SCSU CRISP CCSA Kit Pages 2016

Title of Module: **Bulk Properties of Substances** **LENGTH OF DEMO/LESSON:** **80 – 125 minutes**

Subject or Unit of Study: **Grade 9 Physical Science** **GRADE LEVEL** **Grade 9**

STUDENT OBJECTIVES

Students will...

1. Construct a rationale for the observed bulk properties using a description of the structure (crystalline and amorphic) and composition of those substances at the atomic molecular scale. (HS-PS1-3)

2. Design an investigation, describe the data to be collected, how data is collected, the number of trials, the experimental set up, and the equipment required in the investigation design. (HS-PS1-3)

3. Collect and record quantitative and/or qualitative on bulk properties of substances. (HS-PS1-3)

4. Describe the relationship between the measurable properties of a substance and the strength of the electrical forces between the particles of the substance. (HS-PS1-3)

5. Describe why data about bulk properties would provide information about strength of electrical forces between the particles of the chosen substances, including the following: particle spacing with thermal (kinetic) energy changes, molecular patterns reflect macroscopic patterns with interactions between particles, and patterns observed at multiple scales. (HS-PS1-3)

NEXT GENERATION SCIENCE STANDARDS

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

[Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.]

[Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]

NATIONAL STANDARDS & COMMON CORE

CCSS.ELA-LITERACY.RST.9-10.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
CCSS.ELA-LITERACY.RST.9-10.7: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
CCSS.ELA-LITERACY.RST.9-10.8: Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
CCSS.MATH.PRACTICE.MP7: Look for and make use of structure.
Mathematically proficient students look closely to discern a pattern or structure.

CONNECTICUT STATE STANDARDS

9.4 Atomic Structure and Bonding: The configuration of atoms and molecules determines the properties of the materials.
Describe the general structure of the atom, and explain how the properties of the first 20 elements in the Periodic Table are related to their atomic structures. (D10)

MATERIALS

List all materials needed for this lesson/demonstration

Prince Rupert's Drop:

- *Plastic bag*
- *Borosilicate Glass Rods (standard Na_2O, B_2O_3, $2SiO_2$ glass composition)*
- *Beaker with cold water*
- *Crucible (if using furnace)*
- *Propane torch or furnace*
- *Stainless steel beaker*
- *Safety glasses*
- *Heat-resistant gloves*
- *Scissors or diagonal (dike) pliers*
- *Polarizing material*
- *Light source*

Aluminum vs. Alumina Student Designed Activity:

- *Alumina rod – ceramic knife sharpening rod*
  - *3/8" diameter – 8 ½" length*
  - *http://www.knifecenter.com/kc_new/store_keywords.html?sortType=skuAs&srch=AC71&SUBMIT2.x=23&SUBMIT2.y=10*
  - *Part number – AC71*
- *Aluminum rod*
  - *3/8" diameter – cut to 8 ½" length*
  - *Lowe's or Home Depot*
- *2 ring stands with clamps*
- *propane torch or Bunsen burner*
- *wax (candle or sprue)*
- *digital thermometer, multi-meter (if available)*
- *balance*

SAFETY

List all safety precautions needed for this lesson/demonstration

Prince Rupert's Drop:

Safety glasses and apron required, hair tied back, no loose clothing/jewelry (high heat, molten glass, shattering glass)

Aluminum vs. Alumina Investigation:

Safety glasses and apron required, hair tied back, no loose clothing/jewelry (high heat, melting wax, hot surfaces)

LEARNER BACKGROUND

Describe the students' prior knowledge or skill related to the learning objective(s) and the content of this lesson, using data from pre-assessment as appropriate.

Prince Rupert's Drop:

HISTORY OF A PHYSICS PUZZLE

Prince Rupert of Bavaria (1619-1682), grandson of James I, brought the glass teardrops to Charles II as a gift.

Demonstrations of the stress of glass were introduced to England as a curious party trick.

In 1661, King Charles asked his personal scientific society, which later evolved into the Royal Society, to investigate.

No one could give Charles II a satisfactory explanation of the extraordinary behaviour of how the trick worked.

One of the scientists investigating was Robert Hooke, who became famous for Hooke's Law.

It was not until 1994 that scientists at Cambridge University and Purdue University in Indiana solved the puzzle.

Note: Glass is not a crystal structure but an amorphous solid.

Prince Rupert's Drops (also known as **Dutch tears or Dragon's tail**) are glass objects created by dripping molten glass into cold water, the glass cools into a tadpole-shaped droplet with a long, thin tail. By dropping a blob of molten glass into cold water, the glass hardens at different rates creating that inner tension. When the molten glass cools too rapidly in the water it contracts inside the already solid outer part, it creates stress in the middle of the glass, because the middle of the glass is warm while the outside has cooled faster. When the molten glass on the inside does eventually cool, it contracts and creates that inner tension. This contraction sets up very large compressive stresses on the surface, while the core of the drop is in a state of tensile stress. It is a kind of toughened glass. The very high residual stress within the drop gives rise to counter-intuitive properties, such as the ability to withstand a blow from a hammer on the bulbous end without breaking, but experiencing explosive disintegration if the tail end is even slightly damaged.

If you want to avoid these internal stresses that cause the glass to break you would 'anneal' the glass to make it less fragile. The annealing process keeps the whole object at a uniform temperature, so that there is no internal temperature difference. Normal glass is strengthened by slow cooling in order to reduce the brittleness.

Tapering tail: While the front end is strong, the weak part of the teardrop shape is the thin end, which shatters the whole object quicker than the eye can see

Compressed: The glass has frozen at a different temperature on the outside to that on the inside leaving it with fault lines that create stress running through the middle

Fragile: Watching in slow motion, the tension pushing out from the middle shows the glass disintegrate into crystalline powder

Read more: http://www.dailymail.co.uk/sciencetech/article-2298928/The-mystery-Prince-Rupert-s-Drop-revealed-Fascinating-130-000-frame-second-video-glass-withstand-hammer-blow-end-EXPLODES-scratch-other.html#ixzz4Fe6z9euG

Slow Motion Video illustrating the break: https://www.youtube.com/watch?v=xe-f4gokRBs

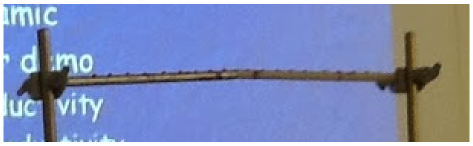
Aluminum vs. Alumina Student Designed Investigation

Alumina is aluminum oxide. Alumina is the most widely used oxide ceramic material. Its applications are widespread, and include spark plugs, tap washers, pump seals, electronic substrates, grinding media, abrasion resistant tiles, cutting tools, bio ceramics, (hip-joints), body armor, laboratory ware and wear parts for the textile and paper industries. Very large tonnages are also used in the manufacture of monolithic and brick refractories. It is also used mixed with other materials such as flake graphite where even more severe applications are envisaged, such as pouring spouts and sliding gate valves.

The characteristics which alumina has and which are important for these applications are shown below.

- High compression strength
- High hardness
- Resistant to abrasion
- Resistant to chemical attack by a wide range of chemicals even at elevated temperatures
- High thermal conductivity
- Resistant to thermal shock
- High degree of refractoriness
- High dielectric strength
- High electrical resistivity even at elevated temperatures
- Transparent to microwave radio frequencies
- Low neutron cross section capture area
- Raw material readily available and price not subject to violent fluctuation

Typically about half the students predict that the metal will have the greatest density while the other half vote for the ceramic. Many of the students rely on their previous experiences with ceramics which involve larger, heavy objects or working with wet clay which leads them to believe that ceramic is a dense material. They know that aluminum is a lightweight metal. This can cause students to come to the conclusion that the alumina is denser than the aluminum. After the masses are measured, give the students an opportunity to hypothesize why the aluminum is in fact denser than the alumina. In the alumina rod, some of the aluminum atoms are replaced by lighter weight oxygen atoms. The way in which the atoms or ions are packed will also have an effect.



LEARNING ACTIVITY OR PROCEDURE:

Explicitly layout the lesson or demonstration

"Hook" Activity/Phenomena: Prince Rupert's Drop (see attached file)

Demo what occurs to the drop. Have students make the drops and then break the drops. Students focus is to answer: Why does this glass drop behave this way? (Why is the teardrop section so hard and the tail brittle causing it to shatter into dust?) Focus students on the amorphic structure of the material (compared to crystalline structure of metals).

How to Make a Prince Rupert's Drop: http://nighthawkinlight.wonderhowto.com/how-to/make-prince-ruperts-drops-glass-fractures-speed-high-explosives-0145492/

Student Exploration: Whole Class Planning for Investigation/Demo of Aluminum vs. Alumina Rod (See attached file)

As a whole class investigation, ask students how the properties of the aluminum rod and the alumina rod will compare. Which is more conductive? More dense? Ask the students to determine how to measure these properties. Guide them towards: obtain mass, measure diameter and length to get volume, use conductivity meter and thermometer. Ultimately you want to put wax beads on the rods and heat the rods from one end at the same time. Guide students toward this set-up as it will allow for comparison when both rods are heated with the same amount of heat at the same location. Record observations, analyze results. Describe why the properties of these substances differ based on the structure of these substances (crystalline and amorphic).

Evaluation:

Lab Report filled out by student.

ASSESSMENT:

The students will be assessed with a rubric.

Activity: Prince Rupert's Drop (Dragon Tears)

Student Learning Objectives

At the end of the activity students will be able to:
• produce a "dragon tear"
• successfully cut the dragon tear in order to observe the effect of tempering and internal stresses.

Materials
• Plastic bag
• Borosilicate Glass Rods (standard Na_2O, B_2O_3, $2SiO_2$ glass composition)
• Beaker with cold water
• Crucible if using furnace

Equipment
• Hand held propane torch or furnace
• Stainless steel beaker
• Safety glasses
• Heat-resistant gloves
• Scissors or diagonal (dike) pliers
• Polarizing material
• Light source

Procedure

Warning: Wear safety glasses at all times.

1. Use the standard Na_2O, B_2O_3, $2SiO_2$ glass composition. Melt a small amount of glass (approximately 50 g) in the furnace at 1050°C for 1/2 to 1 hour. Fill stainless-steel beaker with cold water, and place it near oven.

2. Remove the molten glass from the furnace, and slowly pour the glass, drop by drop into the beaker containing water. Allow long fibers to trail from each droplet of glass. It will take some experimentation to produce whole droplets. Be patient.

3. When glass becomes too viscous to pour, return crucible to furnace for approximately 10-15 min. Step 2 can then be repeated. Set hot crucible on appropriate heat-resistant surface.

Caution: Step 4 is a dangerous step. Make sure all people in the laboratory are wearing their safety glasses.

4. After cooling, remove droplets with their long trailing fibers from the beaker. Place droplet in plastic bag with end of fiber exposed. Hold the droplet with one hand and begin cutting fiber, using diagonal-cut pliers, at the farthest point from the droplet.

Continue cutting fiber, moving progressively closer and closer to droplet. At some distance (usually less than 3-4 cm) the dragon tear will explode into sand-sized particles in the bag.

Video - How to Make a Prince Rupert's Drop: http://nighthawkinlight.wonderhowto.com/how-to/make-prince-ruperts-drops-glass-fractures-speed-high-explosives-0145492/

Introductory Ceramic Demo

Aluminum vs. Alumina
(Al vs. Al_2O_3)

Heat Transfer Demo – metal vs. ceramic

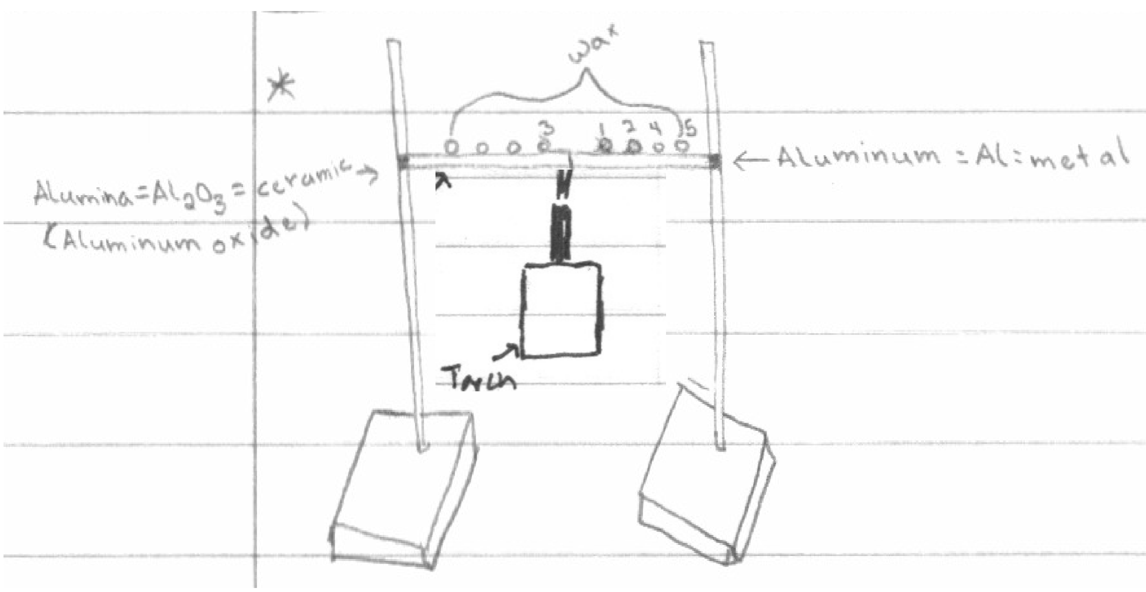
Purpose: contrast metals and ceramics in terms of these properties:
- thermal conductivity
- electrical conductivity
- density

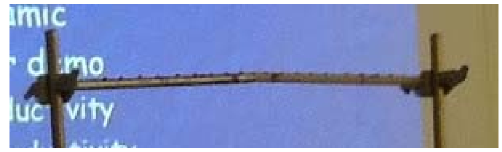
Materials:
Alumina rod – ceramic knife sharpening rod
- 3/8″ diameter – 8 ½″ length
- http://www.knifecenter.com/kc_new/store_keywords.html?sortType=skuAs&srch=AC71&SUBMIT2.x=23&SUBMIT2.y=10
- Part number – AC71

Aluminum rod
- 3/8″ diameter – cut to 8 ½″ length
- Lowe's or Home Depot

2 ring stands with clamps
propane torch or Bunsen burner
wax (candle or sprue)
digital meter
balance

Set-up:





Procedure:

- Place 4 drops of wax evenly spaced about 1 inch apart on each rod. (Touching molten drops to the rod works well.)
- Students make and record observations as the rods are heated by a propane torch – **thermal conductivity**.
- Check the electrical conductivity of each rod using a digital meter – **electrical conductivity**.
- Students predict which rod has the greatest density. Since the two rods have the same volume, relative density can be compared by massing each rod.
- Mass each rod – relative **density**.

Comments:

Alumina is aluminum oxide.

Typically about half the students predict that the metal will have the greatest density while the other half vote for the ceramic. Many of the students rely on their previous experiences with ceramics which involve larger, heavy objects or working with wet clay which leads them to believe that ceramic is a dense material. They know that aluminum is a lightweight metal. This can cause students to come to the conclusion that the alumina is denser than the aluminum. After the masses are measured, give the students an opportunity to hypothesize why the aluminum is in fact more dense than the alumina. In the alumina rod, some of the aluminum atoms are replaced by lighter weight oxygen atoms. The way in which the atoms or ions are packed will also have an effect.

Name(s)
Date
Period

Title

Question – The question generated by you, the teacher or the activity. (complete sentence)

Hypothesis – A suggested answer to the question. The answer here is a prediction about what will happen before you make a procedure, experiment, or research. ***Do not write I think!***

Use this structure for your hypothesis: "If………, then……………". Remember, your hypothesis must be measureable!

Materials -

Beaker	Scale	(If these were the materials
Ruler	Thermometer	used in the lab then this
Graph paper	Microscope	is what this section should
Sand	Water	look like.)

Procedure – 1) Step-by-step instructions for the lab.

2) **Do not** write the word step. It is implied.

3) The numbers for this section line up even if one of the steps involved takes more than one line to write.

4) All the how to dos and what to do must be explained in the procedure. Nothing can be assumed.

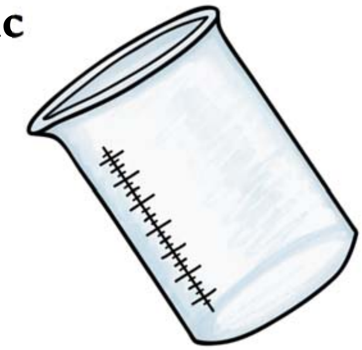
5) Anybody should be able to complete your experiment by reading your procedure.

6) Do not use personal pronouns or peoples names in this section.

Results – This section is written after you have completed your experiment. In this section you simply state **what** happened during the experiment. If there are applicable tables or graphs they would be included in this section. Do not explain the results here.

Conclusion – This section is written after you have completed the Results section. In this section you explain why you got the results you got and what they mean. You discuss if the results prove, disprove, or do not apply to your hypothesis. You also redevelop your hypothesis in this section if needed, explain **sources of error**, and relate anything you have learned by completing your experiment or lab. Do not use personal pronouns in this section.

Lab Report Grading Rubric



Title Page ________ out of 3 points

Introduction

Problem ________ out of 2 points

Hypothesis ________ out of 2 points

Research ________ out of 5 points

Procedure ________ out of 10 points

Data ________ out of 5 points

Graph/Picture ________ out of 5 points

Conclusion

Hypothesis correct?________ out of 2 points

Application ________ out of 2 points

Lab worksheet ________ out of 10 points

BONUS:
Student did not use first person (I or you). +1
Student correctly used passive voice appropriate for lab reports +2

Self	Peer	Teacher		Points
			Appearance/Organization • Lab Report is typed • Lab report uses headings and subheadings to visually organize material • cover page includes name, teachers name, date, title	5
			Abstract (Written last) • The whole paper has been condensed into miniature form. • There are approximately 5-10 sentences. • There is no new information, no supporting material, & limited details.	10
			Introduction • The primary topic/goal of the study is explained in clear, concise terms. • 4 or more reputable background sources were used & cited correctly. • Material is translated into student's own words. • Background information is pertinent to topic & improves reader understanding of the investigation & report.	20
			Materials & Methods • Complete & detailed list of materials in 2 vertical columns. • Methods are listed in clear steps that are easy to follow & reproducible by another person.	10
			Observation Sheet • Observations are clear, accurate, and dated. • Observation sheet is referenced in report.	10
			Results (Answer the question "What did I find out?") • Organized and clear representation of data using tables & graphs with correct titles. • Correct units are used when necessary. • Explain your actual findings. Link your writing to graphs & tables as you present your results. (Save broad generalizations & conclusions for later)	20
			Discussion • Describes what was learned from the experiment. • Explains sources of error. • Discusses variables and trends/patterns found in results. • Predictions are made or an explanation of further studies are addressed. • Explanation of how information applies to the real world.	20
			Spelling/Grammar/Punctuation • There are 1 or fewer errors in punctuation & grammar in the report.	5
			Literature Cited • All references are listed in APA format & cited correctly. • Each source was cited in report.	10

Total= 110 points

Lab Report

Name	Block ☐☐☐☐ 1 2 3 4	Date
Assignment Title:		

Steps of the Scientific Method		
1. State the Problem		
2. Hypothesis	Independent Variable ⇨ ______	IF ______________________________________,
	Dependent Variable ⇨ ______	THEN ______________________________________
		______________________________________.
3. Experiment	Control	Materials

Procedures (list steps)

1.	6.
2.	7.
3.	8.
4.	9.
5.	10.

4. Record and Analyze (draw tables/charts to record data in this space)	

5. Conclusion	Did your data support or refute your hypothesis?	
	What would you do to improve the experiment in the future?	
	What did you learn about this topic?