

Teach Chemistry with Hydrogen and Fuel Cells

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Curriculum Website: sepuplhs.org/hydrogen

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HyTEC: Hydrogen Technology and Energy Curriculum

- Funded by U.S. Dept of Energy
- “Introduction to Alternative Energy: Hydrogen Fuel Cells”
- Developed by a team of scientists, engineers, curriculum developers, teachers, and other educational leaders
- Development process includes extensive classroom testing and feedback
- High School Chemistry (or Physics & Envi. Sci.)



Partners

- Lawrence Hall of Science



Schatz Energy Research Center



AC Transit



FilmSight Productions



LAB-AIDS, Inc.



Teachers and students from SF Bay Area, Washington, Ohio, California, Connecticut, Georgia, New York, and South Carolina

Issue-Oriented Science

- Engages students in learning science and applying it to make evidence-based decisions.
- In most cases, does not advocate a particular decision, but does advocate the use of scientific evidence and concepts in the decision-making process.
- Encourages students to look at various sides of an issue and evaluate the trade-offs involved in a complex decision.

Hydrogen and Fuel Cells in Texas

- For information on fuel cells in Texas, go to <http://www.fuelcells.org/statereport.html> and download the State of the States report
- Texas is on page 59
- UT has a fuel cell hybrid shuttle and fueling station
- There are a number of fuel cell forklifts and small stationery fuel cell installations in Texas
- This document has information about state and regional fuel cell partnerships

Activity #1: Hydrogen for Transportation?



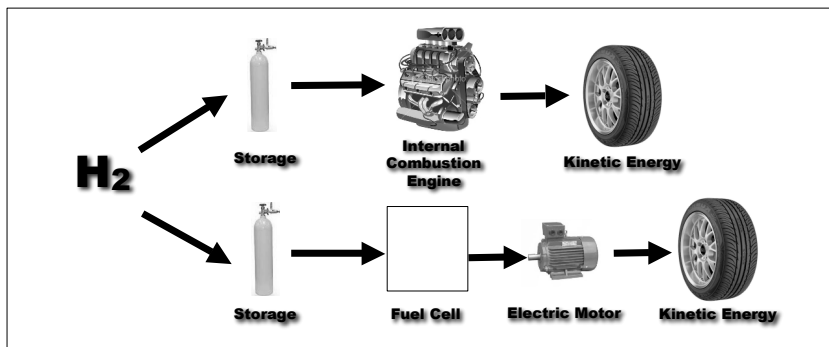
Hydrogen

- Hydrogen is the most common element in the universe.
- The sun is composed mostly of hydrogen gas.
- Where is hydrogen found on Earth?
- Hydrogen occurs naturally as a component of water, air, and hydrocarbon fuels like coal and natural gas.

How do we get Hydrogen?

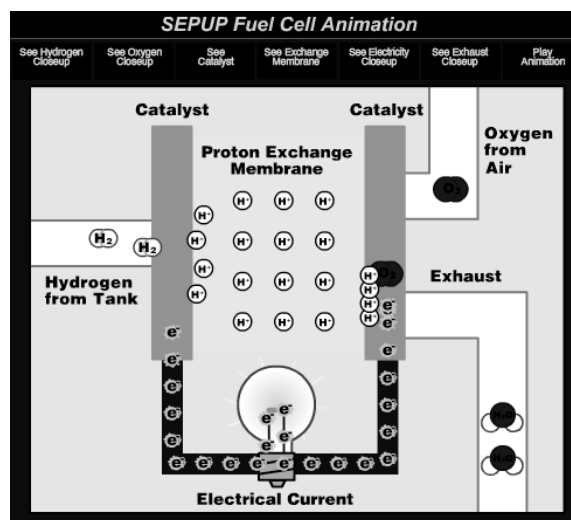


What do we do with Hydrogen?

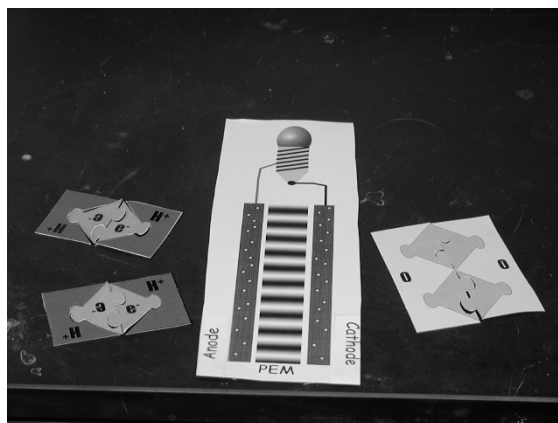


- A way to store energy (like a battery)
- A way to move energy (like electricity)
- NOT an energy source and NOT free

Activity #4: Modeling the Fuel Cell Reaction

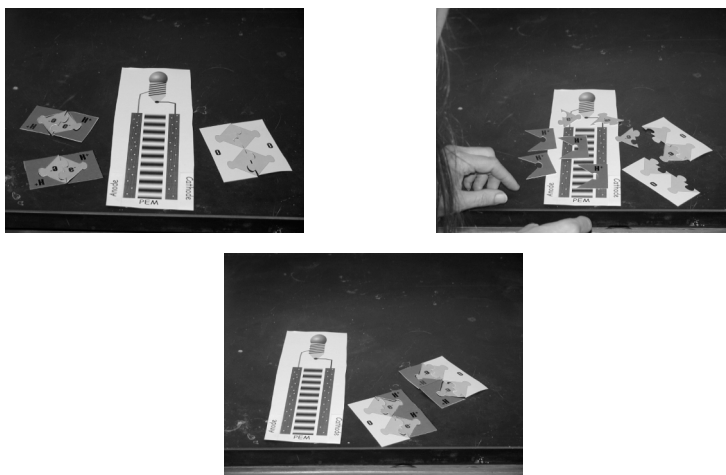


Modeling the Fuel Cell Reaction



Now use the puzzle pieces to model what happens in the fuel cell.

Modeling the Fuel Cell Reaction



Student Activity The Fuel Cell Half Reactions

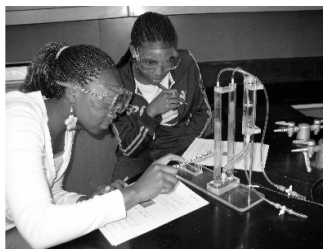
- The half-reactions:
 - Oxidation: $\text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^-$
 - Reduction: $4\text{H}^+ + \text{O}_2 + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$
- Adding the half-reactions:
 - Oxidation: $2\text{H}_2 \rightarrow 4\text{H}^+ + 4\text{e}^-$
 - Reduction: $4\text{H}^+ + \text{O}_2 + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$
- ---
- $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{energy (electricity)}$

The HyTEC Curriculum

- Six activities take approximately two weeks of instructional time.

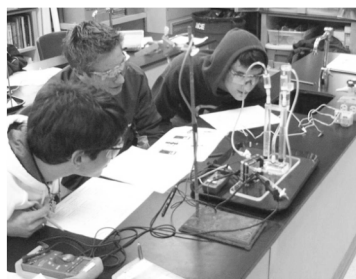
1. **Energy for Transportation** - Students examine trade-offs of various fuel/vehicle combinations.

2. **Obtaining Hydrogen through Electrolysis** - In this hands-on lab, students generate hydrogen and examine the required energy input, stoichiometry, and electrochemistry involved in the process.



The HyTEC Curriculum

3. **Putting a Hydrogen Fuel Cell to Work** - Students generate H_2 and O_2 , and use a single cell fuel cell to perform work.



4. **Modeling a Fuel Cell Redox Reaction** - Students use model pieces and a fuel cell simulation to explore the fuel cell reaction.

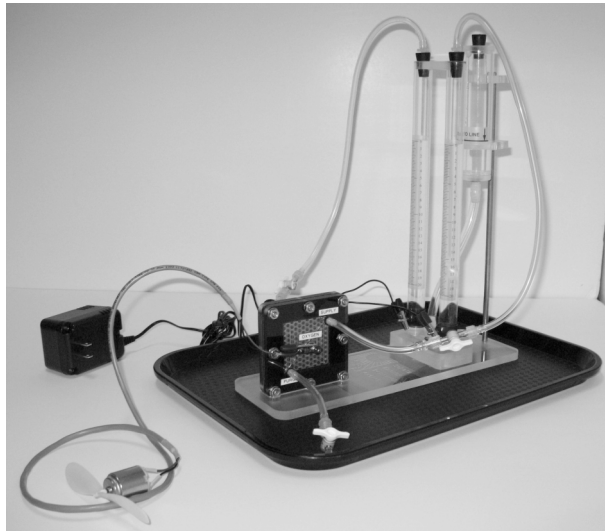
The HyTEC Curriculum

5. Fuel Cell Efficiency - In a hands-on lab, students measure fuel cell efficiency.

6. Hydrogen for Transportation - Students conduct research and engage in a simulated City Council Meeting to present the advantages and challenges of using hydrogen and fuel cells for a city bus program.



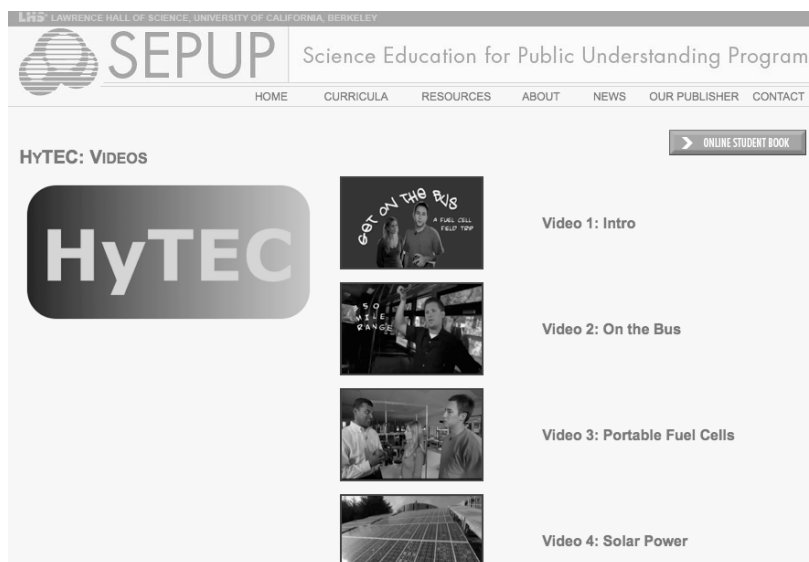
Prototype Kit



Website and Videos

Hydrogen Fuel Cell website:
sepuplhs.org/hydrogen

- Simulation of Fuel Cell
- Clips from video field trip
- Web Resources
- Info on fuel cells



Chemistry TEKS

8A: Mole concept (applied in activity 4 and calculations in Activity 5)

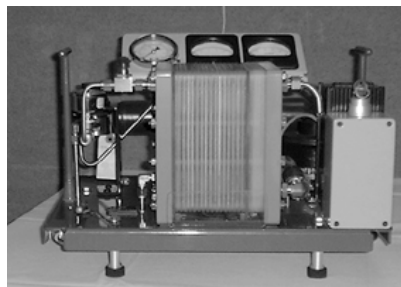
10H: Oxidation-reduction reactions (Activity 4)

11A: Understand energy and its forms (Activities 2-5)

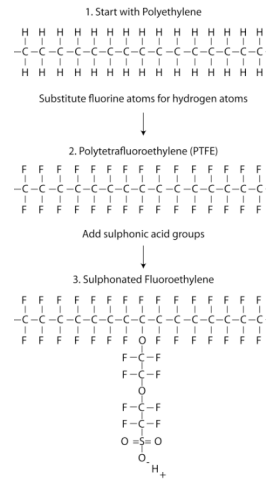
11C: Use thermochemical equations to calculate energy changes that occur in chemical reactions and classify reactions as exothermic or endothermic (Activity 5)

Applications of Fuel Cells

- Video highlights
- Fuel cell bus in Oakland, CA
- Portable applications: video camera, computer
- Production from hydrogen using renewable sources
- Production of hydrogen from landfill gas



- Modified polyethylene hydrocarbon chains
- Fluorine substitutions create polytetrafluorethylene (PTFE: teflon®)
- To make it electrolytic: side chains with hydrophilic sulphonate ($-\text{SO}_3\text{H}$) groups are added



hydrogen endplate

anode gasket

anode screen

anode GDM

membrane electrode assembly

cathode GDM

cathode screen

cathode gasket

air endplate

Challenges to Hydrogen Economy



- Developing infrastructure and improving technology
- Reducing cost
- Addressing public concerns about safety
- Production of hydrogen from water using renewable energy sources

Get Involved!

- Professional Development: Berkeley, Jan. 14-15, 2011
- Contact SEPUP
 - chris_k@berkeley.edu or bnagle@berkeley.edu
- Power point and handouts
 - sepuplhs.org/news.html
- Curriculum Website
 - sepuplhs.org/hydrogen
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