|  |
| --- |
| **Task-level phenomenon:**  Ionic and molecular compounds have different physical properties.  **Synopsis of high-quality task:**  This task generally takes place after lessons on ionic and covalent bonding, but before hydrogen bonding and intermolecular forces. Students engage in an investigation into the properties of ionic and covalent compounds using six different substances: baking soda, baking powder, garlic salt, epsom salt, salt, and sugar. Using the data gathered from the lab, the students determine whether the substances have ionic or covalent bonds. This task will help finalize students’ understanding of ionic and covalent bonding.  **Anticipated student time spent on task:** 60 minutes  **Type of Task (check one):**  \_\_\_ 1. Investigation/experimentation/design challenge  \_\_\_ 2. Data representation, analysis, and interpretation  \_X\_3. **Explanation**  **Student task structure(s):** Partner work/group work |
| **Prior Knowledge:**  Previous Standards from [Strand Map](http://www.doe.mass.edu/stem/standards/StrandMaps.html):  **MS-PS2-3.** Analyze data to describe the effect of distance and magnitude of electric charge on the strength of electric forces.  Clarification Statement: Includes both attractive and repulsive forces.  State Assessment Boundaries:  • State assessment will be limited to proportional reasoning.  • Calculations using Coulomb’s law or interactions of sub-atomic particles are not expected in state assessment.  **HS-PS1-1.** Use the periodic table as a model to predict the relative properties of main group elements, including ionization energy and relative sizes of atoms and ions, based on the patterns of electrons in the outermost energy level of each element. Use the patterns of valence electron configurations, core charge, and Coulomb’s law to explain and predict general trends in ionization energies, relative sizes of atoms and ions, and reactivity of pure elements.  Clarification Statement: Size of ions should be relevant only for predicting strength of ionic bonding.  State Assessment Boundary: State assessment will be limited to main group (s and p block) elements.  **HS-PS1-2.** Use the periodic table model to predict and design simple reactions that result in two main classes of binary compounds, ionic and molecular. Develop an explanation based on given observational data and the electronegativity model about the relative strengths of ionic or covalent bonds.  Clarification Statements:   * Simple reactions include synthesis (combination), decomposition, single displacement, double displacement, and combustion. * Predictions of reactants and products can be represented using Lewis dot structures, chemical formulas, or physical models. * Observational data include that binary ionic substances (i.e., substances that have ionic bonds), when pure, are crystalline salts at room temperature (common examples include NaCl, KI, Fe2O3); and substances that are liquids and gases at room temperature are usually made of molecules that have covalent bonds (common examples include CO2, N2, CH4, H2O, C8H18). |
| **STE Standards and Science and Engineering Practices:**  (Review) **HS-PS1-2.** Use the periodic table model to predict and design simple reactions that result in two main classes of binary compounds, ionic and molecular. Develop an explanation based on given observational data and the electronegativity model about the relative strengths of ionic or covalent bonds. Clarification Statements:   * Simple reactions include synthesis (combination), decomposition, single displacement, double displacement, and combustion. * Predictions of reactants and products can be represented using Lewis dot structures, chemical formulas, or physical models. * Observational data include that binary ionic substances (i.e., substances that have ionic bonds), when pure, are crystalline salts at room temperature (common examples include NaCl, KI, Fe2O3); and substances that are liquids and gases at room temperature are usually made of molecules.   **HS-PS2-7(MA).** Construct a model to explain how ions dissolve in polar solvents (particularly water). Analyze and compare solubility and conductivity data to determine the extent to which different ionic species dissolve. Clarification Statement:   * Data for comparison should include different concentrations of solutions with the same ionic species, and similar ionic species dissolved in the same amount of water   **Science and Engineering Practice**: Analyzing and interpreting data |
| **Connections to the real-world:**  Explores physical properties of some common household chemicals. |
| **Mastery Goals:**  Learning Objective:   * Explain how bond type affects the physical properties of a substance by…   + Distinguishing between the physical properties of ionic and covalently bonded compounds.   + Modeling the differences in electronegativity between molecules that make up ionic and covalent compounds.   + Explaining how ionic and covalent bonds are formed between elements.   + Explaining how the electronegativity difference between elements defines the polarity of a compound.   Performance Objective:   * Use scientific evidence to explain how ionic and covalent compounds behave differently.   Language Objective:   * Use academic vocabulary in a written summary of the laboratory results, including an explanation for how ionic and covalent compounds behave differently * Use academic vocabulary during small group oral discussion |
| **Teacher instructions:**  *Note on timing: This task takes about 60 minutes. The students will have to complete two prior knowledge questions before the investigation, that will take them about ten minutes. This will leave them with about 50 minutes to work on the investigation and answer the questions that follow. Students should be placed in groups and each group should divide and conquer the parts of the lab. Students should also be able to work in their groups to answer the questions.*  **Lab Introduction:**   1. Hand out the lab 2. Review ionic and covalent bonds concepts  * Electronegativity * Formation of ions, salts  1. Review the lab with the students 2. Read through procedure, and clarify any questions 3. Sort students into lab groups (2-3 students each) 4. Set them up in the lab area   **Procedure:**  **Part I: Melting Points**   1. Measure out a small quantity (small scoop) of one substance in a tin foil boat 2. Place aluminum foil boat on a pre-heated hot plate 3. Record the melting time for the substance  * If time exceeds ten minutes write “> 10 minutes”  1. Repeat steps for each of the substances, using the same quantity of substance 2. Record all data in the data table   **Part II: Solubility and Conductivity**   1. Measure 50 mL of water in a 200 mL beaker 2. Add a few scoops of one substance 3. Stir vigorously for 5 minutes 4. Record result (dissolves or does not dissolve) in data table 5. Using the same beaker place under conductivity tester 6. Record result in data table 7. Repeat steps for each substance   **Part III: Unknown**   1. Repeat procedure of part I and part II for one the unknown compounds.   **Lab Monitoring:**   1. Allow students to run the experiment  * Circulate the lab area to supervise * Help clarify any issues  1. Monitor student cleanup and consider assigning roles to different groups 2. After cleanup, send students back to their seats to work on post lab questions 3. Allow students additional class time or home learning time to complete the questions as needed 4. When students have completed their questions, facilitate a class discussion to answer the question “How could you determine if an unknown compound is ionic or covalent?” and encourage students to build on each other’s responses and pose new questions. As students pose new questions, consider recording them to see how their questions could fit into later lessons.   **Teacher tips**   1. Review the difference between ionic and covalent bonds  * Metals-Nonmetals (ionic bonding) and nonmetals-nonmetals (covalent bonding)  1. Provide a demonstration during lab instruction period as needed. 2. Help manage your students’ time by giving them frequent updates about their time. This way they can properly divide their tasks at hand. 3. Actively watch your students to make sure they are using proper lab techniques  * Review the lab prior to having them complete the lab * Review lab safety procedures |
| **Instructional Materials/Resources/Tools**   1. Student directions for completing the task 2. A materials list and/or materials management  * Baking soda, baking powder, garlic salt, epsom salt, table salt, sugar  1. One scoopula per group, one 250 mL beaker, 6 pieces of aluminium foil per group, one hot plate per group, two conductivity meters per class, water supply (sink) 2. Safety information as applicable (e.g., SDS information) 3. Any handouts, links, books, videos, materials, etc. that is needed for the student to complete the task    1. PTable.com link: https://ptable.com 4. Scoring rubric – Focus on including the standards-content and practices for performance criteria. Less focus should be on presentation style, design, etc. unless it is tied directly to an ELA standard. |
| **Task Sources:**  PTable https://ptable.com  Dayah, M. (1997, October 1). *Ptable: The Interactive Periodic Table*. Retrieved July 30, 2020, from Ptable: https://ptable.com |

***Laboratory: Properties of ionic and covalent compounds***

Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date:\_\_\_\_\_\_\_\_\_\_

***Introduction***

Salts are compounds formed from the ionic bonding of a metal and a nonmetal. Salts have unique chemical and physical properties such as electrical conductivity and high melting points. Ionic bonds are relatively strong bonds and therefore require a lot of energy to break resulting in high melting and boiling points. This laboratory will investigate the physical properties of some common household chemicals.

***Prior knowledge***

1. Explain how electronegativity is related to the type of chemical bonds within a compound.

2. Explain ion formation and how it relates to the formation of ionic compounds (*i.e.*, salts).

***Procedure***

The following substances will be tested: baking soda, baking powder, garlic salt, Epsom salt, table sugar, table salt

Part I: melting point

1. Place a small scoop of one of the substances in a foil boat.

2. Place the boat containing the substance on the hot plate. Record the time that it takes for the compound to melt. If it takes longer than 10 min. for the substance to melt, stop the test and record “>10 min.” in the data table.

3. Repeat for each substance. You may reuse a boat if the substance does not melt.

Part II: solubility and conductivity

1. Place a scoop of one of the substances in a beaker containing 50 ml of warm tap water.

2. Stir with the glass rod, and observe to see if compound dissolves. You may need to stir for up to 5 min.

3. Record whether or not the solution dissolves.

4. Then test the electrical conductivity of the solution using the voltmeter.

Part III.

1. Choose one of the two unknown substances.
2. Following the procedures from Part I. and II. above, you are to determine whether or not the unknown substance is ionic or covalent.

***Data: Table I. Common Household Substances***

|  |  |  |  |
| --- | --- | --- | --- |
| **Substance** | **Time to melt** | **Water-soluble?**  **Yes or No** | **Conducts electricity?**  **Yes or No** |
| Baking soda |  |  |  |
| Baking powder |  |  |  |
| Garlic salt |  |  |  |
| Epsom salt |  |  |  |
| Table sugar |  |  |  |
| Table salt |  |  |  |

What do you notice and wonder about the data your group collected? How do you think you could tell an ionic substance (i.e., salt) from a covalent substance?

***Data: Table II. Unknown Substance***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Unknown**  **Substance** | **Time to melt** | **Water-soluble?**  **Yes or No** | **Conducts electricity?**  **Yes or No** | **Ionic or Covalent** |
|  |  |  |  |  |

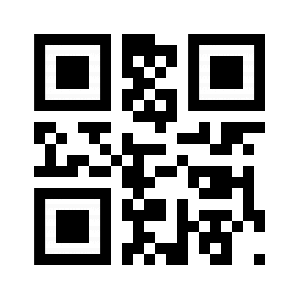
***Data analysis***

1. What properties do ionic compounds (*i.e.*, salts) share?

2. Based on your data, decide if each compound is an ionic or covalent compound

|  |  |
| --- | --- |
| **Substance** | **Ionic or covalent compound?** |
| Baking soda |  |
| Baking Powder |  |
| Garlic salt |  |
| Epsom salt |  |
| Table sugar |  |
| Table salt |  |

3. What are some potential sources of experimental error in this experiment?



4. For each of the compounds in the table, determine the electronegativity difference. Look up the electronegativity values for each element in the compound on PTable.com, and then subtract the two values to determine the difference.

|  |  |  |  |
| --- | --- | --- | --- |
| **Compound** | **Type of bond? Ionic, polar covalent, nonpolar covalent** | **Melting point** | **Electronegativity difference** |
| CaI2 |  | 784 oC |  |
| CCl4 |  | -23oC |  |
| H2S |  | -85.5oC |  |
| H2O |  | 0oC |  |
| MgF2 |  | 1261 oC |  |
| AuCl3 |  | 489.2 oC |  |
| O2 |  | -361.8 oC |  |

5. Graph the data from question 4 (electronegativity vs. melting point)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

6. How are electronegativity, and melting point related? How are these things related to the type of bond (ionic or covalent) holding the compound’s molecules together?

***Conclusions***

1. Write a short summary comparing the physical and chemical properties of an ionic and covalent compound used in the laboratory.

2. Based on the collected data for the unknown sample, write a explanation about how you were able to identify the unknown substance as either ionic or covalent.