 

**MIDDLE SCHOOL**

**Green Chemistry**

**Cookie Equations**

**Goal:** To introduce and reinforce chemical equations

**Objectives:** Students will …

* Understand that chemical equations must be balanced
* Manipulate simulated elements
* Form simulated compounds

**Materials (for a class of 30):**

* 30 copies of Cookie Equation: Student Template
* Cookies (Oreo style with approximately 32 cookies package)
  + 3 packages black cookies with white center
  + 3 packages yellow cookie brown center

\*double stuff is easier for the students to manipulate!

* + Each pair of students will need 6 black & white cookies and 3 yellow & brown cookies
* 15 plastic knives
* Cookie Equations PowerPoint

**Time Required:** 45–60 minute class period

**Standards Met:**

* Change, constancy, and measurement
* Abilities necessary to do scientific inquiry

**Green Chemistry Principles Addressed:**

* Design syntheses so that the final product contains the maximum amount of the starting materials. There should be few, if any, wasted atoms.

**Procedure:**

NOTE

***Be sure to check for food allergies in the students with whom you intend to do this lesson.***

IN CLASS

* Give each student a Cookie Equation: Student Template
  + Give each student 2 cookies (black with white center) and the student sheets.
  + Explain to students that each black cookie part represents 1 hydrogen atom and that each white center represents 1 oxygen atom.
  + Ask students how many hydrogen and oxygen atoms each of them have.
  + Ask students what molecule the cookie represents.
  + Go over the questions on the student sheet.
  + Tell students that when writing a chemical equation the small number written to the right and below an element tells us how many atoms of that element are in that particular molecule while a large number written to the left of the molecule tells us how many molecules of that substance we have have.
    - An atom: *The smallest unit of an element, having all the characteristics of that element (a dense, central, positively charged nucleus surrounded by a system of electrons). An atom typically remains undivided in chemical reactions.* ~adapted from dictionary.com
    - A molecule: *The smallest particle of a substance that retains the chemical and physical properties of the substance and is composed of two or more atoms; a group of like atoms is an element or different atoms is a compound – both are held together by chemical forces.* ~adapted from dictionary.com
  + Their cookie represents 1 molecule of water composed of two atoms of hydrogen and one atom of oxygen.
  + Two molecules of water (2H2O) could be shown with two cookies made up of 4 hydrogen atoms and 2 oxygen atoms. Three molecules of water (3H2O) would be shown by 3 cookies made up of 6 hydrogen atoms and 3 oxygen atoms, and so on.
* Tell students they are going to now form a chemical reaction.
* Explain that in a chemical reaction, whatever elements are on the left side of the equation, will be in the final product on the right side of the equation. The combinations may be different, but the amount on the left must equal the amount on the right. “What goes in must come out”. The Law of the Conservation of matter states that matter is neither created nor destroyed during the course of a chemical reaction. Although they may be combined differently the mass of the atoms in the reactants must equal the mass of the atoms in the product.
* Give each student a yellow and brown cookie
* Direct students to use their cookies to construct a model of the left side of the equation.
  + You may need to refer them to the KEY on the student template
* Have a student share his or her model with the class.
* Tell students to use their cookies to construct a model of the right side of the equation.
* Ask students if there were any cookie parts not used? Why not?
* Have students compare and contrast their models from both sides of the equation.
* Query students as to their familiarity with these chemical compounds. What are their scientific names? What are their common names?
  + NaOH = sodium hydroxide = lye
  + HCl = hydrochloric acid = gastric acid
  + NaCl = sodium chloride = salt
  + H2O = dihydrogen oxide = water
* Discuss toxicity levels of chemical compounds before the reaction, and the toxicity levels after the reaction.
  + Highly toxic before
  + Benign after
* Explain that this is a neutralization reaction; the highly toxic Sodium Hydroxide and Hydrochloric acid combine to form the relatively safe compounds of salt and water.
* Repeat these steps with the second cookie equation.
  + This equation illustrates how methane gas combines with oxygen in the atmosphere to make carbon dioxide, a key component to the Greenhouse Effect.
* Review the principle: Design syntheses so that the final product contains the maximum amount of the starting materials. There should be few, if any, wasted atoms.
* Explain that sometimes chemists make a compound that uses 5 parts to make the reaction, but only 4 parts bind together to make something useful. That means that the 5th part is a by-product and is waste. It must be disposed of properly.
* In Green Chemistry, the purpose is to avoid these by-products.
* Complete the same steps for the final reaction.
* Explain to students that this represents the reaction they can see, hear, and smell when using a product to unclog a drain, like Dran-O. These products typically consist of aluminum and NaOH. When combined with water, an exothermic reaction is created.
  + Al = aluminum
  + NaOH = sodium hyrdroxide
  + Na3AlO3 = an aluminate of sodium
  + H2 = hydrogen gas

**Assessment:**

* Participation in the activity and discussion
* Correct models of the equations

**Cookie Equation – Student Template**

**KEY**

Black cookie = H

White filling = O

H + H + O H2O

How many atoms to you start with?

How many atoms do you end with?

How many molecules do you end with?

**KEY**

Black cookie = H

Yellow cookie = Na

White filling = O

Brown filling = Cl

NaOH + HCl NaCl + H2O

**Cookie Equation – Student Template**

**KEY**

Black cookie = H

Yellow cookie = C

White filling = O

CH4 + 2O2 CO2 + 2H2O

(methane) (oxygen) (carbon dioxide) (water)

What natural process does the formula (above) show?

One of the 12 Principles of Green Chemistry states:

* *Design syntheses so that the final product contains the maximum amount of the starting materials. There should be few, if any, wasted atoms.*

What is created that is desirable or not harmful? What is created that is not, the toxic waste?

**KEY**

Black cookie = H

Yellow cookie = Na

White filling = O

Brown filling = Al

2 Al + 6 NaOH 2 Na3AlO3  + 3 H2

Again, one of the 12 Principles of Green Chemistry states:

* *Design syntheses so that the final product contains the maximum amount of the starting materials. There should be few, if any, wasted atoms.*

What is created that is desireable? What is created that is not, the toxic waste?

**Cookie Equation – Student Template**

**Teacher Answer Key**

H + H + O → H2O

How many atoms to you start with? *3*

How many atoms do you end with? *3*

How many molecules do you end with? *1*

NaOH + HCl → NaCl + H2O

This reaction represents the combination of sodium hydroxide with hydrochloric acid. The result is salt and water.

CH4  + 2O2 → CO2 + 2H2O

(methane) (oxygen) (carbon dioxide) (water)

What natural process does the formula (above) show? *The greenhouse effect*

One of the 12 Principles of Green Chemistry states:

* Design syntheses so that the final product contains the maximum amount of the starting materials. There should be few, if any, wasted atoms.

What is created that is desirable or not harmful? What is created that is not, the toxic waste?

*Water is not harmful, but too much carbon dioxide is thought to be a contributor to global climate change.*

2 Al + 6 NaOH → 2 Na3AlO3 + 3 H2

Again, one of the 12 Principles of Green Chemistry states:

* Design syntheses so that the final product contains the maximum amount of the starting materials. There should be few, if any, wasted atoms.

*What is created that is desirable? What is created that is not, the toxic waste?*

*2 Na3AlO3 is the product that unclogs a drain. The H2 is hydrogen gas, a highly* [*combustible*](http://en.wikipedia.org/wiki/Combustion)[*gas*](http://en.wikipedia.org/wiki/Gas)*. It can be used to lift a balloon, create an explosion, or fuel a car!*