Achieving a Photosynthetic Balance

Background
As you saw in the Amoeba Sisters video, photosynthesis is a very important process for both plants and animals. This process produces glucose, which is the sugar mitochondria need to produce ATP, the energy our cells need to keep working.

Plants require reactants in order to do photosynthesis: water, carbon dioxide, and sunlight. Water and carbon dioxide are represented by their chemical formulas $\text{H}_2\text{O}$ and $\text{CO}_2$. At the end of photosynthesis, plants have produced glucose and oxygen, which are represented as $\text{C}_6\text{H}_{12}\text{O}_6$ and $\text{O}_2$. But, what do these numbers and symbols mean?!

The letter in each compound represents an element found on the periodic table (Ex: $\text{C}$ represents carbon, $\text{O}$ represents oxygen). The tiny numbers appearing behind the chemical symbols are called subscripts. They show the number of atoms of one element needed to make a molecule (Ex: $\text{CO}_2$ is a molecule of carbon dioxide and it has 1 carbon atom and 2 oxygen atoms).

Let’s practice!

$$2\text{H}_2 + \text{O}_2 \to 2\text{H}_2\text{O}$$

1. How many hydrogen atoms make up one $\text{H}_2$ molecule?

2. What type of atoms and how many of each makes up a water molecule (H$_2$O)?

Did you notice the big numbers in front of the $\text{H}_2$ and $\text{H}_2\text{O}$ molecules? Do you know what they represent? These large numbers are called coefficients. They represent how many molecules of each reactant or product is needed to have a balanced reaction. Reactions must be balanced, meaning there needs to be same number each atom on the reactant side as there is on the products side.

Look at the equation given to you earlier. Each $\text{H}_2$ atom looks like this: $\text{H}-\text{H}$. The coefficient lets us know there are 2 of these molecules, meaning there is a total of 4 hydrogen atoms. Another way to picture this equation is:

$$2\text{H}_2 + \text{O}_2 \to 2\text{H}_2\text{O}$$

$\text{H}-\text{H} + \text{O}-\text{O} \to \text{H}-\text{O}-\text{H}$

As you can see, there are 4 hydrogen atoms and 2 oxygen atoms on both sides of the equation. This makes the equation balanced. Today you will be balancing the photosynthesis equation to figure out how the reactants are rearranged to make the products.
Pre-lab Questions
1. What is the law of conservation of mass?

2. What is the chemical equation for photosynthesis?

Objective
By the end of this lesson, I should be able to
- understand how to balance an equation
- understand the law of conservation of matter
- identify where the atoms of reactants are used in the products

Materials
- 30 Toothpicks
- 18 white marshmallows
- 12 pink marshmallows
- 6 blue marshmallows
- Molecule structure cheat sheet
- 2 Paper towels

Safety
- Safety goggles must be worn today.
- Wash your hands thoroughly before beginning the lab and before leaving the lab.
- Food in the lab should be considered a chemical not for consumption.
- Do not consume lab materials! You will be given a treat at the end of class!
- Clean-up:
  o Return safety goggles to the bin
  o Return the molecule cheat sheet to the front of the room
  o Wipe down your desk with a damp paper towel
  o All marshmallows, toothpicks, and paper towels used must be thrown in the garbage can

Procedure
Representation of Atoms
1. In Data Table I, describe the color candy used to represent each type of atom.

Basic Equation
2. Observe the equation of photosynthesis. Build an example of each types of product or reactant molecule used in the equation.

3. Record the “equation” you’ve created in Data Table II below. Then, count and record the number of each type of atom you see.

4. Is the equation balanced? Probably not. Let’s try to balance the equation.
Balancing the Equation

Reactants Team Instructions:
1. It takes six atoms of carbon (C) and twelve atoms of hydrogen (H) to make one molecule of glucose (C₆H₁₂O₆). These atoms come from carbon dioxide (CO₂) and water (H₂O). How many molecules of water and carbon dioxide do you predict a plant will need to make one glucose molecule? _________

2. Students on team reactant should construct the exact number of water and carbon dioxide molecules using the toothpicks and marshmallows. Remember to use the right color for the right atoms!

3. Count your number of carbon and hydrogen atoms used to build your molecules. Did you use six carbon and twelve hydrogen atoms? If not, you need to repeat steps 1-2. If you used the correct amount, you can continue to step 4.

4. In data table III, record the number of each molecule you created by adding coefficients to equation given. Then, count and record the number of carbon, oxygen, and hydrogen atoms you have on the reactant side.

5. Pass the “reactants” you’ve created to the products team.

Products Team Instructions:
1. It takes six atoms of carbon (C), six atoms of oxygen (O) and twelve atoms of hydrogen (H) to make one molecule of glucose (C₆H₁₂O₆). It takes two oxygen atoms to make one oxygen molecule (O₂). How many glucose molecules and oxygen molecules do you think you will be able to create using the reactants given? Glucose____  Oxygen ____

2. Students on team products should construct their predicted number of glucose and oxygen molecules using the toothpicks and marshmallows. Remember to use the right color for the right atoms!

3. Count your number of carbon and hydrogen atoms used to build your molecules. Did you use six carbon and twelve hydrogen atoms in your glucose molecule? Do you have the number of oxygen molecules that you expected? If not, you need to repeat steps 1-2. If you used the correct amount, you can continue to step 4.

4. In data table III, record the number of each molecule you created by adding coefficients to equation given. Then, count and record the number of carbon, oxygen, and hydrogen atoms you have on the product side.

Test yourself
1. Pass the products back to the reactants team.
2. The reactant team should de-assemble the products and turn them back into correct number of reactants (based on the balanced equation you’ve created). If you have no atoms left over, you know that your equation is balanced!
Data & Observations

<table>
<thead>
<tr>
<th>Data Table I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atom colors</td>
</tr>
<tr>
<td>Atom</td>
</tr>
<tr>
<td>Carbon</td>
</tr>
<tr>
<td>Hydrogen</td>
</tr>
<tr>
<td>Oxygen</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Data Table II: Basic Equation</th>
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</thead>
<tbody>
<tr>
<td>Equation:</td>
</tr>
<tr>
<td>Reactants</td>
</tr>
<tr>
<td>Carbon</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data Table III: Balanced Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equation: <em><strong>CO₂ + H₂O → C₆H₁₂O₆ + O₂</strong></em></td>
</tr>
<tr>
<td>Reactants</td>
</tr>
<tr>
<td>Carbon</td>
</tr>
</tbody>
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Analysis

1. Where do plants get the carbon atoms needed to make glucose?

2. Where do plants get the oxygen atoms needed to make oxygen molecules?

3. Why do plants take in 6 CO₂ molecules, but only make 1 C₆H₁₂O₆ molecule?
Conclusion

*How does the law of conservation of mass relate to photosynthesis?*

Write a short paragraph answering this question. In your response be sure to answer the following questions.

- What is photosynthesis?
- What are the products and reactants of photosynthesis?
- How do balanced equations represent the law of conservation of matter?
- Why should we look at a balanced equation when predicting how much glucose a plant can make based upon how much water it receives?