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Name: _____ Date: _____

Part I: Chemical Equation Basics

Chemical reactions are processes that occur all around us. There are chemical reactions occurring in your body and chemical reactions occurring in the atmosphere. Chemical equations are written to represent what occurs during these chemical reactions. Below is an example of a chemical reaction that occurs when rocket fuel is burned. This reaction is represented by the chemical equation, which also shows the formation of water.

A Balanced Chemical Equation

coefficient coefficient

$O_2\,(g) + 2\,H_2\,(g) \rightarrow 2\,H_2O\,(l)$

reactants products

In this process, oxygen gas (O_2) and hydrogen gas (H_2) combine to form liquid water (H_2O). The O_2 and the H_2 are the reactants in this equation, and H_2O is the product. Written on the left side of the arrow, the reactants are the starting substances that will be transformed during the chemical change. On the right side of the arrow, the products are the ending substances created during the chemical change. The arrow shows the direction of the reaction.

A chemical equation does more than just show which compounds are involved in a chemical reaction. It also represents the proportion of each compound needed for that reaction to occur. In order to properly represent this, the equation must be balanced.

A balanced chemical equation is one in which mass is conserved and each side of the equation has the same number of atoms of each element. Coefficients, numbers placed in front of a chemical symbol or formula, are used to balance these equations. In the equation above, one oxygen molecule and two hydrogen molecules are required to make two water molecules. Note if only one unit of compound is needed, then no coefficient is placed before that compound—the one is assumed. Note how the same number of atoms of each element is on either side of the equation.

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Part I: Chemical Equation Basics, continued

It is critical that the number of reactant atoms (on the left side of an equation) equal the number of product atoms (on the right side), resulting in a balanced equation. Why? Because mass can neither be created nor destroyed. Therefore, all chemical equations must follow a law known as the law of conservation of mass. This law states that mass is conserved and can neither be created nor destroyed in a chemical reaction. Therefore, the total mass of the reactants must equal the total mass of the products.

Burning wood is a good example that illustrates the law of conservation of mass. When a piece of wood burns, the wood ignites and produces smoke and ash. This is actually a chemical reaction in which the wood is one of the reactants and the ash is one of the products. However, the ash left over does not "weigh" the same amount as the starting piece of wood. So, how does this reaction, known as a combustion reaction, follow the law of conservation of mass? Because there are other reactants and products involved. Look at the actual equation for the burning of wood. We will use the formula for the polymer of cellulose (one of the main compounds found in wood) to represent the piece of wood.

A Chemical Equation

$$\underset{\text{cellulose}}{C_6H_{10}O_5} + 6\,O_2 \rightarrow 6\,CO_2 + 5\,H_2O \text{ (+ ash)}$$

The cellulose reacts with oxygen gas (as it is being burned) to produce carbon dioxide gas and water vapor. The ashes produced are from the other mineral components that are part of the wood. The total mass of the product gases and ash will balance with the total mass of the reactants. Coefficients (numbers in front of reactants and products) are used to make sure the same number of atoms is on each side of the equation, so that it is a balanced chemical equation.

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Part II: Types of Chemical Reactions

There are five types of chemical reactions that require balanced equations according to the law of conservation of mass, as the number of reactant atoms must equal the number of product atoms. Notice the "state of matter" symbols (**s**=solid, **l**=liquid, and **g**=gas) included in each of these equations. The descriptions include a general equation and also a specific example.

Synthesis Reaction (also known as a combination reaction): Two reactants and one product. Both the reactants and product can be compounds.

$$A + X \rightarrow AX$$

$$O_2\,(g) + 2\,H_2\,(g) \rightarrow 2\,H_2O\,(l)$$

Decomposition Reaction: One reactant breaks down into two or more products.

$$AX \rightarrow A + X$$

$$2\,KClO_3\,(s) \rightarrow 2\,KClO_2\,(s) + O_2\,(g)$$

Combustion Reaction (also known as a "burning reaction"): A compound containing carbon, hydrogen, and (sometimes) oxygen reacts with oxygen gas to produce carbon dioxide gas and water.

$$C_XH_YO_Z + O_2 \rightarrow CO_2 + H_2O$$

$$C_{12}H_{22}O_{11}\,(s) + 12\,O_2\,(g) \rightarrow 2\,CO_2\,(g) + 11\,H_2O\,(l)$$

or

$$C_XH_Y + O_2 \rightarrow CO_2 + H_2O$$

$$CH_4\,(g) + 2\,O_2\,(g) \rightarrow CO_2\,(g) + 2\,H_2O\,(g)$$

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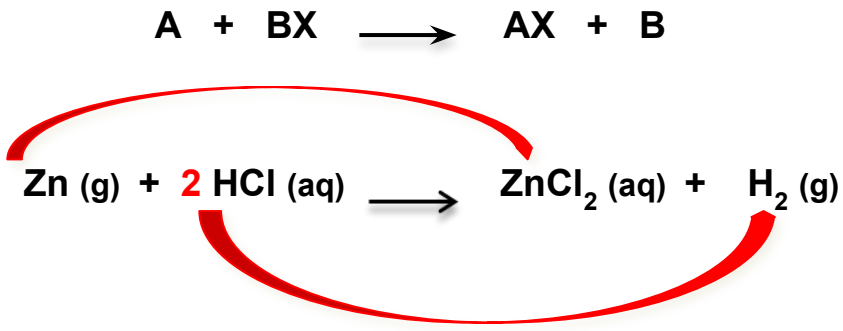
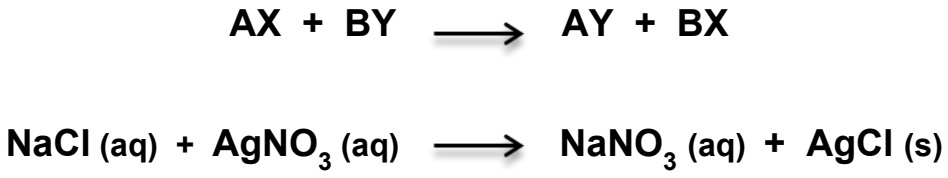
Part II: Types of Chemical Reactions, continued

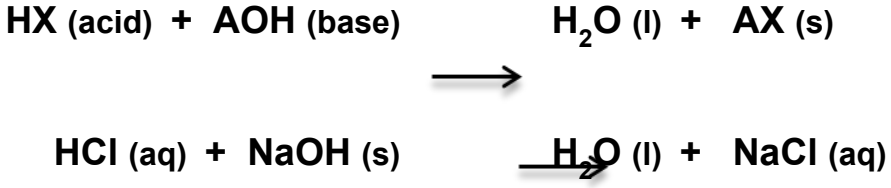
Single Replacement Reaction: From two reactants (one element + one compound), one element displaces (replaces) another. For this to occur, the element doing the replacing of Element **A** must be a more active element than Element **B**.



Double Replacement Reaction (also known as a metathesis reaction): Solutions of two different reacting compounds are mixed, and the positive ions from one compound combine with the negative ions from the other compound. (Metals are written first; negative ions switch places.)



Neutralization Reaction (a type of double replacement reaction): Equal amounts of an acid are added to a base, so that the acid and the base neutralize each other, forming water and a salt.



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Part II: Types of Chemical Reactions, continued

Guidelines for reading and writing chemical equations:

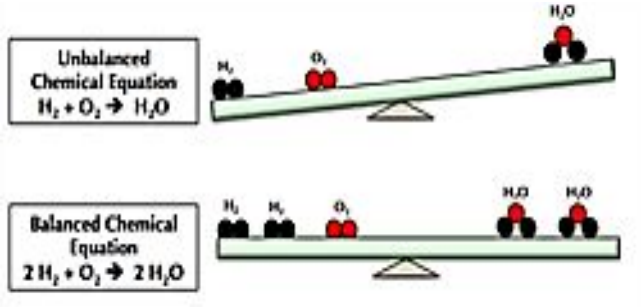
- The letters **A**, **B**, **X**, and **Y** represent general elements. Focus on how those elements combine on the reactant and product sides of the equations.

- The "state of matter" symbols are commonly used when writing chemical equations. These symbols identify the state of the element or compound: **(s)** for solid, **(l)** for liquid, **(g)** for gas, and **(aq)** for aqueous solution.

- When no coefficient is present in front of an element or compound, there is an assumed coefficient of **1**.

- Always check the number of atoms carefully. How many *total* H atoms are on the reactant side in this unbalanced equation? $C_2H_5OH + O_2 \; CO_2 + H_2O$ **(Answer: 6 H atoms)**

- The number of atoms of each element on the reactant side of a balanced equation equals the number of atoms of each element on the product side (law of conservation of mass).



Helpful information for understanding chemical equations:

- In a single replacement reaction, if Element **A** and **B** are metals, review the "Activity Series of Metals" on a Reference Chart. Element **A** must be a more active metal to displace or replace Element **B**. If it is not, then *no* reaction will occur.

- In a combustion reaction, or a reaction in which a substance is burning, "complete combustion" yields CO_2 and H_2O; however, if "incomplete combustion" is occurring, the products are CO (carbon monoxide) and H_2O.

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Part III: Creating Chemical Equations

You will now use what you have learned about the law of conservation of mass to create balanced equations for the different types of chemical reactions. Be sure to read all the instructions before you begin.

Procedure

1. Obtain three labeled bags of cut squares:
   Bag 1 will contain large white squares to represent the reactant(s) of the chemical reaction.
   Bag 2 will contain large colored squares to represent the product(s) of the chemical reaction.
   Bag 3 will contain small white squares for coefficients, two plus signs, and an arrow.
   There may be more reactant and product squares than you need for completing this activity.
2. Using the table of equation descriptions in Part III your Student Journal, locate the number of squares needed for the first equation.
3. With a dry erase marker, write the chemical formulas for the reactants on separate white squares.
4. Write the chemical formulas for the products on separate colored squares.
5. Place the reactants on the table, separated by a plus sign if necessary.
6. Place the yield sign after the reactants.
7. Place the products after the yield sign, separated by a plus sign if necessary.
8. Place additional reactant and product molecules on each side to balance the equation.
9. Once the equation is balanced, place coefficient squares in front of the molecules.
   Identify the type of reaction represented.
10. Record the reactants, products, balanced equation, and reaction type in the two tables in your Student Journal.
11. Erase the writing on the squares and reuse them for the next equation.