Stoichiometry

Goals

- Predict reaction yields with stoichiometry
- Use an electrolyzer to generate H2 and O2
- Make calculations based on data

Background

When reactants combine in a chemical reaction, they always do so in known ratios. Molecules contain precise ratios of atoms, so we can calculate the ratios of products in any known reaction. Stoichiometry is the the name given to the calculations of these ratios, which enable us to predict the yields of chemical reactions.

The law of conservation of mass says that matter can neither be created nor destroyed in a chemical reaction. So the amount of matter in the reactants must be equal to the amount of matter in the products. Consider the following reaction:

$$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H2O$$

A molecule of methane reacts with two molecules oxygen to yield one molecule of carbon dioxide and two molecules of water. The molecules on either side of the equation are different, but the number of each type of atom is the same.

The ratios of the molecules involved can also be thought of as moles of reactant and product in the reaction. So in the above reaction, one mole of methane would combine with two moles of oxygen, yielding one mole of carbon dioxide and two moles of water. Since we can convert moles to grams, we can predict how much product should be produced with given amounts of reactants.

In this activity, we will use the simple reactions of water in an electrolyzer and fuel cell to study the stoichiometric ratios of the reaction and compare them to our measured yields.

Procedure

1. You can use the electricity from the solar panel to generate hydrogen gas using the electrolyzer. The electrolyzer is the square with “H2” and “O2” printed on either side. What do you think will happen if you connect it to a source of electricity like the solar cell?
2. Your electrolyzer is also a hydrogen fuel cell that can generate electricity from hydrogen and oxygen. It has two small tubes attached to it. Is there anywhere else on the fuel cell that you could attach the longer tubes?
3. Look at the remaining pieces of your kit. If the fuel cell splits water into hydrogen and oxygen gases, what could you use to trap the gases so they don’t float away?
4. Connect the tubes of your fuel cell so that you can trap the gases. To generate hydrogen, you’ll need to supply an electric current. You can do this with the battery pack or the solar cell. Try both. Which is better at producing hydrogen? How do you know?
5. When you’ve produced hydrogen, you can use the fuel cell to power the motor just like you did with the solar cell. Plug the motor into the fuel cell and it should start turning. Note in your observations if you see any difference in how the motor works with the fuel cell instead of the solar cell.

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Observations

Experimentation

1. With the fuel cell attached, try tilting the solar panel so that it changes the angle of the light that hits it. Can you tilt it far enough that the fuel cell stops generating hydrogen and oxygen? Does it matter which direction you tilt the panel? Using a protractor, measure the biggest angle at which you can still run the fuel cell.

2. Generate more hydrogen and oxygen using the fuel cell, as before. Can you tell how much hydrogen you've generated? What is the volume of hydrogen and oxygen produced? Does your data match what you would expect?

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Measurement

For this section, you will need a multimeter or the Horizon Renewable Energy Monitor. For an introduction to using a multimeter, click here.

1. Measure the current in Amps and the voltage in Volts while generating hydrogen and oxygen using the solar panel and fuel cell. Record your answers below:

Current: _____ A

Voltage: _____ V

2. Voltage is equal to the current multiplied by the resistance (V = IR), so according to your data what is the resistance of the fuel cell?

Resistance: _____ Ω

3. Measure the current in Amps and the voltage in Volts while combining the hydrogen and oxygen to produce water using the fuel cell. Record your answers below:

Current: _____ A

Voltage: _____ V

4. Does it take more energy to split the hydrogen and oxygen or combine them? Explain your reasoning.

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Analysis

1. Make a scientific claim about what you observed while running the fuel cell.

2. What evidence do you have to back up your scientific claim?

3. What reasoning did you use to support your claim?

4. Use your observations to design an experiment you could run to increase the amount of electricity generated by the fuel cell. Describe your experiment below.

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Conclusions

1. How did the volumes of hydrogen and oxygen that you measured reflect the stoichiometry of the reaction that produced them?

2. What were some potential sources of error that might have made your measurements differ from the expected ratio of hydrogen to oxygen?

3. We know that reaction products are always created in known ratios of moles. But if all products are gaseous, would a reaction always create products in the same ratios for the volumes of those gases? Why or why not?