Forces of Attraction and Chemical Bonding
Boise High Accelerated Chemistry
Instructor: Seth Garrison

Our class: Accelerated chemistry at Boise High is a fast paced chemistry class whose curriculum and standards are very similar to the traditional high school chemistry class. Accelerated and high achieving sophomores are encouraged to take this class as they transition from junior high to high school. Therefore, most of my students are sophomores. This unit is presented during 2nd quarter. Students have already worked through units on matter and measurement, atomic and electronic structure, and the periodic table. On another note, we use a standards based grading system for our class. Each objective is therefore graded on a 4 pt. scale that then translates to a percentage and letter grade.

<u>Standards / Objectives</u>

Idaho Science Standard: Structure and Properties of Matter (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.

Science Practices: Planning and carrying out investigations, analyzing and interpreting data, and obtaining, evaluating, and communicating scientific information.

Unit Content Objectives: Unit content objectives are based on Boise School District's chemistry curriculum. They have been slightly modified and at times condensed and written in a "I can" format. Please see attached unit study guide after lesson design.

<u>Essential Question</u>

People form bonds with each other and with materialistic objects. Each bond you form is unique. Some bonds are very strong such as the bond between you and a family member or the bond between you and your cell phone. Some bonds are weaker. Elements also form bonds with each other, but just as in life, every bond is unique demonstrating very different properties. Thus, a primary focus of our bonding unit will attempt to answer the following question:

"What are the resulting properties of ionic, covalent, and metallic bonding?"

Subquestion for ionic bonding: If you were to sprinkle some elemental sodium in your mouth, it would explode. If you were to breath in some chlorine gas, you could die. Why then can we douse our French fries in sodium chloride salt producing that oh so "yummy" and wonderful taste sensation when we eat them?

I think a teacher can go a lot of different directions here, but I love salty French fries and this question provides a segway between a recent demo (sodium in water) in our last unit to our current unit in which we will investigate table salt and its properties in the lab.

Subquestion for covalent bonding: Some things in life look a lot alike, but may have very different physical or chemical properties. Salt and sugar look a lot alike, but how do they differ physically and chemically?

Threshold Knowlege

When elements bond together, the new resulting molecule / compound has completely different properties than the elements that make it up. Electrons are the key to bonding, and differentiating what happens to electrons in ionic, covalent, and metallic bonding is essential to understand the resulting properties we see in these three classes of compounds. This also marks the start of really investigating different forces of attraction. Bonding forces are strong, intramolecular forces of attraction.

This is a challenging idea. We have been working on individual elements and have learned specific properties of individual chemicals, but when it comes to bonding elements together it's tough for students to understand that the properties of individual elements go out the window. The type of bonds that form then dictate the new resulting properties we see in the lab. When electrons are given and taken, shared locally, or shared as a "sea of electrons" very different properties result. Thus, it's our investigations and resulting observed properties that provide insight on the type of bond formed.

Frontloading

Students have just finished a unit on the periodic table in which we examined properties of certain families and specific elements. During that unit, one demonstration performed involved adding solid, elemental sodium to water. Sodium and the alkali metal family reacts violently with water. I use this demo and a YouTube video to connect to our new unit and its essential question.

We perform the sodium demo again, and watch a quick youtube video on chlorine gas. Then, I show a quick excerpt of someone putting salt on their french fries and eating them. I ask, "what's salt made of?" Students answer with sodium and chlorine. I then ask, " well why didn't they blow up or die when they ate the salted French fries?" Hhhhmmmmmm…I sense deep thought and sounds of crickets. I throw some table salt in water nearby, jumping back and hiding awaiting an explosion. But there is no explosion. Why?

I can further ask, "what's in bananas?" Kids respond with potassium. "Isn't that an alkali metal reactive with water and air? Why don't you blow up when you eat a banana?" I further ask, "why do athletes drink Gatorade?" Kids respond with electrolytes. "Did you know the electrolytes are sodium, potassium, and chloride ions?" Hhhhhmmmmmm. Kids at this point start to get the sense that there are different "forms" of elements and that when elements change into ions or bond with different elements, chemical properties change.

Culminating Project and Summative assessments

Culminating project: Students will synthesize an informative presentation that demonstrates, explains, and differentiates 3 physical or chemical properties of ionic, covalent, and metallic bonding. This project incorporates our overarching NGSS, district content objectives, and various science practices. The project itself is attached at end of this unit design along with its grading rubric.

Summative Assessments: Each content objective included in our unit is formally assessed with either a quiz (written responses) or lab activity assessment. As you look at the attached study guide, at the conclusion of each section associated with a content objective, the type of formal assessment is noted (ie. Quiz LO 1, lab write-up LO 4, etc.)

Unit Curriculum / Scaffolding

This is a big, long unit. I take a lot of time to work on naming and writing formula of compounds since that knowledge is essential to success in our future units. The ability to draw Lewis structures identifying covalent bonding is also important for future lessons on molecular shape, polarity, and solubility. Students are able to reassess any summative assessment to improve their standing. A number of students usually do this when it comes to naming and chemical formulas. My unit study guide can be seen here: G:\Chemistry I 2016\Bonding unit study guide.doc

Successful culminating projects are due to the knowledge we construct and assimilate during our unit. There are three investigations students will use to assist them with their culminating project. First, during this unit students will investigate properties of table salt, sodium chloride, an ionically bonded compound. This activity is a guided inquiry activity in which I help them investigate conductivity, melting point, solubility, and external structure. Students then summarize their findings with a fill in the blank template of ionic properties. See activity here: G:\Chemistry I 2016\Ionic Compound Activity 2016.doc Later in our unit, we perform very similar guided investigations with sugar, sucrose, a covalently bonded molecule. Students are able to see the different properties of sugar and salt due to the different type of bonding. See activity here: G:\Chemistry I 2016\Molecular Compound Activity.doc I then have students look back at a lab investigation we performed in our periodic table unit. In this investigation, students investigated properties of metals, nonmetals, and semimetals. We refer back to the properties of metals and discuss metallic bonds and how they produce the properties we see in metals. Se activity here: Metals, nonmetals, and metalloid Lab 2016.doc

Now that students have the background knowledge of bonding and resulting properties, it is time to let them loose. I introduce their culminating project. The project includes 6 unknown chemicals and they are to determine 3 chemicals that demonstrate the three different types of bonds: ionic, covalent, and metallic. They then produce a presentation of their investigations. The ionic and molecular guided inquiry activities are also included at the end of this document. Our unit outline and what we did is included below.

Monday Nov. 7
Introduce new unit with essential question, sodium demo, and discussion questions
LO1: Use Bonding ppt. to go through bonding, stability, energy, octet rule, valence electrons, and lewis dot diagrams

Tuesday Nov. 8
LO 2: Ionic compounds (table salt) inquiry investigation (formative assessment); investigating properties of ionic bonding

Wednesday Nov. 9
Continue with ionic compounds inquiry lab and informal write up
Check for completion and go discuss results and summary together

Thursday Nov. 10
Garrison gone to BSWP workshop
Quiz LO 1 summative assessment

% composition worksheet (formative) due Friday

Friday Nov. 11
Check % composition worksheet
LO 3: Introduce naming elements, ions, and ionic compounds (nomenclature)
Start in on formative worksheet

Monday Nov. 14
Continue with naming and formulas
Finish worksheet

Tuesday Nov. 15
LO 4: Hydrate lab

Wednesday Nov. 16
Hydrate lab write up summative assessment

Thursday Nov. 17
Hydrate lab write up due
More practice naming and formulas
If going to be gone tomorrow take quiz today

Friday Nov. 18
Quiz LO 3 Summative assessment

Thanksgiving Break

Monday Nov. 28th
Review bonding and LO1 discussing ionic vs. covalent (metals and nonmetals, electronegativity, sharing vs. exchanging)
Introduce molecular compound inquiry activity LO 2: investigating physical and chemical properties of covalent bonding (formative assessment)

Tuesday Nov. 29th
Garrison gone to district meeting; Mr. Garner subbing
Finish molecular compounds activity and complete summary template
Lab due tomorrow

Wednesday Nov. 30
Check lab completion and discuss outcomes and results
LO 3: Naming and writing formulas of molecular compounds
HW: practice worksheet naming molecular compounds

Thursday Dec. 1
Combined naming practice in class
HW: finish worksheet for tomorrow and quiz Friday

Friday Dec. 2
Quiz LO 3: Naming ionic and covalent compounds, ions, and elements
Start into Lewis structures and covalent bonding LO 5 working with Lewis structure handouts and practice worksheet

Monday Dec. 5
Continue with Lewis structures and covalent bonding LO 5
Introduce Bonding performance task: creating an informational presentation on bonding characteristics
HW: start thinking about project

Tuesday Dec. 6
Quiz LO 5 lewis structure and covalent bonding Thursday Dec. 8; Lewis structures practice worksheet passed out and due tomorrow
Bonding performance task investigations

Wednesday Dec. 7
Check worksheet; go over rest of lewis structure worksheet; last 20 mins. organize project
Bonding performance task time

Thursday Dec. 8
Quiz Lewis structures
Bonding project lab time and computer time

Friday Dec. 9
Bonding project lab time and computer time

Monday Dec. 12
LO 6 Molecular shape inquiry activity with clay (VSEPR theory) and practice with some problems
HW: Molecular shape worksheet due Wednesday

Tuesday Dec. 13
Bonding performance task presentations

Wednesday Dec. 14
Molecular shape worksheet due
Bonding performance task presentations

Thursday Dec. 15
Quiz LO 6 Molecular shape
Review periodic table and bonding units for MC test tomorrow

Friday Dec. 16
Quarter 2 MC Test: periodic table and bonding units

Unit Reflection

I came up with my culminating project to assess just intra forces and bonding properties. This project and unit could be expanded or reshuffled. One option is to teach bonding, intra forces, and add in inter or IMFs at this time. You could then expand the project a bit to include molecular solids held together by intermolecular forces of attraction. Now the project and the unit really meets the Idaho standard on forces of attraction and resulting properties at the bulk scale. This could then lead to a reworked chemistry unit on Forces of attraction, not just bonding, in which intra forces (bonds) and inter forces are taught. It seems very logical to do this but there is A LOT of chemistry in this unit and some teachers may be hesitant since IMFs may be usually taught or emphasized much later in the year. However, I think teaching both intra and inter forces together now with a culminating project could be very powerful. The culminating project and most of the content could also be taught during a unit on Solids or creating a bigger unit including solids, liquids, gases, and forces of attraction.

I have to be honest and say that I was very happy with my culminating projects when they were all said and done. I had done my guided inquiry investigations on metals, salts, and sugar in the past, and assumed students had a strong understanding of bonding properties after these investigations. I don't think that was the case though as I observed students working through the culminating project. After I threw the project at them and opened the doors to the lab with 6 unknown chemicals, it took kids a while to figure out where to start and how to connect their previous investigations to the task at hand. Even a day into investigations, it was apparent students didn't really grasp that all ionic compounds have "these" properties and that metals have "those" properties. As time went on though, I started to hear the conversations I wanted to hear on day 1 such as "ionic compounds don't conduct as a solid" or "that can't be molecular, it didn't melt when heated." I also included summary templates during the formative investigations that I think really helped the kids review and look back over what they did.

I believe the project allowed all students the opportunity to demonstrate mastery of the objective and science practice I wanted to assess. The overall design of the project is OK, but I need to a do a bit more on the additional content required for a 4. I'd like to shift that optional, additional content to connect to a different NGSS standard: **Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.** I need to think on this one a bit more but I perhaps I can help lead kids in the right direction to relate to what they saw in the lab to real life applications of designed materials.

Below are a few of the links to some of our culminating projects. Hopefully they can be opened ☺

https://drive.google.com/open?id=1MODdmPV5Tt8E3J9gXFbrWmsxR4LENujGcmUloXOF8h8

https://drive.google.com/open?id=0B24dUq9EGuohMzRuZlNaSGRSX0U

https://drive.google.com/open?id=1-iMmGr0LYjzETnjhSLkqmRusutwCzlYD51v8cOF-a04

http://prezi.com/zludyi-ttnu7/?utm_campaign=share&utm_medium=copy

Chemical Bonding Study Guide

Chemical bonding is discussed in chapters 6 and 7 of your textbook. We will study three types of bonds: ionic, covalent, and metallic bonding. This unit is a big one and will take us weeks to work through.

Bonding LO 1: I can use the octet rule to determine the number of valence electrons of an element to draw Lewis dot diagrams and predict the type of bond that will form with another element to increase stability and lower potential energy.

- **Identify relationships between bonding, stability, and energy**
- **Understand that valence electrons determine chemical reactivity**
- **Define and use the octet rule to determine number of valence electrons**
- **Draw Lewis dot diagrams of elements displaying their valence electrons**
- **Define and compare and contrast ionic, covalent, and metallic bonding by discussing the role of valence electrons in each type of bond.**
- **Identify which elements tend to form ionic bonds and which tend to form covalent bonds considering their placement on the periodic table (1. electronegativity differences of bonding atoms 2. Metals and nonmetals OR nonmetals and nonmetals OR metals and metals)**

Introduction to Bonding Section 6-1 and Powerpoint Bonding on our website

- Why do atoms bond together?
- What does it mean to be stable? Are stable elements reactive or unreactive?
- What is a valence electron?
- *Fact: the number of valence electrons determine chemical activity of an element. An element's specific chemical properties are a result of the number of valence electrons it possesses.*
- What is the octet rule?
- *Fact: The octet rule applies to the main block elements only (s and p sublevels). One does not use the octet rule to predict charges of transition metals (d block) or inner transition metals (f block). These charges are determined by looking at a reference (ion charges for transition metals are on the back of your periodic table near the bottom).*
- If a STABLE element belongs to the main block (s or p sublevel), how many electrons will be in its outer energy level?
- *Fact: Elements gain, lose, or share electrons to form bonds because it makes them more stable. A stable atom or element is one that has lower potential energy.* ***Thus, elements gain, lose, or share valence electrons to form bonds to increase their stability and decrease their potential energy.***
- How do you determine if a bond between two elements is ionic or covalent?
- When two atoms bond together, the difference in their electronegativities ("electron tug of war") determines what properties that bond will have. What electronegativity difference equals a bond with ionic properties? What is the difference for a polar covalent bond? Nonpolar covalent?
- What is an ionic bond?
- What is an ionic compound? Realize an ionic compound is neutral overall despite it is made of charged ions
- How is a covalent bond different from an ionic bond?
- What is the difference between a polar and nonpolar covalent bond?
- Metallic bonding is referred to as a "______" of electrons. How do valence electrons behave differently in metallic bonds in comparison to ionic and covalent bonds?

Quiz LO 1

Bonding LO 2: I can, through investigation, determine and discuss chemical and physical properties of ionic compounds.

- **Identify chemical and physical properties of ionic compounds, molecules that are covalently bonded, and substances that are metallically bonded.**
- **Explain the chemistry behind the observed physical and chemical properties.**

Bonding characteristics Sec. 6-3 and 6-4 and Bonding Powerpoint on our website

- What are some of the major physical and chemical properties of compounds that are ionically bonded? Covalently bonded? Metallic bonding characteristics? Compare physical appearance, melting points, structures, states of matter at room temperature, and electrical conductivity as solids and when in solution.
- Describe the unique crystal lattice structure of an ionic compound that produces unique ionic properties
- Describe the "sea" of electrons in metals that results in unique properties of metals

Bonding Group Performance Task: What are the properties of ionic compounds? Covalently bonded compounds? Metallic bonding?

Bonding LO 3: I can write and name elements, ions, ionic compounds, and molecules (compounds involving covalent bonding are referred to as molecules).

- **Name and write chemical symbols of elements and ions**
- **Name and write chemical formulas of ionic compounds**
- **Name and write chemical formulas of molecules.**

Naming ions and compounds Sec. 7-1 and Bonding powerpoint on our website

- Refer to your green naming handout for guidelines on how to name various chemicals

Ions and Ionic compounds

- What is an ion?
- What is a cation? Give examples. Do cations give or take electrons?
- What is an anion. Give examples. Do anions give or take electrons?

Nomenclature (Naming ions and ionic compounds)

- How do you name monatomic cations? Give examples
- How do you name monatomic anions? Give examples.
- How do you name polyatomic ions?
- How do you name a binary ionic compound with two monatomic ions?
- What is an empirical formula?
- Know how to determine the empirical formula for two given ions. For example, Na and Cl. First you must determine the charge, then balance the charges to create the compound.
- How do you name compounds with polyatomic ions in them?
- Which ion is written first in a name and a formula?
- You will have to write empirical formulas from compound names, and vice versa.
- You'll be expected to learn the prefixes used for naming molecules and be able to write and name molecules that are covalently bonded

Quiz LO 3

Bonding LO 4: I can calculate and correctly write empirical formulas using percent composition and other quantitative data.

- **Determine the molar mass of an ionic compound and be able to convert from grams to moles**
- **Calculate % composition of ionic compounds and hydrates**
- **Determine the empirical formula of a hydrate using quantitative lab data**

Calculations with ionic compounds and Hydrates Section 7-3 and 7-4

- What is the difference between an atomic mass number and molar mass number?
- Be able to determine the molar mass of an ionic compound
- What is a hydrate? How do you write the formula of a hydrate? How do you name a hydrate
- Calculate the molar mass of an ionic compound and calculate a percent composition of a compound or hydrate.

LO 4 Hydrate lab: determining the empirical formula of a hydrate

Bonding LO 5: I can draw Lewis diagrams demonstrating the covalent bonding and structure of molecular compounds (and polyatomic ions).

- **Draw Lewis structures for various molecules including polyatomic ions**
- **Recognize that a Lewis structure is a model and all models have limitations or even flaws; real life chemistry is 3D including numerous bonding exceptions to the "Lewis structure rules" including expanded octets, incomplete octets, resonance, etc.**

Covalent bonding and Lewis Structures Sec. 6-2 and Bonding powerpoint on our website

- What is the octet rule? This should be a little review.
- *We will cover Lewis structures in depth with lots of practice. The next set of bullets are some vocab words associated with Lewis structures.*
- Define unshared pairs of electrons. Provide an example and identify the unshared pairs in your example.
- A shared pair of electrons is the premise for a covalent bond. Provide a written example and identify the shared pair or covalent bond.
- Compare and contrast single, double, and triple bonds.
- Examine sample problems 6-3 and 6-4 for practice and explanations on how to draw lewis structures.
- Resonance—examine the book's definition. When we draw resonance structures on paper, technically, none of our models are accurate because in real life, the bonding is an average of what we see on paper. All models have limitations.

Quiz LO 5

Bonding LO 6: I can define and explain the VSEPR theory and use it to identify molecular geometry / shape.

- **Define and explain VSEPR theory**
- **Define and explain electron clouds or domains**
- **Identify the following shapes: tetrahedral, trigonal pyramidal, trigonal planar, bent, and linear**
- **Identify the # of clouds and bonding angles in tetrahedral, pyramidal, planar, bent, and linear molecules**

Molecular Shape or Molecular Geometry Sec. 6-5 and VSEPR theory / shape powerpoint on our website

- Define the VSEPR model. Realize its main principle is that electrons try to get as far away from each other as possible.
- Define electron cloud.
- Examine Table 6-5 on pg. 186. We will create a similar model of this table in class as we create models with the model kits. You are accountable for the names of each shape, the angle, and predicting shapes of molecules provided a chemical formula.
- Examine sample problems 6-5 and 6-6 for practice.

Molecular models activity

Quiz LO 6

Bonding Performance Task

Bonding Content Objective: I can identify, demonstrate, and explain ionic, covalent, and metallic bonding characteristics using laboratory demonstrations (x3).

Science Practice: I can obtain, evaluate, and communicate scientific information and evidence by producing a formal presentation (x3).

Background: We have been studying the physical and chemical characteristics involved with three major forms of bonding: ionic, covalent, and metallic. You conducted investigations on the ionic solid NaCl as well as the molecular compound sucrose. If you recall when we opened up our unit on the periodic table, we conducted a lab differentiating metals, nonmetals, and semimetals. So you have also investigated characteristics of metals and metallic bonding. Now is the time to demonstrate your understanding of bonding characteristics.

Here is your task:

> **Synthesize an informative presentation that demonstrates, explains, and differentiates 3 physical or chemical properties of ionic, covalent, and metallic bonding.**

Let's break this task down.

1. Synthesize an informative presentation: You are the teacher and will teach others the differences between bond characteristics by presenting information. Your presentation could be a recorded video, a power point or prezi presentation, a live demonstration, etc. You can work in groups of up to 3 and your presentation should last between 5-10 mins. Please no longer than 10 mins.
2. Demonstrates: perform investigations and state observations and data. You will be given a number of different chemicals to investigate and you must find one that is ionically bonded, one that is covalently bonded, and one that is metallically bonded.
3. Explains and differentiates: explain the "why this happened" or the chemistry behind the result you observed. Using atomic structure and discussion of bonding, explain why this chemical produced this result and why that chemical produced a different result.
4. 3 properties: 3 physical or chemical properties of EACH type of bonding; 3 properties of ionic bonding, 3 properties of covalent bonding, and 3 properties of metallic bonding.
5. Physical and chemical properties of ionic, covalent, and metallic bonding: your results of your investigations demonstrate certain physical and chemical properties of a specific type of bonding. You will identify three different chemicals that exhibit the three types of bonding and demonstrate with actual investigations the resulting physical and chemical properties.

What could help you in your investigations? Your former labs on table salt, sugar, and you metal, nonmetal, metalloid lab write-up. Questions????

Individual component: INDIVIDUALLY, summarize your findings for your three investigations. Feel free to use the following template to help you. Perform this summary for your three chemicals tested. Thus, you will have 3 small paragraphs.

> *The atoms in Chemical # ___ are held together and attracted to one another by _________ bonds. We investigated 3 properties: ____________, ____________, and ____________. Results of our investigations that helped provide evidence of the type of bonding stated include __(include specific results of your tests that support the type of bond you listed)_____________________.*

Assessment Rubric Bonding Performance Task

Standards	4--Advanced	3--Proficient	2--Developing	1--Lacking / Insufficient
Bonding Content Objective	In addition to proficient requirements, student explanations of properties are thoroughly and accurately explained; included visuals to enhance instruction of chemistry involved; real-life applications of specific ionic, covalent, and metallic substances and how a specific property results in the application or technology we use it for	3 different forms of bonding are defined and correctly identified in three different chemicals; 3 properties were identified **through investigations** and explained accurately for EACH of the three chemicals; a solid understanding of the three forms of bonding and resulting characteristics was demonstrated	May contain some inaccurate information but majority of information is accurate; did not identify at least 3 properties of EACH of the three chemicals; incomplete explanations of specific properties	May inaccuracies; limited properties listed and explained; properties lack explanation and discussion; investigations not performed properly or missing
Science practice: communicating information	In addition to requirements listed for proficiency, the presentation of information was very professional and extensive. Your teacher should give out academy awards for this presentation and cinematography.	Information was presented in a manner that enabled all students to learn and understand information as if they have never seen the information before; video OR slideshow OR demonstration was formal and of high quality for instruction; visuals demonstrating and showing investigations performed and data collected are included in presentation	Presentation allowed audience to learn and understand most of the material; some parts of the presentation lacked specific requirements or was difficult to follow at times; presentation may have lacked professionalism at times or included slightly informal or inappropriate information	Presentation lacked key requirements; information presented was unable to be understood; no visual evidence presented; audience gained little to no understanding of bonding characteristics; presentation included inappropriate material
***Participation**		You and your group members believe you participated fully and helped produce a successful project	You did an ok job and helped out for the most part	Your “used to be friends” now don’t like you as much because you did little to nothing for the team

*You will rate yourself and each group member on one half sheet of paper and turn in your eval. to me at the conclusion of your presentation. If you rate anyone including yourself below a 3, then partial credit will be lost OR the individual will need to come up with an individual project demonstrating their knowledge of the objectives and ability to communicate information.

Ionic Compound Physical and Chemical Properties Inquiry Activity

Bonding LO 2: I can, through investigation, determine and discuss chemical and physical properties of ionic compounds.

- **Identify chemical and physical properties of ionic compounds**
- **Explain the chemistry behind an ionic compounds physical and chemical properties**

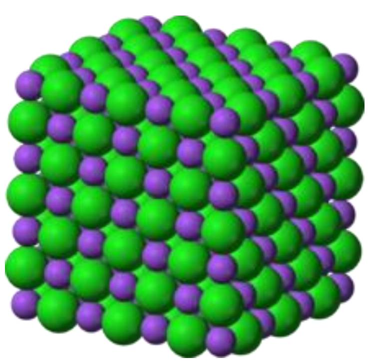
Purpose: The purpose of this investigation is to actively determine the physical and chemical properties of ionic compounds.

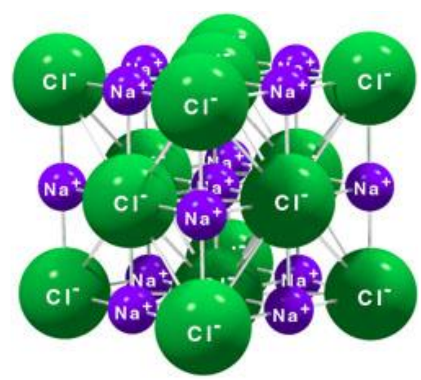
Background: Salts are ionic compounds. The most well known salt, table salt or NaCl, is not the only salt in the world. The term salt is a general chemistry term that represents an ionic compound. The purpose of today's investigation is to determine properties of ionic compounds or salts. You will take notes on your investigations as you proceed and ultimately summarize the physical and chemical properties you observe.

1. *Take out a separate sheet of paper. Label these notes as Properties of Ionic Compounds.*
2. Using a 50ml beaker, obtain about 10 ml of salt that you will use in your investigation.
3. Note: italics indicates you should be writing or adding to your notes.

I. External and Internal crystal structure of ionic compounds

1. *On your notes, make a subheading for External and Internal crystal structure of ionic compounds*
2. Using a microscope, place a few salt crystals on a slide and examine the cube structure of the salt. *Sketch out and discuss in your notes the external crystal structure of an ionic compound. (Try to find a crystal that is a cube shape--one that is not fractured)*
3. Place some salt crystals on your table top. Using a hard, metal object crush the salt. Why? This demonstrates that salts are hard and brittle. *Include this characteristic in your notes.* Attempt to examine salt crystals that have been broken to some that have not been crushed using your microscope. You should see again the cube structures of crystals that have not been broken and crystal fragments from those that have been broken.
4. Unfortunately, you cannot see the internal structure of your ionic compound. An ionic compound forms a crystal lattice structure. A crystal lattice structure is an orderly arrangement of positive and negative ions that maximizes attractions between ions. See the crystal lattice structure below.





Note that each sodium ion (Na^+ small ball) is surrounded by six chloride ions (Cl^- or larger ball). This structure then results in each chloride ion surrounded by six sodium ions. This lattice structure maximizes the positive negative attractions and results in a crystal with strong bonds between its atoms. *In your notes, define crystal lattice structure adding any details you need to fully understand this structure (such as a diagram).*

II. Melting pts. of ionic compounds (melting—when a solid changes to a liquid)

1. *Make a second subheading for melting pt.*
2. Place a small amount of salt (1/4 to ½ an in.) on a small square of aluminum foil.
3. Place the foil and salt on a ring clamp to heat.
4. Using a Bunsen burner, heat the salt attempting to melt the solid salt for 1-2 mins. and then stop. Did the salt melt?
5. *Discuss in your notes what this investigation proves. Do ionic compounds have a high or low melting point (and thus a high/low boiling pt. as well)? Bunsen burners can get up to anywhere between 300 – 600 degrees Celsius.*
6. A high melting pt. indicates very strong attractions between atoms. It means that the attractions or bonds that hold atoms together are very strong and that it would take a lot of energy to separate them. *In your notes, based on your investigation, state whether ionic compounds have strong or weak bonds (and thus strong or weak attractions).*
7. Think back to the crystal lattice structure discussed in the first investigation. How does that structure contribute to the high or low melting pt. you determined. *Explain this in your notes.*
8. Throw the salt away when you are done and put the aluminum foil back. Return the Bunsen burner to your drawer if and when cool.

III. Ability to conduct electricity when in aqueous solution of ionic compounds

1. *In your notes, make a third heading as seen above.*
2. A conductivity tester has been set up at your table.
3. Dry the conductivity tester with a paper towel IF need be. Dry the inside opening as well but be VERY careful not to damage the internal structure of the probe. It needs to be completely dry. Test solid salt for conductivity. *Record results.*
4. Obtain a small beaker form the lab drawer. Test a very small amount of distilled water **only** for conductivity. *Record your results.*
5. Add some salt and distilled water to your beaker. Stir with a glass stirring rod from your drawer. Test the electrical conductivity. *Note this in your notes.*
6. Why did salt water conduct electricity but solid salt and pure water did not (or minimally conducted)? Salt **dissociates** when placed in water. It is soluble. Dissociates means to break up and separate into ions (also called ionization). The compound NaCl is held together by ionic bonds, or attractions between oppositely charged ions. When placed in water, the salt separates into Na^+ ions and Cl^- ions that are free to move around. Free moving, charged particles in solution now conduct an electrical current. But why didn't the solid ionic compound conduct electricity? Because the ions are bonded together rigidly forming a neutral compound. But why doesn't pure water conduct electricity or conduct only to a very, very small degree? Water for the most part stays bonded and stays as a neutral molecule (some water does dissociate but it is a very, very small percentage). To conduct electricity, the chemicals in solution must have a charge. *In your notes, summarize this information discussing when and why and salt conducts electricity.*
7. Test tap water to see if it conducts electricity. If it does, *hypothesize as to how tap water is different that pure water (distilled water) based on what you just learned.*
8. Rinse out all glassware and place it and all equipment back in your drawer or wherever it is supposed to go.

Conclusion—Copy and fill in template in your notes.

When viewed with a microscope, ionic compounds form a _________ shape due to their internal _________ ________ structure in which positive ions and negative ions surround each other maximizing attractive forces. Because of this internal structure, ionic compounds are physically _____ and _______. Ionic compounds have _______ melting points because of the 3-D network of ionic bonds. Ionic compounds conduct electricity when _____________, but not when they are ________.

Molecular Compound and Covalent Bonding Activity

Bonding LO 2: I can, through investigation, identify and explain observed chemical and physical properties of ionic bonding, covalent bonding, and metallic bonding.

- **Identify chemical and physical properties of ionic compounds, molecules that are covalently bonded, and substances that are metallically bonded.**
- **Explain the chemistry behind the observed physical and chemical properties.**

Purpose: The purpose of this investigation is to actively determine the properties of molecular compounds and report these as notes. You will be examining sucrose ($C_{12}H_{22}O_{11}$) sugar.

1. *Take out a separate sheet of paper. Label these notes as Properties of Molecular Compounds.*
2. Using a 50ml beaker, obtain a small sample of sugar (no more than 5 ml) that you will use in your investigations.
3. Note: italics indicates you should be writing or adding to your notes.

I. External structure of molecular compounds

4. *On your notes, make a subheading for External structure.*
5. Using a microscope, place a few sugar crystals on a slide and examine the external structure. *Sketch out and discuss in your notes the external crystal structure.*
6. *How does this structure compare to salt (ionic compound) that you studied earlier. Similarities? Differences?*
7. Crush some sugar crystals on your table. *Are they hard and brittle like salt cystals or do they crush much easier?*
8. The forces of attraction that hold sugar molecules together forming a sugar crystal are different than the forces of attraction that hold ionic compounds together. Remember back to the crystal lattice structure of an ionic compound. The 3D cubic structure is held together by ionic bonds which are referred to as intramolecular forces of attraction. Intra- means within, thus the ionic bonds within the structure. Bonds or Intra forces are very strong forces of attraction.
    a. Here's where it gets a little confusing, so hang in there and keep reading. A sugar molecule, ONE sugar molecule is held together by covalent bonds. Covalent bonds are also strong forces of attraction. But here is the difference between salt and sugar. Salt has millions of sodium and chloride ions all bonded in a 3D network. A sugar crystal is not held together only by covalent bonds. Yes the C, H, and O atoms that make up sugar are covalently bonded together, BUT each molecule of sugar is stuck to each other by much weaker INTERmolecular forces of attraction. These are attractive forces that molecules have to one another but they are much weaker than the INTRA forces of bonds that hold atoms or ions together. A crystal of sugar has thousands of sugar molecules all sticking together, but they because the forces that hold that crystal together are much weaker, we see quite different properties in comparison to ionic crystals.
9. *So, think back after that long learning moment to you crushing the sugar crystal. Was it easier to crush and separate the crystal (separating sugar molecules)? Why?*

II. Melting and Boiling pts. of molecular compounds

10. *Make a second subheading for melting and boiling pts.*
11. Place a small amount of sugar onto a small square of aluminum foil (foil needs to be large enough to rest on your ring clamp attached to the post).
12. PLEASE READ ALL THEN PERFORM. Using a Bunsen burner, heat your sample until it shows any sign of melting AND TURN THE GAS OFF IMMEDIATELY UPON ANY SIGN OF MELTING.

13. *Discuss in your notes what this investigation proves. Do molecular compounds have a high or low melting point (and thus a high/low boiling pt. as well)?*
14. A high melting pt. indicates very strong attractions between sugar molecules. When a molecular substance like sugar melts the attractions between this sugar molecule and that sugar molecule are broken (INTERmolecular forces). When sugar melts, you are NOT breaking the covalent bonds between the atoms in sugar (bonds are called intramolecular forces). *In your notes, based on your investigation, state whether molecular compounds have strong or weak intermolecular forces of attraction.*
15. Silicon is an element that forms a covalent network solid. This means that all of the Si atoms are interconnected and bonded to each other by covalent bonds. There are no intermolecular forces of attractions, only covalent bonds. Are covalent bonds strong? *Put a small chunk of Silicon on aluminum foil over a Bunsen burner. Heat it for 30 secs. Remember, that high melting points indicate strong forces of attraction. Are covalent bonds strong bonds? Are covalent bonds stronger than the intermolecular forces of attraction that hold sugar molecules together?*
16. *Let the silicon cool and replace it when finished.*

III. Ability to conduct electricity

17. *In your notes, make a third heading as seen above.*
18. A conductivity tester has been set up like before.
19. Dry the conductivity tester with a paper towel. Dry the inside opening as well but be VERY careful not to damage the internal structure of the probe. It needs to be completely dry. Test solid sugar for conductivity. *Record results.*
20. Obtain a small beaker form the lab drawer. Test a very small amount of distilled water only for conductivity. *Record your results.*
21. Add some sugar to the distilled water in your beaker. Stir with a glass stirring rod from your drawer. Think back to your ionic compound testing. When ionic compounds "dissolve" in water they dissociate or ionize. When sugar and other molecular compounds "dissolve" in water they simply separate because the intermolecular forces of attraction are broken. The atoms in sugar remain covalently bonded to one another resulting in an overall neutral molecule. Test the electrical conductivity. *Note this in your notes.*
22. *Based on your three conductivity test, analyze your data. Why does or doesn't sugar conduct electricity? Think back to your salt lab and why it did conduct electricity.*
23. Rinse out all glassware and place it and all equipment back in your drawer or wherever it is supposed to go.

Summary: Please add this template to your notes like we did before.

The atoms WITHIN molecular compounds are attracted to each other by ___________ bonds. Covalent bonds occur when atoms __________ electrons. Covalent bonds are ________ bonds evidenced by covalent network solid's (such as silicon) ________ melting point. Intramolecular forces of attractions (bonds) are much stronger forces of attraction in comparison to _________________ forces of attraction (forces between molecules). Molecular compounds are attracted to each other by weaker forces of attraction, thus have _______________ melting points, especially in comparison to ionic substances and metallic substances. Molecular substances may be hard, but are crushed _____________ and are not brittle. While a molecular substance may still form a crystal, it does not form a geometric crystal lattice structure like ionic compounds thus crystal shape is irregular. Molecular compounds ____________ conduct electricity because when they dissolve in water, molecules are separated from each other but remain as a bonded molecule that is overall ____________ and not electrostatically charged.