailed title, axes labels, and units where needed	Graph is neat and accurate, buy may be missing detail in title, axes labels, or units where needed	Graph is accurate, but is missing details in title, axes labels, or units, and its neatness is questionable	Graph is messy or incomplete and is missing most details for proper graph construction

SCIENCE LAB PORTFOLIO - ANALYZING AND INTERPRETING

CRITERIA	4 ▪ WOW!	3 ▪ YES!	2 ▪ YES, but...	1 ▪ NOT QUITE
ANALYSIS QUESTIONS	Questions are answered thoroughly and accurately, and demonstrate clear understanding of the relationship between _____ and _____	Questions are answered accurately and demonstrate understanding of the relationship between _____ and _____	Questions are answered, but may not be completely accurate, and student's understanding of the relationship between _____ and determining _____ is unclear	Questions are incomplete and may not be completely accurate, and student's understanding of the relationship between _____ and _____ is unclear

ASSESSMENT

Assess how well students understand key concepts using the journal entry below.

SCIENCE JOURNAL

Scientist: Date:

Today I discovered that:

I also learned that:

The most interesting part of the experiment was:

I am still wondering:

SCIENCE JOURNAL RUBRIC

3 = Satisfactory 2 = Needs Improvement 1 = Unsatisfactory

Completed journal and wrote down information accurately	3	2	1
Clearly showed knowledge learned	3	2	1
Provided detailed descriptions using scientific terms	3	2	1
Made correct conclusions	3	2	1

Total Points earned: **Total points possible: 12**

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STUDENT SHEET
Chemical Change

MATERIALS:

- safety goggles (if you don't already wear glasses)
- calcium chloride
- 1 small cup
- 1 small plastic bag
- sodium bicarbonate
- phenol red
- plastic spoons
- thermometer

1. Put on your safety goggles.
2. Describe the solids and the liquid materials you will be using in the lab. Use the chart for your observations. If you can't think of a way to describe the material, compare it to something that it reminds you of.
3. Take the temperature of each chemical. Add it to your chart.

OBSERVATIONS OF THE CHEMICALS BEFORE THE EXPERIMENT:

Calcium chloride ($CaCl_2$)

COLOUR	SIZE	TEXTURE	SHAPE	SMELL remember to waft	TEMPERATURE

SODIUM BICARBONATE ($NaHCO_3$)

COLOUR	SIZE	TEXTURE	SHAPE	SMELL remember to waft	TEMPERATURE

PHENOL RED SOLUTION

COLOUR	SIZE	TEXTURE	SHAPE	SMELL remember to waft	TEMPERATURE

- Predict what you think will happen when the three reactants are mixed together. Write down your prediction on the sheet.

Prediction

_____

_____

_____

- Place your small plastic bag flat on your table.
- Put one level spoonful (5 ml) of baking soda into the bag.
- Put two level spoonfuls (10 ml) of calcium chloride (either whole or crushed) into the bag.
- Fill the small cup half full of phenol red and sit it upright into the bag.
- Zip the bag up tightly and be ready to write down what happens inside.
- Be ready to use your watch to time the reaction.
- Tip the cup to add the phenol red to the solids, and mix the chemicals together.
- As soon as the materials stop bubbling, record the time and take the temperature inside the bag. Write the results in the chart.

How long did the reaction take?

_____

_____

• Describe the size, shape, colour, and odour (use wafting) of the material that remains in the bag.

OBSERVATIONS AFTER THE REACTION

COLOUR	SIZE	SHAPE	SMELL remember to waft	TEMPERATURE

• Wash and dry all the equipment and put it away according to your teacher's directions.

STUDENT SHEET

How Small is a Nanometre?

• Trace around your 30 cm ruler and cut out the tracing.
• Cut the tracing in half to get a 15 cm piece.

• A nanometre is one billionth of a metre. It takes 50,000 nanometres to go across a human hair. Predict how many more times you will need to cut the 15 cm piece in half to get a nanometre-sized piece.

Prediction: _____

• Keep cutting each half in half as far as you can. How many cuts did you get?

Number of Cuts: _____

You would have to cut the piece in half 28 times to get to a nanometre!

STUDENT SHEET
Nano Sunscreen Demonstration

• Which newspaper turns yellows first?

_____

• How does the colour of the sunscreen affect how the sunscreen works?

_____

• Which sunscreen keeps the sunlight out best? Why do you think it works better?

_____

One of the things people don't like about sunscreens is that they don't rub in very well. The main ingredients–zinc oxide (ZnO) and titanium dioxide (TiO_2)–leave white streaks on the skin. People prefer a sunscreen that doesn't show up on their skin.

Nanotechnology to the rescue! Nanoparticles replace the usual forms of ZnO and TiO_2, making the sunscreen more invisible.

Source: www.nanowerk.com/spotlight/spotid=714.php

NOTES:

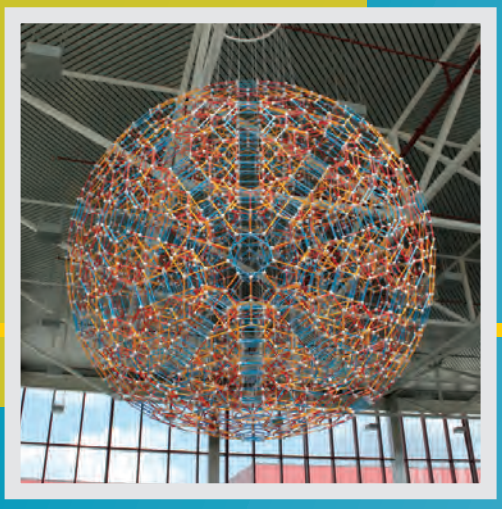
WHAT YOU'LL FIND HERE

- a "pick-up-and-go" lesson plan that will add science currency to your science program
- activities that meet science curriculum learning outcomes
- interesting subject matter that is engaging to teach
- easy to implement experiments (no specialized training needed)
- a quickly adaptable lesson with worksheets and rubrics for your class needs

Nano is... the scientific term meaning one-billionth (1/1,000,000,000). It comes from the Greek word meaning "dwarf".

Nano Science is... the discovery, research and understanding of all things nano.

Nanotechnology is...
the application of science at the molecular level.



Nanotechnology
is revolutionizing medicine, energy production, environmental protection, bioindustries and more!

Government of Alberta