Name: _____ Date: _____

Student Exploration: Chemical Equations

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

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)

1. A candle is placed on one pan of a balance, and an equal weight is placed on the other pan.

   What would happen if you lit up the candle and waited for a while? _____

   _____

2. Suppose the candle was placed in a large, sealed jar that allowed it to burn for several minutes before running out of oxygen. The candle and jar are balanced by an equal weight.

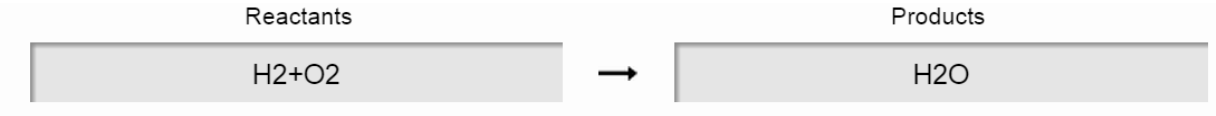
   In this situation, what would happen if you lit up the candle and waited? _____

   _____

Gizmo Warm-up

Burning is an example of a **chemical reaction**. The law of **conservation of matter** states that no atoms are created or destroyed in a chemical reaction. Therefore, a balanced **chemical equation** will show the same number of each type of atom on each side of the equation.

To set up an equation in the *Chemical Equations* Gizmo™, type the **chemical formulas** into the text boxes of the Gizmo. First, type in "H2+O2" in the **Reactants** box and "H2O" in the **Products** box. This represents the reaction of hydrogen and oxygen gas to form water.

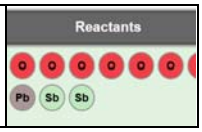


1. Check that the **Visual** display is chosen on each side of the Gizmo, and count the atoms.

   A. How many hydrogen atoms are on the **Reactants** side? ____ **Products** side? ____

   B. How many oxygen atoms are on the **Reactants** side? ____ **Products** side? ____

2. Based on what you see, is this equation currently balanced? _____

Activity A: **Interpreting chemical formulas**	Get the Gizmo ready: • Erase the chemical formulas in each text box. • Check that the **Visual** displays are selected.	

Introduction: To balance a chemical equation, you first need to be able to count how many atoms of each element are on each side of the equation. In this activity, you will practice counting the atoms that are represented in chemical formulas.

Question: How do we read chemical formulas?

1. Observe: Type "H2" into the **Reactants** box and hit **Enter** on your keyboard. Note that the formula is shown as H_2 below. The small "2" in H_2 is a **subscript**.

   A. What does the "2" in H_2 represent? _____

   B. In general, what do you think a subscript in a chemical formula tells you? _____

   _____

   C. Try typing in other subscripts next to the H, such as 3, 4, and 5. Is your answer to question B still true? Explain. _____

2. Count: Clear the **Reactants** box, and type in a more complex chemical formula: "Ca(OH)2." Look at the number of atoms shown.

   A. How many of each type of atom do you see? Ca: _____ O: _____ H: _____

   B. In general, what happens when a subscript is found outside of parentheses?

   _____

   C. Try typing in other subscripts next to the (OH), such as 3, 4, and 5. Is your answer to question B still true? Explain. _____

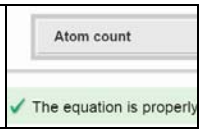
3. Practice: For each of the real chemical formulas below, calculate how many of each element there are. Check your answers for the first three formulas using the Gizmo.

   $AgCl_3Cu_2$ Ag: _____ Cl: _____ Cu: _____

   $Ba(AsO_4)_2$ Ba: _____ As: _____ O: _____

   $(NH_4)_3PO_4$ N: _____ H: _____ P: _____ O: _____

   $MnPb_8(Si_2O_7)_3$ Mn: _____ Pb: _____ Si: _____ O: _____

Activity B: **Balancing equations**	Get the Gizmo ready: • Erase the chemical formulas in each text box.	

Introduction: In a chemical reaction, the **reactants** are the substances that enter into the reaction, and the **products** are the substances that are made in the reaction. A chemical reaction is balanced if the numbers of reactant atoms match the numbers of product atoms.

Goal: Learn to balance any chemical equation.

1. Observe: To model how hydrogen and oxygen react to make water, type "H2+O2" into the **Reactants** box and "H2O" into the **Products** box.

   As the equation is written, which element is not in balance? _____

   Explain: _____

2. Balance: To balance a chemical equation, you are not allowed to change the chemical formulas of the substances involved in the reaction. You *are* allowed to change the number of **molecules** of each substance by adding **coefficients** in front of the formulas.

   A. To balance the oxygen atoms, add a "2" in front of the "H2O" in the **Products** box.

      How many oxygen atoms are found on each side of the equation now? _____

   B. To balance the hydrogen atoms, add a "2" in front of the "H2" in the **Reactants** box.

      How many hydrogen atoms are found on each side of the equation now? _____

   C. Is this equation currently balanced? _____ Click **Show if balanced** to check.

3. Apply: Now enter a more complex chemical reaction: $Ca(OH)_2 + HBr \rightarrow CaBr_2 + H_2O$. List the numbers of each element in the tables below:

Reactants

Ca	O	H	Br

Products

Ca	O	H	Br

   A. Which elements are out of balance? _____

   B. Add coefficients to balance first the bromine (Br) and then the hydrogen (H) atoms. When the equation is balanced, write the complete formula below:

      _____

(Activity B continued on next page)

Activity B (continued from previous page)

4. Practice: Chemical reactions are generally classified into five groups, defined below. Balance each equation, using the Gizmo for help.

Combination (or *synthesis*) – two or more elements combine to form a compound.

- $Na + O_2 \rightarrow Na_2O$ _____
- $La_2O_3 + H_2O \rightarrow La(OH)_3$ _____
- $N_2O_5 + H_2O \rightarrow HNO_3$ _____

Decomposition – a compound breaks down into elements and/or simpler compounds.

- $KNO_3 \rightarrow KNO_2 + O_2$ _____
- $NaN_3 \rightarrow Na + N_2$ _____
- $NH_4NO_3 \rightarrow N_2O + H_2O$ _____

Combustion – a fuel reacts with oxygen to release carbon dioxide, water, and heat.

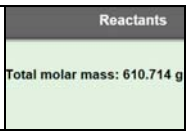
- $CH_4 + O_2 \rightarrow CO_2 + H_2O$ _____
- $C_3H_8 + O_2 \rightarrow CO_2 + H_2O$ _____
- $C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$ _____

Single replacement – an element replaces another element in a compound.

- $KCl + F_2 \rightarrow KF + Cl_2$ _____
- $Mg + HCl \rightarrow MgCl_2 + H_2$ _____
- $Cu + AgNO_3 \rightarrow Cu(NO_3)_2 + Ag$ _____

Double replacement – two compounds switch parts with one another.

- $AgNO_3 + K_2SO_4 \rightarrow Ag_2SO_4 + KNO_3$ _____
- $Mg(OH)_2 + HCl \rightarrow MgCl_2 + H_2O$ _____
- $Al(OH)_3 + H_2SO_4 \rightarrow Al_2(SO_4)_3 + H_2O$ _____

Activity C: **Molar mass**	Get the Gizmo ready: • Erase the chemical formulas in each text box. • In the middle menu, select **Molar mass**.	

Introduction: Chemists are often interested in obtaining a certain mass of product from a chemical reaction without wasting any reactants. But how is this done? To calculate the masses of reactants needed for a desired mass of product, it is necessary to understand a unit of quantity called the **mole**.

Question: How do chemists know how much of each substance to mix?

1. Observe: The mass of a molecule of a substance is its **molecular mass** (M). Molecular mass is measured in universal mass units (u). One universal mass unit (1 u) is approximately the mass of a proton. Hydrogen gas has a molecular mass of 2.0158 u.

   A. Type the formula "H2" into the **Reactants** box. What is the **molar mass** of hydrogen gas, H_2? _____

   B. What is the relationship between the molecular mass and the molar mass of a substance? _____

   A mole is defined as 6.0221415×10^{23} molecules (or atoms) of a substance. This value, called **Avogadro's number**, is special because a mole of a substance has a mass in grams that is equal to the molecular mass of the substance. Moles are handy because a mole of one substance contains the same number of particles as a mole of another substance.

2. Gather data: The balanced equation to synthesize water is: $2H_2 + O_2 \rightarrow 2H_2O$. Use the Gizmo to find the molar masses of each substance in this equation:

   $2H_2$ _____ O_2 _____ $2H_2O$ _____

3. Analyze: Based on the molar masses, how can you tell that an equation is balanced?

   _____

   _____

4. Apply: Suppose you had one mole of oxygen (O_2). How many moles of hydrogen (H_2) would react completely with the oxygen, and how many moles of H_2O would be produced?

   _____

   _____

(Activity C continued on next page)

Activity C (continued from previous page)

5. Calculate: Suppose you had 2.0158 grams of hydrogen (H_2).

   A. How many moles of hydrogen do you have? _____

   B. How many moles of oxygen would react with this much hydrogen? _____

   C. What mass of oxygen would you need for this reaction? _____

   D. How many grams of water would you produce? _____

6. Challenge yourself: Suppose you wanted to make 100 grams of water.

   A. What is the molar mass of water (H_2O)? _____

   B. How many moles of water are in 100 grams? _____

   C. How many moles of hydrogen will you need? _____

   D. How many moles of oxygen will you need? _____

   E. How many grams of hydrogen and oxygen will you need?

      Hydrogen: _____ Oxygen: _____

   F. Is your answer reasonable? Why or why not? _____

      _____

      _____

7. Summarize: Why is it useful to use moles to measure chemical quantities? _____

   _____

   _____

   _____

   _____

   _____

   _____

   _____