PEROVSKITE STRUCTURES AND ELECRICAL COMPONENTS

Subject Area(s) Physical Science, Chemistry

Associated Unit Energy, energy resources, physical and chemical structures

Lesson Title **Using perovskite structures to store and create energy**

Grade Level 8 (8-12)

Time Required 90 minutes

Summary
Students learn about the history of perovskites, the perovskite structure, and their applications in solar energy and electronics. They acquire knowledge about the design and development perovskite inks used with inkjet printers, and photovoltaic implications. They learn about materials science, solar energy, and printing circuitry.

Engineering Connection
Chemical and material engineers and scientists can create structures used to store and generate electricity. Material scientists study the characteristics and properties of the perovskite structures. Engineers create the equipment and devices that can be used in practical applications.

Engineering Category =
Choose the category that best describes this lesson's amount/depth of engineering content

2. Engineering analysis or partial design
3. Engineering design process

Keywords
A site, anions, B site, cations, inkjet printing, material science, perovskite structure, perovskites, photovoltaic cells, solar power, X site

Educational Standards (List 2-4)

NGSS/Idaho State STEM Standards (Idaho)

PSC1-HS-1. Develop models to describe the atomic composition of simple molecules and extended structures.

- Further Explanation: Emphasis is on reviewing how to develop models of molecules that vary in complexity. This should build on the similar middle school standard (PS1- MS-1). Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.
- Content Limit: Students will be provided with the names of the elements, a list of common ions, a list of numerical prefixes and their meanings, and the charges of all cations and

anions within the item as necessary. Confine element symbols to the representative and familiar transition metal elements.

PSC1-HS-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.

- Further Explanation: 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.
- Content Limit: Metallic, ionic, and covalent bonds may be included. Graphical representations of melting or boiling points of different substances may be used in the item (e.g., graph of boiling points vs. molar mass or simple bar graph). Structural formulas of compounds may be used to compare the melting/boiling points of compounds

PSC1-HS-5. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

- Further Explanation: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.
- Content Limit: Assessment is limited to provided molecular structures of specific designed materials. For questions involving polar vs. nonpolar bonds, item distractors containing ionic bonds may not be used. Electronegativity differences of < 0.5 should be used for nonpolar covalent bonds. Electronegativity differences of 0.5 – 1.7 should be used for polar covalent bonds.

Pre-Requisite Knowledge

Basic understanding of crystalline structures. Also, must understand what an ion is and how it forms. Should know what solar power is and how it's generated. Know how to operate a multimeter.

Learning Objectives

After this lesson, students should be able to:

- Describe the basic perovskite structure.
- Explain the characteristics of a perovskite structure.
- Explain how a perovskite structure material can be utilized.

Introduction / Motivation

Can you print electrical wire on paper? How about through a printer? Would you believe you can do BOTH?!

The students will be introduced to graphite circuits.

Video of printed circuits https://www.youtube.com/watch?v=BwKQ9Idq9FM

Today's exercise will begin with simple pencil and paper (3x5 notecards are preferred). On the paper, have the students draw a 5 mm x 2 cm rectangle, and color it in with a regular pencil.

The coloring must be dark and shiny to be effective. Next, give the students a brief review/tutorial on how to use the multimeter.

- Test the multimeter leads by putting the multimeter on continuity and touch the leads together. There should be a beep sound.
- Measure the resistance, in Ohms, of the pencil strip using the multimeter.
- Attach a 9 volt battery to the strip, and using an LED. Will the strip will conduct enough electricity to light an LED?
- Move the LED back and forth on the circuit. What happens?
- The exercise will continue later, with a “printed” circuit.

Lesson Background & Concepts for Teachers

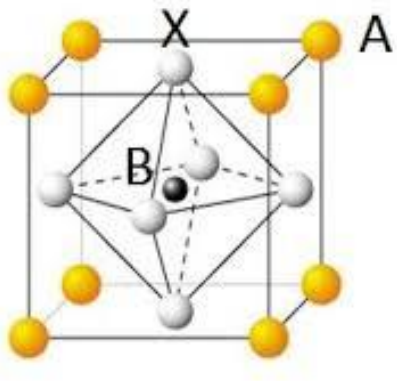

Image 1

Image file:
http://solarcellanatsuga.blogspot.com/2017/01/perovskite-solar-cell.html

ADA Description: Diagram shows the perovskite structure as both a single crystal, and a lattice of multiple crystals. The A sites (yellow), B sites (black), and X sites (white) are color coded and show what type of ions and atoms are present and where they are located in the structure. A and B are cations, X (typically O) is an anion, that keeps the forces in check and the structure together. The “layers” are positive, then the negative, then the positive in the center.

Lesson

Review with the students how power is transferred, generated, and stored. This should be a review of concepts from the prior energy unit. Discuss photovoltaic power, in particular.

Begin the power point. Any teacher notes that might be needed are in the “notes” section of the ppt, otherwise the presentation is pretty self-explanatory. The students will take 3 column notes on their own paper while going through the presentation, using the following format;

Term or phrase – definition and/or uses – pictures (if applicable)

The presentation will cover the history, structure, some uses of perovskite structures, and the activity of making a perovskite model. There is a section discussing my personal summer Research Experience for Teachers (RET) research, and can be replaced or omitted.

Vocabulary / Definitions

Word	Definition
anion	atom that has gained an electron for an overall negative charge
capacitor	A device for accumulating and holding electric charge
cation	atom that has lost an electron for an overall positive charge
calcine	To reduce a metal to an oxide, by the action of heat
characteristics	A feature or quality belonging to person, place, or thing
conductivity	The degree to which a specific material conducts electricity
continuity	Checking of an electric circuit to see if current flows
crystallographic structure	description of the ordered arrangement of atoms, ions or molecules in a crystalline material
multimeter	an electronic measuring instrument that combines several measurement functions in one unit.
magnetoresistance	tendency of a material (preferably ferromagnetic) to change the value of its electrical resistance in an externally-applied magnetic field.
octahedron	a polyhedron with eight faces, twelve edges, and six vertices.
perovskite	a yellow, brown, or black mineral consisting largely of calcium titanate, any of a group of related minerals and ceramics having the same crystal structure as this.
photovoltaic	relating to the production of electric current at the junction of two substances exposed to light.
superconductivity	the property of zero electrical resistance in some substances at very low absolute temperatures.

Lesson Closure

Activity – Make a perovskite structure. Follow the power point instructions, making an octahedron inside a paper box (this could also be done with different color toothpicks and marshmallows).

Materials

- Toothpicks (two different colors)
- Mini marshmallows (two different colors)
- Paper for boxes (optional)

Associated Activities

Graphite Circuits

Perovskite models

Assessment

Two Column Notes

Models

Posters

Lesson Extension Activities

Have the students label all sites on the perovskites.

Students can make the outside crystalline structure (box) out of paper, or continue with marshmallows and toothpicks.

Posters could be made describing the process of making photovoltaic cells, and their potential.

References

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Supporting Program

Research Experience for Teachers – Boise State University