



UTAH OFFICE OF ENERGY DEVELOPMENT

Hydrogen Fuel Development in Utah

Grade/Subject: Chemistry

Strand/Standard CHEM.4.3 Design a device that converts energy from one form into another to solve a problem. *Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution.* Emphasize chemical potential energy as a type of stored energy. Examples of sources of chemical potential energy could include oxidation-reduction or combustion reactions. (PS3.B, ETS1.A, ETS1.B, ETS1.C)

Lesson Performance Expectations:

- Students will develop an argument related to the use of hydrogen as fuel and design a device that separates hydrogen from water.

Materials per group:

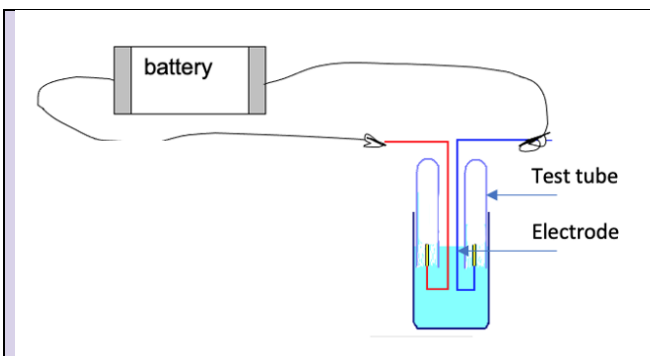
- 2 platinum electrodes
- Baking soda,
- Salt, .1 M HCl, weaker solution of baking soda or other liquids the students might choose in their redesign
- 9 V battery (different sized batteries for redesign)
- 2 ignition test tubes
- Wooden splints
- 500-1000 mL beaker
- 2 alligator clips
- Lighter
- 2 stoppers that fit in the test tubes.

Time: 2 90-minute periods

Teacher Background Information: Platinum electrodes can be purchased at:

https://www.homesciencetools.com/product/electrolysis-electrodes/?gclid=Cj0KCQiA37KbBhDgARIsAIzce15P2uyD2w_hrMQZslpkQrsx2mZ6Gfz9A2u6HwtllbuLaaKjWnHJGSlaAra0EALw_wcB

A picture of a simple set up:



Student Background Knowledge:

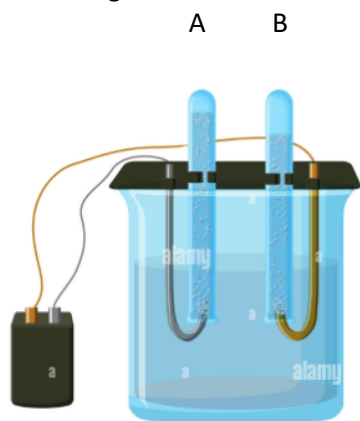
- Students should understand that water is made from two hydrogen atoms bonded to an oxygen atom and that oxygen and hydrogen have different properties.
- Society is in need of additional energy sources to meet the needs of a growing population while reducing emissions to address air quality and climate change.

Teacher Step by Step: A 3-D lesson should insist that students think deeply. Provide time and space for the students to experience the phenomenon and ask questions. The student sheet provided below provides guidance but is only an example of how students might respond.

1. **Phenomenon:** Students will follow the directions for the electrolysis of water and observe the reaction of hydrogen with a flame and oxygen with a glowing splint.
2. Prepare solution of water and baking soda (saturated solution)
3. Ask students for questions that they have about the phenomenon. Students record them on their student sheet.
4. Allow students to repeat the experiment and make design changes. They should report their results. **Do not allow students to mix the hydrogen and oxygen gasses in a single test tube, it will burn explosively.**
5. Ask students to read the article about Delta (printed below) <https://www.kuer.org/business-economy/2022-07-20/can-delta-utahs-green-hydrogen-project-save-both-a-coal-town-and-the-climate>, Utah and the proposed hydrogen storage facility.
6. Assign students to do the research and fill in the data table. They should investigate at least 3 other sites.
7. Ask selected students to read their or a partner's argument. Perhaps take a class "vote" to see if money should be appropriated for additional research or funding of hydrogen projects.
8. An extension would be to ask students to draw a hydrogen powered car. It might include a pressurized tank, a solar panel and some kind of motor.

Assessment of Student Learning.

Use this diagram to answer the next two questions:



1. Which energy conversion takes place between the battery and the electrodes?
 - a. Chemical to electrical*
 - b. Electrical to potential
 - c. Chemical to light
 - d. Electrical to kinetic

2. Which test tube contains the hydrogen after the experiment proceeds?
 - a. The "A" tube because hydrogen is less dense than oxygen
 - b. The "A" tube because hydrogen is highly flammable
 - c. The "B" tube because water has twice as much hydrogen.*
 - d. The "B" tube because oxygen is less dense than hydrogen.

3. How does using hydrogen as a fuel provide an important advantage over the use of fossil fuels?
 - a. Hydrogen is flammable.
 - b. Hydrogen is less dense.
 - c. Hydrogen is odorless.
 - d. Hydrogen burns cleanly.*

4. What challenges must be addressed to store a gas such as hydrogen?
 - a. Hydrogen is invisible and difficult to see if it escapes.*
 - b. Hydrogen is flammable.*
 - c. Hydrogen is stored under pressure to increase the amount stored.*
 - d. Hydrogen reacts with substances found in rock layers.

Extension of lesson and Career Connections: Research how hydrogen is used as a fuel in heavy equipment, cars or rockets. Report and use diagrams to show where and how hydrogen is used.