GRID & SILICON

Parent / teacher guide

Fuel Cells: Making Electricity Through Chemistry

Word help: gridandsilicon.com/glossary/

Quick answer key

Time: about 30–40 minutes. **Materials:** Pencil, student sheet and explainer; extension materials are listed below.

- I can trace energy through fuel cells.
- I can use the model to explain a new situation.
- I can explain one limit or tradeoff.

NGSS connections: 4-PS3-2: energy transfer by heat and electrical currents (concept connection). 4-PS3-4: devices converting energy between forms (concept connection; lesson alone does not meet the full design expectation). These are partial teaching connections, not certification.

Warm-up: 1. Hydrogen and air · 2. Heat

Multiple choice: 1. B · 2. B · 3. C · 4. C · 5. A · 6. A · 7. B · 8. A · 9. C

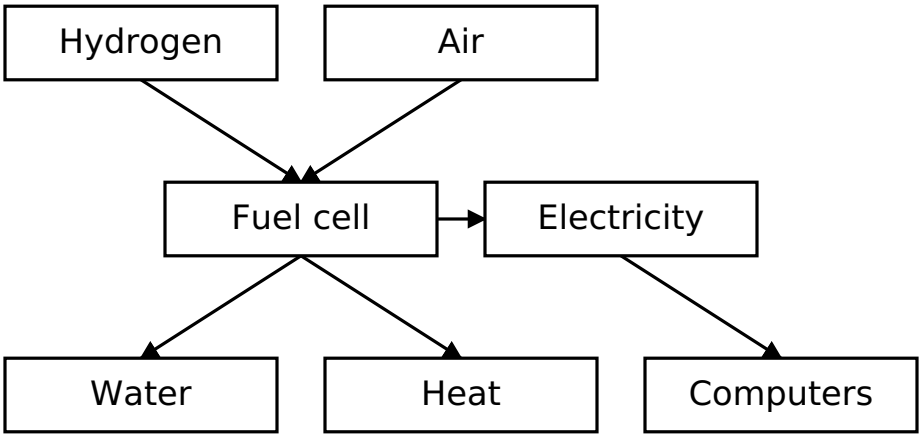
Fill-in: fuel cell · anode · cathode

Diagram labels, by number: 1. Hydrogen · 2. Air · 3. Fuel cell · 4. Electricity · 5. Computers · 6. Water · 7. Heat

Open responses: accept a clear link between the example and the technology. See the samples below.

The big idea

A fuel cell uses a chemical reaction to make electricity. In the hydrogen-cell example, hydrogen and air enter different sides. Charged particles take different routes, and the outside route supplies electric current. Fuel must keep arriving for the cell to keep producing power.



Words to know

fuel cell: A fuel cell makes electricity through a chemical reaction. Like a small chemical power workshop that needs ongoing supplies. · electrodes: Electrodes are the cell parts where chemical reactions take place. Like the two working sides of the cell, with different jobs. · anode: The fuel enters at one side, called the anode. Like the entrance marked for fuel in this hydrogen-cell example. · cathode: Air enters at the other side, called the cathode. Like the entrance marked for air in this example. · electrolyte: Between these sides is an electrolyte, a material that lets certain charged particles pass. Like a special passage that allows certain charged particles through. · catalyst: A catalyst is a material that helps a chemical reaction happen. Like a helper that enables a difficult step.

Question guide

1. Which process lets a fuel cell supply electrical energy?

B. A controlled chemical reaction. Compare chemistry with the turbine's moving blades.

> **Evidence:** "A fuel cell makes electricity through a chemical reaction."

Other choices: A: A rechargeable battery stores energy; a fuel cell receives fuel. C: Spinning blades describes a turbine rather than cell chemistry.

If stuck: Compare chemistry with the turbine's moving blades.

2. In the hydrogen example, which electrode receives fuel?

B. Anode. Follow the hydrogen input in the diagram.

> **Evidence:** "The fuel enters at one side, called the anode."

Other choices: A: The cathode receives air in this hydrogen example. C: The outside circuit carries electrons rather than fuel.

If stuck: Follow the hydrogen input in the diagram.

3. A tube supplies air to the hydrogen cell. Which electrode receives it?

C. Cathode. Air and fuel enter different sides.

> **Evidence:** "Air enters at the other side, called the cathode."

Other choices: A: The external wire carries current rather than incoming air. B: The anode receives fuel rather than air.

If stuck: Air and fuel enter different sides.

4. A cell designer adds a material that helps its reaction occur. What is that material called?

C. Catalyst. The helper and the charged-particle passage have different jobs.

> **Evidence:** "A catalyst is a material that helps a chemical reaction happen."

Other choices: A: The electrolyte passes charged particles; the catalyst helps reaction. B: A fuel tank stores supply rather than helping reaction chemistry.

If stuck: The helper and the charged-particle passage have different jobs.

5. An engineer wants current to do work in a device. Which electron route is useful?

A. Through the external wire circuit. Trace the outside route through the equipment.

> **Evidence:** "Electrons travel through the outside circuit, providing an electric current."

Other choices: B: Fuel pipes are not the outside electrical circuit. C: The useful electron current travels in the outside wire.

If stuck: Trace the outside route through the equipment.

6. A hydrogen cell is running. Which outputs need handling besides electricity?

A. Water and heat. Do not confuse incoming reactants with outgoing products.

> **Evidence:** "This hydrogen-cell reaction produces water and heat."

Other choices: B: A working fuel cell produces water and heat too. C: Fuel and air are inputs, not reaction products.

If stuck: Do not confuse incoming reactants with outgoing products.

7. A data center makes electricity beside its building. What does on-site describe?

B. Where the electricity is made. Location does not determine fuel or emissions.

> **Evidence:** "This is called on-site power, meaning power made where it is used."

Other choices: A: On-site names location rather than stored energy. C: Location alone cannot guarantee zero emissions.

If stuck: Location does not determine fuel or emissions.

8. A delivery problem stops the fuel supply. What limits continued operation?

A. The reaction needs incoming fuel. A fuel cell uses a continuing supply rather than an unlimited store.

> **Evidence:** "A fuel cell needs a continuing supply of fuel to keep producing power."

Other choices: B: A fuel cell does not make power by spinning blades. C: The electrolyte does not provide unlimited stored energy.

If stuck: A fuel cell uses a continuing supply rather than an unlimited store.

9. A data-center fuel cell runs on natural gas. Which claim is most careful?

C. Its system can release CO2. Separate the hydrogen example from a carbon-containing fuel.

> **Evidence:** "Natural gas contains carbon, and these systems give off some carbon dioxide, or CO2, a gas that warms the climate."

Other choices: A: Water-only describes the hydrogen example, not every fuel. B: Natural gas does not guarantee processing is unnecessary.

If stuck: Separate the hydrogen example from a carbon-containing fuel.

Warm-ups, vocabulary and labels

Which two inputs meet at the fuel cell? Hydrogen and air. Which output carries warmth away from the cell? Heat.

Use the labeled diagram to check each numbered blank. Arrows show the path through this technology.

1. fuel cell — A fuel cell makes electricity through a chemical reaction.

2. anode — The anode receives hydrogen in this example.

3. cathode — The cathode receives air in this example.

Think about it: sample answers

A battery-powered torch dims after long use. How is its energy supply different from a fuel cell's? The torch uses a limited stored amount. A fuel cell receives a continuing fuel supply while operating.

A service calls its electricity clean because it uses fuel cells. What would you ask about its fuel? I would ask whether it uses hydrogen or natural gas and what emissions come from the fuel supply and system.

Look for a correct connection to the new situation, not a memorized sentence.

Common mix-ups

- A fuel cell makes electricity through a chemical reaction.
- The anode receives hydrogen in this example.
- The cathode receives air in this example.
- Fuel-cell outputs depend on the fuel, not only the equipment's name.
- A diagram is a simplified model, not a construction plan.

Exit ticket

1. Name one input and one output.
2. Explain what one part does.
3. Predict what changes if a needed input stops.

Check for a valid input/output, the correct job of a named part, and a prediction that follows the energy path.

How to help

Read aloud, pause after one section, and allow a look back at the model. Praise a useful strategy. If frustration grows, take a break and resume with one manageable step.

Safe at-home extension

Draw two supply plans for a torch: stored battery energy and a continuing fuel supply for a fuel cell. Use paper only; do not handle fuels or build a cell.