Solution Conductivity

Lesson Plan, Student Version, Teacher Version and Supplemental Materials

Topic:

- Solutions
- Bonding
- Periodic Table
- Physical Properties

Subject/Grade Level:

- 8th Grade Physical Science

Lab Duration:

- Day 1: Introduce circuitry and equipment
- Day 2: Pre-lab activity and safety awareness
- Day 3:-4 Data collection
- *Days 5-10: In-class writing, follow-up discussions, peer review and final drafting *(Honors only)*

Materials:

- Conductivity Placemat
- Test Solutions
    - DI water
    - Soda
    - Bleach water (1 M)
    - Coffee
    - Salt water (1 M)
    - Gatorade
    - Vinegar
    - Sugar water (1 M)
    - Jello
    - Red Bull
- 9 V Batteries and Battery Connector
- 14.4 V Lightbulbs and Lightbulb Holders
- 22 gauge wire
- Multimeters
- Aluminum Foil
- Beakers
- Card stock

Supplemental Resources:

- http://dsc.discovery.com/tv-shows/mythbusters/videos/appliances-in-the-bath-minimyth.htm

Middle School 8th Grade Physical Science Standards:

3. Structure of Matter: Each of the more than 100 elements of matter has distinct properties and a distinct atomic structure. All forms of matter are composed of one or more of the elements. As a basis for understanding this concept:
    c. Students know that compounds are formed by combining two or more different elements and that compounds have properties that are different from their constituent elements.
    d. Students know atoms and molecules form solids by building repeating patterns, such as the crystal structure of NaCl or long-chain polymers.
    f. Students know how to use the periodic table to identify elements in simple compounds.

7. Periodic Table: The organization of the periodic table is based on the properties of the elements and reflects the structure of atoms. At a basis for understanding this concept:
    a. Students know how to identify regions corresponding to metals, nonmetals, and inert gases.
    c. Students know substances can be classified by their properties, including their melting temperature, density, hardness, and thermal and electrical conductivity.

9. Investigation and Experimentation: Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:
    e. Construct appropriate graphs from data and develop quantitative statements about the relationship between variables.
    f. Apply simple mathematical relationships to determine a missing quantity in a mathematical expression, given the two remaining terms.
    g. Distinguish between linear and nonlinear relationships on a graph of data.

Inquiry Objective:

- Students will be able to design a conductivity experiment and determine which solution is the best conductor.
- Students will identify how conductivity changes with concentration.
- Students will be able to explain if it is better is be in an ocean, lake or bath tub of jello during a lightning storm.

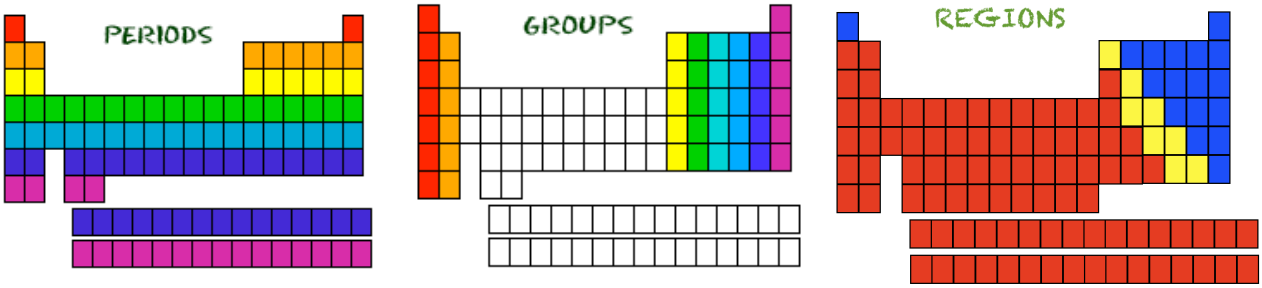
Learning Objectives:

- Students will be able to build a *Solution Conductivity Tester*
- Students will be able to collect voltage data for a variety of ionic and covalent solutions
- Students will be able to identify why soluble ionic solutions conduct electricity based on ionic bonds, while insoluble ionic compounds or molecules do not conduct electricity.
- Students will be able to measure voltage as a function of amount of solute in solution

Background Information:

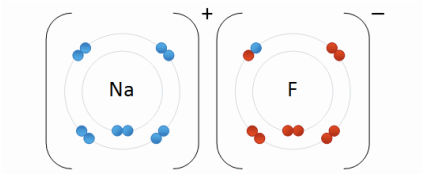
- **Physical and Chemical Properties:** Properties that describe the look or feel of a substance, such as color, hardness, density, texture or phase. Physical properties also include melting and boiling points and conductivity. Chemical properties refer to a substance ability or inability to react with other substances.

- **Periodic Table:** While the periodic table looks like a fairly simple way to organize the elements based on atomic number, it actually includes several patterns and relationships that group elements by reactivities, number of orbitals, atomic radius, etc. Elements in the same column (called groups or families) have similar physical and chemical properties. Elements in the same row (periods) show increasing atomic number and electronegativity, while also showing a decrease in atomic size. The periodic table also include three major regions, including metals, semimetals and nonmetals. These three regions of atoms also exhibit similar properties and reactivities.

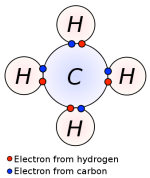


- **Bonding:** Individual elements have their own specific physical and chemical properties, however, these properties change once elements are bonded together. Three type of bonds can be formed depending on the elements.

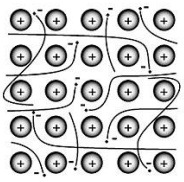
    - **Ionic Bond:** Formed between metal and nonmetals atoms and held together by an electrostatic attraction. The metal atom will donate its electron(s) from its valence orbital in order to complete its octet (forms positive ion), while the nonmetal will accept electrons in order to fill its valence orbital (forms negative ion). This mutual transferring of electrons allows ionic compounds to form lattices of alternating positive and negative ions. Ionic compounds form solids with low thermal/electrical conductivity and extremely high melting points, however in aqueous solution, ionic compounds can be excellent conductors.



    - **Covalent Bond:** Covalent bonds are formed between nonmetal atoms by sharing electrons. Since nonmetals will not donate electrons like metals in an ionic compound, the nonmetals atoms complete their octet by sharing electrons between their valence orbitals. Covalent molecules can be solids, liquids or gases, are poor conductors and poor solubility.



    - **Metallic Bond:** Metallic bonds refer to electrostatic forces between delocalized electrons of metal atoms. Since metals atoms are large, the electrons are less attracted their own nucleus and are able to travel through an "electron sea". This mobility allows metals to excellent conductors of heat and electricity, however, metals are insoluble and have much lower melting and boiling points.



- **Solutions:** A solution is a homogeneous mixture comprised on a solute and solvent.
    - **Solute:** The solute is the substance being dissolved in solution.
    - **Solvent:** The solvent is the substance "doing" the dissolving.
    - **Unsaturated, Saturated, Supersaturated:** Can hold more, maximum or too much solute in solution based on the solvent ability dissolve or dissociate solute.

- **Electricity:** Electricity is described as the presence and flow of an electrical charge
    - **Circuit:** An electrical network containing a closed loop for current to travel
    - **Voltage (V):** Current can only flow through a material only when a difference in electrical potential exist.

Instructional Design: This activity includes three activities in which students require information from periodic table, bonding and physical properties lessons. Students will practice making a hypothesis, build their own experiment, collect and plot data, and make conclusions.

- **Part 1:** In the Pre-Lab students will review the periodic table and bonding in the context physical properties of elements and compounds/molecules. Students will also watch a clip from MythBusters to introduce them to the concept of conductivity of liquids.

- **Part 2:** In Part 2, students will use their observations from the MythBusters videos to respond to "Where would be worst place to be during a lightning storm? Ocean water, lake water or bathtub full of jello?" Following this initial activity, students will build their own *Conductivity Tester*, learn how to measure a voltage using a multimeter and then test a variety of solutions and solids. This data will be plotted and followed up by a series of conclusion questions that examine the properties of each mixture, specially ionic versus covalent solutions.

- **Part 3:** For the final part of the lab students will be allowed to pick type of solution to explore further. Students will test the voltages of regular water and then increasing amounts of solute. Students will plot their data and discuss their results, including saturation levels, bond types and other properties of solutions.

Assessment: Students assessment will be based on the completion and accuracy of Parts 1-3.
- Writing in complete sentences
- Detailed experiment design, data collection and analyses
- Organized data tables and graphs

Honors Assessment: Students assessment will be based on the completion and accuracy of Parts 1-4, as well as formal lab report using the provided outline and rubric.