RESET AN AEOP EFFORT aeop | 5E STEM Unit: Why do cell phone batteries sometimes overheat? (7 days)

Authors

Thelma Sanga

Chelsa Burch

SUBJECT/GRADE LEVEL

Subject Area: Chemistry (11th)

Grade Level: High School

Materials

- Demonstration: Conductivity in Potato vs Potato Chips
  - Student Handout
  - Physical Materials: Raw Potato, Potato Chips, Copper Wires, Insulated Wire With Alligator Clips, Multimeter
- Lab 1 - Electrical Conductivity Lab
  - Lab report template
  - Physical Materials: Beakers, Mineral Oil, Water, Salt, Sugar, Conductivity Testers
- Lab 2 - Fruit Lab
  - Student Handout
  - Physical Materials (per group): Multimeters, Metal strips (copper, iron, magnesium, tin, lead, nickel, aluminum, carbon, and zinc) Steel Wool, Lemon
- Project-Based Assessment
  - Student Handout and Grading Rubric
  - Poster Boards (1 per group)
  - Sticky notes
- Content Articles and Handouts
  - "The Smartphone Battery and Its Charging System"
    - Student Handout and Answer Key
  - Current Research: Porous Silicon
- Final Presentation Assessment Handout and Rubric

STANDARDS

Next Generation Science Standards

- HS-PS1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

Science and Engineering Practice: Constructing Explanations and Designing Solutions.

- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, and peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Mathematics Standards | Common Core State Standards

- CCSS.MATH.CONTENT.HSN-Q.A.1: Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2).
- CCSS.MATH.CONTENT.HSN-Q.A.3:Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2).

English Language Arts Standards | Common Core State

- CCSS.ELA-LITERACY.WHST.9 -12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2).
- CCSS.ELA-LITERACY.WHST.9 -12.5: Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2).

LESSON OBJECTIVES

SWBAT understand how voltaic cells work to generate electric energy that is used to force nonspontaneous chemical reactions.

SWBAT explain oxidation reduction reactions and apply their new understanding to explain why cell phone batteries sometimes explode.

CAREER CONNECTIONS

Mentor Background:

Aaron Henson is a Materials Scientist at the Army Research Lab where his team works collaboratively on a material called porous silicon (pSi). The team's current focus is on transitioning this technology from the laboratory demonstrations to proving the function of the technology in the environments that it will be potentially operating in. Military technology is required to operate in very extreme environments which require complex, innovative designs.

STEM Careers:

Chemist,

Chemical Engineer,

Electrical Engineering Technician, Electrical/Electronics Engineer:

ENGAGEMENT Day 1 (60 min)

Brief Description: Students will begin to connect their real world experiences with batteries to the chemical reactions that occur within batteries on the atomic scale. They will investigate the basic principles of conductivity to generate essential questions that drive this unit.

Procedures:

1) **Introduction** - This activity engages students and helps check for prior knowledge.
    a) Show a video of a cell phone combusting due to overcharging
        i) Investigative News Story: Exploding Cell Phones
        ii) Michigan Engineering: Why Batteries Explode
    b) Students list (using a collaborative website) the components of various types of batteries and their function.
    c) Students discuss battery function. Essential questions:
        i) Where does the electric current in the battery come from?
        ii) Why do overheated batteries have so much energy (enough to cause harm or destroy properties)?

2) **Teacher Demo**: Whole class demonstration on electricity conduction in fresh potato vs potato chips. This activity extends the original introduction to consider how conductivity works.
    a) Student worksheet
    b) Students explore the properties of raw potatoes and analyze data collected from the demo to explain why electricity conducts in one and not the other.

Watching for misconceptions: Students may infer that the potato "contains" electricity.

3) **DQB and Initial Model:** Students begin generating questions that intrigue them.

    The driving questions can be revisited periodically as the lesson progresses, to add or address questions as students acquire new knowledge and address misconceptions.

    a) Students **draw an initial model of a battery** - In this model students should attempt to address the following items:
        i) What are the parts of the battery you selected and how does it function (focus on the current flow - how is current moving through your battery choice?)

    Note: Students are learning globally about how batteries work. For this activity, a model of ANY battery will work. Later in this unit, students will need to connect the knowledge of how cell phone batteries work, specifically, in order to answer the Unit's question.

EXPLORATION Day 2-3 (120 min)

Brief Description: Students gather additional details about how batteries function to explain REDOX reactions that take place within batteries.

Procedures:

Reading: Students read "The Smartphone Battery and Its Charging System" and engage in guided activity to ensure they gather relevant information about REDOX reactions and basic electrochemistry.

a) Guided Reading Worksheet to complete independently while reading.
b) Students will then meet with their small groups to revise and add to their answers.

> **Suggested Reinforcement Activity**
>
> Students watch a video to connect the concept of redox reactions back to the batteries in their cell phones.
>
> - Link to video on YouTube:: "How a lithium battery actually works"
> - Edpuzzle option for asynchronous instruction

Investigation:

- **Penny Battery Lab:** This lab will help students .
  a) Lab Instructions and Worksheet: This penny lab gives students a chance to begin considering how cell phone batteries function. Students use two different metals and some sour, salty water to create an inexpensive battery

     Link to Teacher resource for this lab.
- Post-Lab discussion:

  Debrief the lab with students (see student worksheet for debrief questions)

Closing: Whole Class Discussion AND models revision

- **Whole Class Discussion:** Discussion questions are suggestions. Based on student responses, you will know where to drive the discussion as the goal is to ensure students have adequate understanding of what makes a battery function. This discussion is a critical junction in the lesson.

  > Students have engaged with three important events and the class discussion is intended to highlight what students should know at this junction. Review the worksheet for this short list for reference.

  Note to teacher: This discussion session should take place after students have completed the async work and submitted the accompanying EdPuzzle assignment.
- **Revising the initial Model: 5-7 mins**

  What new information can students add to the model? How can they revise their models?

  Use the checklist worksheet to encourage independent reflection and revision of the model.

Watching for Misconceptions:

1) *The potato is creating or generating the electric current: the potato is the electrolyte needed for the proper transfer of ions from cathode to anode.*
2) *The chemical reaction helps generate the electrical current. Actually there are two chemical reactions processes: one is a chemical reaction to generate electrical current and the other is the use of electrical current to induce a chemical reaction*.

EXPLANATION Day 4 (60 min)

Brief Description: Direct Instruction: What does chemistry have to do with battery function in my cell phone? Then, they explore REDOX reactions that occur in their daily lives to complete a project-based assessment.

Procedures:

1) **Direct Instruction:** Teacher will use the attached instruction guide to teach about oxidation-reduction (REDOX) reactions
    a) What are REDOX reactions
        i) Students will learn how to assign oxidation numbers to atoms
        ii) Students will practice identifying redox reactions

    Extension for AP/Honors classes:)

        iii) Learn how to balance reactions (background knowledge requisite here – balancing chemical reactions (Extension for AP/Honors classes) - This resource is assigned text from Chem Libre Texts, open source Chemistry Textbook (includes examples and practice opportunities.

2) **Assessment**: At the end of this lesson, student understanding of redox reactions should be assessed.
    a) **Traditional Assessment**: Questions can include a combination of questions that give students a chance to independently practice identifying redox reactions, assigning oxidation numbers, and balancing equations.
    b) **Project-Based Assessment**: Investigate the real-world connection of oxidation-reduction chemistry to their daily lives.
        i) Learners will work in small groups to **research** four naturally occurring redox reactions or redox reactions that are useful for humans. They will write the equations for these reactions on poster boards (and use half-reaction methods to balance them for Honors/AP classes).
        ii) Learners **model** their reactions with photographs and drawings
        iii) **Gallery Walk**: Display posters around the room. Students take a gallery walk, traveling in small groups. Teacher should assign a time limit and announce when groups should move to the next piece in the exhibit. Students leave feedback on the posters they visit (one feedback per person or per team - teacher's choice). Give original teams time to revisit the feedback and incorporate any feedback or ask questions if they choose.

ELABORATE Day 5 (60 min)

Brief Description: Students will complete the fruit lab to solidify how batteries generate charge and how redox reactions use electricity in a reaction. The lab should help students answer the question: How does the type of metal affect reactivity?

Procedures:

Fruit Battery Lab

In this section, students will use a lab to begin constructing a chemistry explanation for how electrical current is generated. They will explore the ideal conditions that make the generation of current possible. They will deep dive into the electrochemical potential, or voltage, which can be generated by the oxidation and reduction reactions. Reactive metals like lithium or calcium are more likely to oxidize, losing electrons to become aqueous ions. In this lab, students will test the reactivity of 5 different metals by testing voltage produced in systems designed to imitate the "battery".

1) **Activity:** Students will collaborate with their groups to complete the fruit lab procedure and handout to collect and analyze relevant data. Analysis questions are included to facilitate discussion and look for misconceptions.
2) **Assessment:** Lab worksheets(fruit lab procedure and handout) will be collected and reviewed for understanding. This also provides an opportunity to find and address any misconceptions.

***Watching for misconceptions**: Students may believe the fruits contain electricity. They should be redirected to consider why changing the metal strips would affect conductivity. They should revisit the Battery article from Day 2 for clarification.*

EVALUATION Day 6-7 (120 min)

Brief Description: An opportunity to showcase learning. Students use knowledge acquired over the course of this lesson to answer the unit question: Why do cell phone batteries sometimes overheat?

Procedures:

1) Group Project: Students collaborate to create a video presentation using a media source of their choice (padlet, youtube are all possible options). Using information gathered thus far, students will work with their groups to create a 7 minute presentation that addresses the following items:
    - Based on what you have learned about cell phone batteries and how electricity is generated and used, explain how a cell phone can overheat and, potentially combust (as observed in our introduction video)
    - Explore using porous silicon as a solution (related to chemistry) for this challenge (highlight industry solutions that address this challenge). What is one way you can address this issue for cell phone users? Consider the benefits and challenges of using porous silicon in batteries.
        - Link to literature produced by research scientist (adapted for high school reading level)
2) Student Reflection: Each student will be assigned 2-3 peer videos to watch to foster critical thinking about the content and constructive feedback skills peer video presentations. They should receive the links to these videos via email or the class platform. After watching the videos, students will write constructive feedback for each peer. Each feedback should include:
    a) One thing you liked about the presentation.
    b) One area for improvement.
    c) Suggestions on how they could enhance their presentation in the future.

    Caution students to be respectful and supportive in feedback. Remind students that the goal is to help their peers grow and improve. Students will submit their feedback in a form or on a handout to be

reviewed by the teacher and shared with peers when appropriate. Material for supporting students to give good feedback.

Reference

Brief Description: Resources and other materials used are given credit duly.

- (n.d.). *Oxidation and Reduction reaction*. Khan Academy. Retrieved July 26, 2024, from https://www.khanacademy.org/science/chemistry/oxidation-reduction
- Studdy Buddies.org - This website has the Fruit Battery lab as well as other variations (depending on available resources and student interest).
- Department of Education Open Textbook Pilot Project, the UC Davis Office of the Provost, the UC Davis Library, the California State University Affordable Learning Solutions Program, (n.d.). *Oxidation Reduction reaction*. Chem Libre Text. Retrieved July 28, 2024, from https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Beginning_Chemistry_(Ball)/14%3A_Oxidation_and_Reduction/14.02%3A_Oxidation-Reduction_Reactions
- Youtube
- http://www.theatlantic.com/national/archive/2012/05/do-cell-phones-belong-in-the-classroom/257325/
- https://www.commonsensemedia.org/educators/blog/for-stem-learning-real-world-application-matters
- (n.d.). *Penny Lab*. Exploratorium. Retrieved July 28, 2024, from https://www.exploratorium.edu/snacks/penny-battery#:~:text=By%20stacking%20additional%20matboards%20and,with%20sulfuric%20acid%20between%20them.
- Kotz, J. C., Treichel, P. M., Townsend, J. R., and Treichel, D. A. (2015). Oxidation–Reduction Reactions. In Chemistry and Chemical Reactivity, Instructor's Edition (9th ed., pp. 125-131). Stamford, CT: Cengage Learning.
- Zumdahl, S. S., and Zumdahl, S. A. (2014). Oxidation–Reduction Reactions. In Chemistry (9th ed., pp. 170–175). Belmont, CA: Brooks/Cole