Teacher Guide: Chemical Equations

Learning Objectives

Students will …

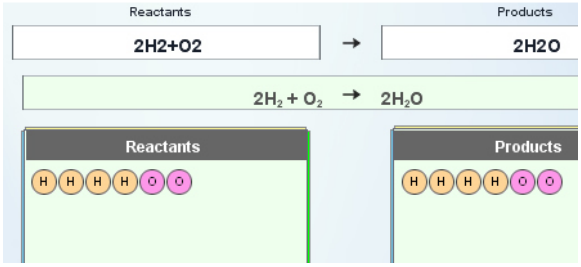
- Understand that conservation of matter implies that chemical equations must be balanced.
- Interpret chemical formulas.
- Balance a wide variety of chemical equations.
- State the relationship between molecular mass and molar mass.
- Determine the masses of reactants and products in a chemical reaction.

Vocabulary

Avogadro's number, chemical equation, chemical formula, chemical reaction, coefficient, combination, combustion, conservation of matter, decomposition, double replacement, molar mass, mole, molecule, product, reactant, single replacement, subscript

Lesson Overview

The *Chemical Equations* Gizmo™ allows students to visualize the atoms in any chemical equation and to use several representations to help balance the equation. Students can enter any chemical equation into the Gizmo, adjust the coefficients of each term, and check if the equation is balanced.



The *Chemical Equations* Gizmo works well as a follow up to the *Balancing Chemical Equations* Gizmo, which covers similar topics at an introductory level.

The Student Exploration sheet contains three activities:

- Activity A – Students learn to interpret chemical formulas.
- Activity B – Students balance chemical equations.
- Activity C – Students determine the molar mass of various substances.

Suggested Lesson Sequence

1. **Pre-Gizmo activity: Burning candle** (10 – 20 minutes)
   To demonstrate conservation of matter, place a large candle on a triple-beam balance, and carefully measure its mass so that the balance is balanced. Light the candle and wait for about one minute. What happens to the mass of the candle, and how can you tell? Where did the missing mass go?

   Blow out the candle, and invert a large jar over the candle. Rebalance the candle and jar, then remove the jar, light the candle, and replace the jar. The candle should burn for several seconds before running out of air and burning out. What happens this time? Why doesn't the mass of the candle/jar change now?

2. **Prior to using the Gizmo** (10 – 15 minutes)
   Before students are at the computers, pass out the Student Exploration sheets and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class, but do not provide correct answers at this point. Afterwards, if possible, use a projector to introduce the Gizmo and demonstrate its basic operations.

3. **Gizmo activities** (15 – 20 minutes per activity)
   Assign students to computers. Students can work individually or in small groups. Ask students to work through the activities in the Student Exploration using the Gizmo. Alternatively, you can use a projector and do the Exploration as a teacher-led activity.

4. **Discussion questions** (15 – 30 minutes)
   As students are working or just after they are done, discuss the following questions:
   - How does balancing chemical equations relate to conservation of matter?
   - While balancing a chemical equation, why are you allowed to change the coefficients but not the subscripts?
   - Why is the mole used as a unit to measure amounts of substances?
   - How do you calculate how much hydrogen and oxygen is needed to produce 100 grams (or any other amount) of water?

5. **Follow-up activity: Stoichiometry** (45 – 60 minutes)
   Stoichiometry is the process of computing the amounts of reactants and products involved in a chemical reaction. Solving these problems involves first calculating the molar masses of each element and compound involved in the equation, and then multiplying these molar masses by the corresponding coefficients in the equation. Practice these skills with your students.

   The *Stoichiometry* Gizmo allows students to convert between molecules, moles, grams, and liters of a substance. These conversions help students solve a wide variety of stoichiometry problems.

Scientific Background

A *chemical reaction* occurs when substances, called *reactants*, are mixed and changed to a new set of substances, or *products*. In this process, chemical bonds between atoms are broken and new bonds are formed, but the atoms themselves remain intact. The law of conservation of matter states that in a chemical reaction, no matter is created or destroyed. (Note: In a nuclear reaction, some matter is converted to energy.)

A chemical equation is a symbolic representation of a chemical reaction. To satisfy conservation of matter, a chemical equation must be balanced, meaning that there are the same numbers of each type of atom on each side of the equation. This is achieved by adding coefficients to the substances in the equation.

For example, the equation below is unbalanced because there are two oxygen atoms on the reactants side of the equation and only one oxygen atom on the products side of the equation.

$$SnO_2 + H_2 \rightarrow Sn + H_2O$$

This problem is remedied by adding a coefficient of 2 in front of the H_2O term on the right. However, this causes an imbalance in hydrogen atoms so a second 2 is added in front of the H_2 term on the left:

$$SnO_2 + 2H_2 \rightarrow Sn + 2H_2O$$

The resulting equation shows one tin atom, two oxygen atoms, and four hydrogen atoms on each side of the equation.

Balancing chemical reactions is useful because it allows you to calculate how much of each reactant you will need to produce a desired amount of product. Scientists use the *mole* (mol) to measure amounts of substances. A mole of a substance has a mass in grams that is equal to the atomic mass of one molecule of the substance. For example, water has an atomic mass of 18 u (universal mass units), so a mole of water is 18 grams of water. Examine the balanced equation below:

$$2H_2 + O_2 \rightarrow 2H_2O$$

From this equation, you can deduce that it requires 2 moles of hydrogen gas (4 grams) and 1 mole of oxygen gas (32 grams) to produce 2 moles of water (36 grams).

Historical Connection: Lavoisier and conservation of matter
Although a variety of philosophers and scientists had formulated ideas similar to conservation of mass, the principle is generally credited to the French chemist Antoine Lavoisier (1743–1794). Lavoisier was one of the first chemists to carefully measure the mass of reactants and products in a chemical reaction. By conducting the reaction in a closed container, he was able to demonstrate that the total mass did not change during the course of the reaction.

Antoine Lavoisier

In addition to conservation of mass, Lavoisier discovered oxygen, determined the composition of water, demonstrated that combustion took place in the presence of oxygen, and proved that cellular respiration was the slow combustion of food. Lavoisier contributed to the development of the metric system and devised a chemical nomenclature still used today.

Although politically liberal and an early supporter of the French Revolution, Lavoisier's past employment as a tax collector sealed his fate, and he was guillotined in 1794. His friend Joseph Lagrange wrote, "It took them only an instant to cut off that head, and a hundred years may not produce another like it."

Selected Web Resources
Balancing chemical equations: http://richardbowles.tripod.com/chemistry/balance.htm
Stoichiometry: http://www.shodor.org/UNChem/basic/stoic/
Antoine Lavoisier: http://www.biographybase.com/biography/Lavoisier_Antoine_Laurent.html

Related Gizmos:
Balancing Chemical Equations: http://www.explorelearning.com/gizmo/id?408
Stoichiometry: http://www.explorelearning.com/gizmo/id?515
Collision Theory: http://www.explorelearning.com/gizmo/id?553
Limiting Reactants: http://www.explorelearning.com/gizmo/id?365