Nanotechnology Research Experience for Teachers

Rice University
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WHAT'S THE MATTER? AN INSIGHT ON PHYSICAL AND CHEMICAL CHANGES & PROPERTIES

Subject	Chemistry, (Regular/Pre-AP) and IPC
Grade Levels	10^{th} -12^{th} grade
Essential Question	What is the difference between a physical property and a physical change? What is the difference between a chemical property and a chemical change? How can pure substances and mixtures be distinguished from each other in the laboratory?
Science Objectives	The student will be able to differentiate between chemical and physical changes and properties. Students should also understand that by changing a substance chemically, a new substance will be created with new properties.

LESSON ACTIVITIES

Engage	The teacher will pose questions to the students: What is the difference between chemical and physical properties? Chemical and physical changes? The teacher should ask the students to give examples of the different types of chemical changes and physical properties. This information could be used to assess prior knowledge of the material.
Explore	The students will observe a PowerPoint presentation on the vocabulary used to describe matter and change. They will use examples to compare and contrast (in a T-chart) what are physical and chemical properties and what are chemical changes. Students engage in a brief activity on physical and chemical changes and properties to re-enforce the material shown and to build a further knowledge base of the concept.
Explain	Student discussions should include description of physical changes in a substance as not changing what the substance is, and descriptions of chemical change involving a chemical reaction when a new substance is formed and energy is either given off or absorbed. At this point, a demonstration on alloys should be conducted to help explain how there are processes that change substances. The end result is a new substance that has different physical properties.

Elaborate	In a research lab, scientists are able to SYNTHESIZE materials, which are creating new substances through chemical changes. During my research, we synthesized a superconductor (YBCO 123) from the compounds yttrium oxide, copper oxide, and barium carbonate. The superconductor was produced in a thermo chemical reaction and one of the properties of this compound is the ability to repel magnetic forces resulting in zero resistivity (SEE SUPERCONDUCTIVITY). This is a property that is unique in the superconductor and not the precursors of that chemical combination.
Evaluate	The students will be conducting a lab experiment on making an alloy. They will see how to create a new substance with new properties from two different elements. The students will describe what changes have taken place after the new substance is formed by evaluating its properties.
Materials	Pre-Assessment (optional), (Chemical/Physical Properties and Changes Activity Worksheet, PowerPoint Presentation, Making an Alloy Lab Worksheet)
Assessment Products	Chemical/Physical Properties and Changes Activity Worksheet, Making an Alloy Lab Worksheet

INFORMATION FOR TEACHERS

Standards	(4) Science concepts. The student knows the characteristics of matter and can analyze the relationships between chemical and physical changes and properties. The student is expected to: (A) differentiate between physical and chemical changes and properties; (B) identify extensive and intensive properties; (D) classify matter as pure substances or mixtures through investigation of their properties.
Prior Student Learning	**Beginning in 2010,** sixth grade students have experience in classifying matter by knowing that an element is a pure substance represented by a chemical symbol (6.5A) . Also in sixth grade, students differentiate between elements and compounds on the most basic level and identify the formation of a new substance by using the evidence of a possible chemical change such as production of a gas, change in temperature, production of a precipitate, or color change (6.5C & 6.5D). In seventh grade, students distinguish between physical and chemical changes in matter in the digestive system (7.5B) . Students in IPC know how to investigate changes of state as it relates to the arrangement of particles of matter and energy transfer (I 7A). Students are also able to recognize that chemical changes occur when substances react to form different substances and that these interactions are largely determined by valence electrons (I 7.B). The Classification of Matter unit is no longer taught in IPC. Chemistry will be the first time all high schools students will see this unit which is now a part of the Matter and Change unit.

	Prior to 2010, students first identified matter as solids, liquids, and gases in 3rd grade. Students who took IPC fully understood the states of matter because this topic was powered. IPC students distinguished between physical and chemical changes in matter such as oxidation, digestion, changes in states, and stages in the rock cycle. ****** Students should have a basic understanding of a mixture and a pure substance. Students should also have some knowledge of physical and chemical changes.**
Possible Prior Misconceptions	Students may become confused with the differences between chemical or physical properties and changes. Students may be unclear in understanding that a mixture can only become a new substance through a chemical change.
Lesson Sequence	The students will first be engaged by posing questions on what a chemical and physical property and change are as well as list some examples. The teacher can also take an assessment to determine what the students know prior to asking question on the overhead projector (get students to raise their hands for the correct answer choice). The students will then look at a PowerPoint presentation on the vocabulary of the matter and change chapter and afterwards, do an activity on physical and chemical properties to re-enforce the content.
Background Information	The properties of a substance are those characteristics that are used to identify or describe it. When we say that water is "wet", or that silver is "shiny", we are describing materials in terms of their properties. Properties can be divided into the categories of physical properties and chemical properties. **Physical properties** are readily observable, like; color, size, luster, or smell. **Chemical properties** are only observable during a chemical reaction. For example, you might not know if sulfur is combustible unless you tried to burn it. Another way of separating kinds of properties is to think about whether or not the size of a sample would affect a particular property. No matter how much pure copper you have, it always has the same distinctive color. No matter how much water you have, it always freezes at zero degrees Celsius under standard atmospheric conditions. Methane gas is combustible, no matter the size of the sample. Properties, which do not depend on the size of the sample involved, like those described above, are called **intensive properties**. Some of the most common intensive properties are; density, freezing point, color, melting point, reactivity, luster, malleability, and conductivity. **Extensive properties** are those that do depend on the size of the sample involved. A large sample of carbon would take up a bigger area than a small sample of carbon, so volume is an extensive property. Some of the most common types of extensive properties are; length, volume, mass and weight. Pieces of matter undergo various changes all of the time. Some changes, like an increase in temperature, are relatively minor. Other changes, like the combustion of a piece of wood, are fairly drastic. These changes are divided into the categories of Physical and Chemical change. The main factor that distinguishes one category form the other is whether or not a particular change results in the production of a new substance. **Physical changes** are those changes that do not result in the production of a new substance. If you melt a block of ice, you still have H_2O at the end of the

change. If you break a bottle, you still have glass. Painting a piece of wood will not make it stop being wood. Some common examples of physical changes are; melting, freezing, condensing, breaking, crushing, cutting, and bending. Special types of physical changes where any object changes state, such as when water freezes or evaporates, are sometimes called **change of state operations**. **Chemical changes**, or chemical reactions, are changes that result in the production of another substance. When you burn a log in a fireplace, you are carrying out a chemical reaction that releases carbon. When you light your Bunsen burner in lab, you are carrying out a chemical reaction that produces water and carbon dioxide. Common examples of chemical changes that you may be somewhat familiar with are; digestion, respiration, photosynthesis, burning, and decomposition. (http://www.mcwdn.org/chemist/pcchange.html)

Adaptations for Special Learners

If you have students that have difficulty understanding the concepts or language, you may want to include a small activity that uses a more visual approach to the material. Have them work in groups and separate a word matching activity where they group pictures with words. Also you can set up a small lab station with common materials to see if they understand and can observe the properties and any changes that the substances have after each stage in the procedure.

Extensions

As an extension, the teacher may discuss new findings in science and research that involve superconductivity. The teacher could demonstrate the Miessner Effect of a superconductor to show that it has a fascinating property that allows it to levitate a magnet at low temperatures. This is a good way to show how a thermo chemical reaction produced a new substance with new properties.

http://www.youtube.com/watch?v=nWTSzBWEsms

Resources

http://www.ornl.gov/info/reports/m/ornlm3063r1/pt3.html

http://imr.chem.binghamton.edu/labs/super/superc.html

http://www.youtube.com/watch?v=mJrAUQa7WnY

http://www.chem4kids.com/files/matter_chemphys.html

STUDENT ACTIVITIES (SEE ATTACHMENTS BELOW)

Essential Question

What is the difference between a physical property and a physical change?

What is the difference between a chemical property and a chemical change?

How can pure substances and mixtures be distinguished from each other in the laboratory?

Pre-Assessment: (Overhead Projector)

1. An unknown yellow powder has a constant melting point and does not physically or chemically separate into other substances. The unknown substance is classified as:

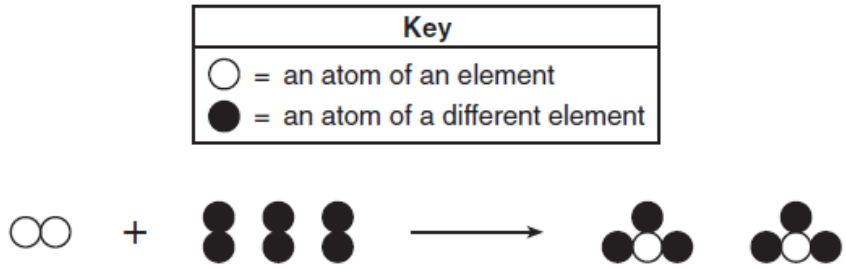
A. An element

B. A compound

C. A mixture

D. An alloy

Answer: A



2. Which statement describes the type of change and the chemical properties of the product and reactants?

A. The equation represents a physical change, with the product and reactants having different chemical properties.

B. The equation represents a physical change, with the product and reactants having identical chemical properties.

C. The equation represents a chemical change, with the product and reactants having different chemical properties.

D. The equation represents a chemical change, with the product and reactants having identical chemical properties.

Answer: C

Explore	The students will show their knowledge of physical and chemical changes and properties through activities and a lab investigation.
Materials	Pre-Assessment (optional), Chemical/Physical Properties and Changes Activity Worksheet, PowerPoint Presentation, Making an Alloy Lab Worksheet
Explain/Product	Students will have a more in depth understanding of physical and chemical properties. Students will also understand that the formation of a new substance will have different properties.
Elaborate	It is important that the students connect the major differences between a physical and chemical change (making a mixture and a new substance).
Evaluate/Test, rubric, skill, etc.	The teacher should evaluate if the students can compare and contrast chemical and physical changes and properties (turn in activity and answer lab questions).

Name_____Date_____Period_____

CHEMICAL AND PHYSICAL PROPERTIES AND CHANGES ACTIVITY

1. A **physical property** is observed with the senses and can be determined without destroying the object. Examples of physical properties include mass, shape, color, odor, length. In a **physical change**, the original substance still exists. It has only changed form.

2. A **chemical property** indicates how a substance reacts with something else. In a **chemical change**, a new substance is produced. Energy changes always accompany chemical changes. Chemical changes are always accompanied by physical changes.

3. Which of the following processes are physical changes? Which are chemical changes?

a. combustion	e. evaporation	i. boiling
b. melting	f. filtration	j. electrolysis
c. dissolving	g. fermentation	k. decomposition
d. metabolism	h. distillation	

4. Identify the following properties as physical or chemical.

	Physical	Chemical
Blue color		
Density		
Flammability		
Solubility		
Supports combustion		
Sour taste		
Melting point		

	Physical	Chemical
Odor		
Luster		
Neutralize an acid		
Boiling point		
Hardness		
Reacts with acid to form H_2		
Reacts with water to form a gas		

5. Classify the following examples as physical or chemical changes.

a. Sodium chloride dissolves in water _____

b. Hydrochloric acid reacts with sodium hydroxide to produce a salt, water, and heat. _____

c. A pellet of sodium is sliced in two pieces. _____

d. Water is heated and changed to steam. _____

e. Potassium chlorate decomposes to potassium chloride and oxygen gas. _____

f. Iron rusts. _____

g. Ice melts. _____

h. Acid on limestone produces carbon dioxide gas. _____

i. Wood rots. _____

j. cracking an egg _____

k. bake a cake _____

Teacher Demonstration: Silver and Gold Penny

Purpose: To show students how an alloy is made.

Materials: salt, vinegar, zinc powder, spoons (2), hot plate, Bunsen burner, distilled water, sodium hydroxide, striker, beakers (3), and 3 pennies

Procedure:
1. Place the pennies in a beaker filled with vinegar and salt to clean them.
2. Leave the pennies in the beaker for 10 minutes.
3. Take another beaker and add distilled water, sodium hydroxide, and zinc.
4. Stir the solution until the mixture becomes slightly cloudy.
5. Place the beaker of zinc solution on the hot plate and allow to heat until a gentle boil.
6. Place a penny in the zinc solution for 5 minutes (make sure that the penny has contact with the zinc in order for the reaction to take place).
7. Using a spoon, take the penny out and place it into a beaker filled with distilled water to clean.
8. Dry the penny off and allow the penny to cool.
9. Repeat steps 6-8 with another penny.
10. Taking one of the zinc-plated pennies, light a Bunsen burner and evenly move the penny back and forth over the fire for 30seconds or so until you see a color change(do this on both sides).

Now you have a "gold"(brass), "silver"(zinc), and copper penny to show to your class!
(See visual teacher instructions for more information)

Name_____ Date_____ Period_____

Making an Alloy Lab

Time: 40 minutes
<u>Objective:</u> To make an alloy and compare its properties (chemical and physical) to existing elements.

<u>Scientific Principles:</u> Brass is an alloy of zinc and copper. Zn and Cu are dissolved in one another to form a metallic solution. Alloying one metal with other metal(s) or non metal(s) often enhances its properties. They do not form a compound in the normal sense that we use the term "compound" meaning a definite molecular composition. In the same sense we do not classify salt dissolved in water as a "compound" because over most of the concentration range the relative amounts of salt and water can be varied continuously. There are some compounds that do form specific compounds with water, and there are some metallic combinations that do have a fixed composition forming inter-metallic compounds.

<u>Uses:</u> Brass is used in instruments, coins, and many varied fixtures such as doorknobs, bolts, etc. Brass is also used to decorate many household items such as clocks and mirrors. During the medieval and ancient times, brass was used to decorate armor as well as forge cannons. Steel was used in cannons upon its discovery.

<u>Students Prior Knowledge:</u> Students know reactant atoms and molecules interact to form products with different chemical properties.

<u>Pre-Lab Questions:</u>

1. **What is an alloy?_____**
   _____
2. **Describe the difference between a mixture and a compound._____**
   _____
3. **Compare a cake that has been cooked to the mixed ingredients of a cake (cake batter). Do they both have the same properties? Why or why not?-**
   _____
   _____
   _____

<u>Materials:</u>

1 Copper pellet	Balance beam
1 Zinc pellet	Graduated cylinder
Crucible	Carbon powder (optional)
Pipe clay triangle	Heat resistant mat
Spatula	

Bunsen burner
Tripod
Tongs
Metal sand trays or sturdy metal lids
Casting sand
Thermal couple
CBLs (TI graphing calculator)

Procedure:

1. Take out one pellet each of copper and zinc. Put them both into the crucible.

2. If using casting sand, fill one of the sand trays with casting and push your finger into it to make an indent. This is your cast.

3. Put the crucible onto a pipe clay triangle. Make sure that it is stable on a tripod and mat.

4. Heat the crucible strongly with a Bunsen burner until the copper and zinc is molten. Add a spatula of carbon powder to the top of it to prevent a skin forming.

5. Mix the zinc and copper with a spatula until the metals are both molten and thoroughly mixed.

6. Move the Bunsen away from the tripod and put it onto a yellow flame. Wearing thermal protection gloves, pick up the crucible using the tongs, and pour the molten metal into the cast or onto a ceramic tile. **Take great care as you do this to avoid splashing or dripping.**

7. Let it cool down completely before you remove it from the cast.

Testing the alloy:

1. Hardness testing Try to scratch the alloy with the zinc, and the zinc with the alloy. The one which does not scratch is the hardest. Which one is the hardest, the alloy or zinc (refer to the Mohs scale)?_____

_____

2. Density testing Hold the zinc in one hand and the alloy in the other. Which seems to be the heaviest/most dense? _____Now measure the volume (water displacement) and find the mass to determine the density. Which one has the greatest density?_____

3. Melting-point testing Put the alloy into the thermal couple (which is attached to the CBL). Place the thermal couple over the Bunsen burner and allow the CBL to read the melting point of the alloy. Repeat procedure for zinc and copper.

Observations:

Substance	Color	Melting Point(°C)	Hardness(Mohs Scale)	Density(by weight)	Density(D=g/mL)
Zinc					
Copper					
Brass(alloy)					

Post-Lab Questions:

1. What type of change are the following:
    a. Metal rusting_____
    b. Silver tarnishing_____
    c. Water boiling_____
    d. Paper burning_____

2. How is a mixture different from a compound?_____

_____

_____

3. In the lab, when the alloy was being made, what type of change took place? How could you tell?

_____

_____

4. Using the data, determine if a new substance was formed. Explain why or not.

_____

_____

Teaching notes

The expected results of the tests are that the alloy is clearly harder and scratches the zinc and the copper. The zinc does not leave a mark on the alloy.

The density and melting points of the substances is below:

Substance	Density (g/mL)	Melting Point (°C)
Brass	8.4-8.7	930°C
Zinc	7.14	419.53°C
Copper	8.96	1083.0 °C

Make sure you get the students to weigh the alloy and to work out its volume by displacement. They could then calculate the density (mass/volume). The lead melts first, followed by the tin. The alloy has the highest melting point – demonstrating clearly very different properties from its constituent metals.

Make sure that the students take the highest temperature from the thermal couples for each substance (the thermal couple has a limitation as to how high it can measure the temperature of each substance). The range for each substance should be substantially different which will reflect that there melting points are varied. **Note: the metals may or may not melt before you get the highest temperature.**

This experiment can stand alone as a demonstration of how the properties of a metal can be changed by alloying, or you could follow it up by asking students to explain the results of the hardness testing in terms of the structure of the metals.

A good answer includes reference to the layer structure of metals and how alloying can prevent the layers from sliding over each other, making it more difficult to change the shape of the metal. This results in the alloy being harder than the pure metal. It will be more difficult to change its shape and therefore to scratch it.

For those doing this as a fun experiment, it is possible to cast the alloy in a variety of shapes by changing the shape of the cast in the casting sand.

What the students should obtain from this lab is that by making brass, you have made a new substance with very different properties. This is an important concept to know as the students are lead into chemical reactions (which are chemical changes).

References: http://www.newton.dep.anl.gov/askasci/chem03/chem03403.htm
http://www.practicalchemistry.org/experiments/making-an-alloy-solder,131,EX.html

Mohs Scale of Hardness

The table below incorporates additional substances that may fall between levels:

Hardness	Substance or mineral
0.2-0.3	Caesium, Rubidium
0.5-0.6	Lithium, Sodium, Potassium
1	Talc, Graphite
1.5	Gallium, Strontium, Indium, Tin, Barium, Thallium, Lead
2	hexagonal Boron nitride,[11] Calcium, Selenium, Cadmium, Sulfur, Tellurium, Bismuth
2.5 to 3	Magnesium, Gold, Silver, Aluminium, Zinc, Lanthanum, Cerium
3	Calcite, Copper, Arsenic, Antimony, Thorium, Dentin
4	Fluorite, Iron, Nickel, Brass
4 to 4.5	Platinum, Steel
5	Apatite, Cobalt, Zirconium, Palladium, Tooth enamel
5.5	Beryllium, Molybdenum, Hafnium
6	Orthoclase, Titanium, Manganese, Germanium, Niobium, Rhodium, Uranium
6 to 7	Glass, Fused quartz, Iron pyrite, Silicon, Ruthenium, Iridium, Tantalum
7	Quartz, Vanadium, Osmium, Rhenium
7.5 to 8	Hardened steel, Tungsten, Emerald
8	Topaz, Cubic Zirconium
8.5	Chrysoberyl, Chromium
9-9.5	Corundum, Carborundum (SiC), Tungsten carbide, Titanium carbide, Stishovite
9.5-10	Rhenium diboride, Tantalum carbide, Titanium diboride, Boron [12][13]
10	Diamond
>10	Nanocrystalline diamond (hyperdiamond, ultrahard fullerite)