Name: _____

Balancing Chemical Equations

Background Information and Vocabulary

A word equation is changed to a symbolic equation to show us what happens to the substances that are involved in a chemical reaction.

Example:
Silver nitrate and magnesium chloride solutions react to form solid silver chloride and magnesium nitrate solution.

$$2AgNO_3\ (aq) + MgCl_2\ (aq) \rightarrow 2AgCl\ (s) + Mg(NO_3)_2\ (aq)$$

- A *reactant* is a chemical substance that is present at the start of the reaction. In the reaction above, silver nitrate and magnesium chloride are reactants. There can be one or more reactants involved in a chemical reaction.
- A *product* is a new substance that is formed during a chemical reaction. The example shows silver chloride and magnesium nitrate as products.
- A *chemical reaction* is a process that involves the rearrangement of the atoms in reactant molecule(s) to form new molecules, which are referred to as the product(s). As you can see in the reaction, the reaction are rearranged to form the products.
- When a chemical reaction occurs you will observe one or more of the following: energy is produced or used, a color change, the formation of a precipitate, or the formation of a gas. In this example, the formation of a precipitate serves as evidence that a reaction occurred.
- A *chemical formula* is a symbolic representation that uses element symbols and numbers to show the composition of a chemical substance.
- A *chemical equation* is a symbolic representation of what occurs when reactants and converted to products during a chemical reaction. As shown above, the reactants and products of a reaction can be converted into chemical formulas and a symbolic equation.
- *Subscripts* are used to show the number of each type of atoms in a chemical substance. They are written as a small number after the element symbol. The equation above shows that there is one magnesium atom and two chlorine atoms present in magnesium chloride ($MgCl_2$).
- In some cases, the subscript is outside of a group of atoms that are surrounded by *parenthesis*. The reaction above includes magnesium nitrate ($Mg(NO_3)_2$) as a product. The parenthesis indicate that the nitrate is a group of atoms bonded together – one nitrogen and three oxygen. The subscript after the parenthesis tells us that there are two nitrates involved in the reaction.
- A *coefficient* is a number written before a chemical formula to show how many molecules (or moles) are present. The coefficient of 2 in front of the silver nitrate and silver chloride indicates that there are two of each involved in the reaction.
- After each formula there is a symbol that indicates the state of the substance: solid *(s),* liquid *(l),* gas *(g),* aqueous solution *(aq).*
- *The Law of Conservation of Mass* states that the mass of the reactants must equal the mass of the products. Additionally, the number of each type of atom on the reactant side of the equation will equal the number of each type of atom on the product side of the equation.

Rules for balancing chemical equations:

1. Mentally, draw a box or circle around chemical formulas – you cannot change any symbol or subscript in the formula to balance equation.
   a. Example 1: You cannot change a subscript - H_2O is different than H_2O_2!!
   b. Example 2: You cannot insert coefficients in middle of formula - H_22O is not correct.
2. Count up the number of each type of atom on both sides of the equation. You might want to make a simple table to keep track as you learn how to balance equation.
3. Add coefficients to the front of the boxes to balance the equation and update your element count. **Coefficients must be whole numbers.**
4. These tips will help you balance equations
   Remember to write the seven diatomic elements (H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2) with the subscript$_2$. Once they react, they will exist as individual atoms in a molecule.
   a. If the same polyatomic ion appears both side of the reaction, put a mental box around it and treat it as a single unit
   b. In some types of ionic reactions it will help to write water as H–OH instead of H_2O.
   c. Balance the elements in compounds first. Start with metals and then balance nonmetals.
   d. Leave the reactants and products that are elements until the end.
5. When the number of atoms of each element is the same before and after the reaction, equation is balanced.

Sample Problems

Example 1

Step 1: Determine the number of each type of atom that are on the reactant and the product side of the equation:

___Mg (s) + ___HCl (aq) → ___H_2 (g) + ___$MgCl_2$ (aq)

Reactant	Atom	Product
1	Mg	1
1*	H	**2***
1*	Cl	**2***

Mg is balanced but H and Cl are not.
and Cl are not.
There are twice as many products as reactants for H and Cl.dd a coefficient of 2 in front of HCl.

(*) indicates that the atoms are not balanced in the equation.
Coefficients must be used.

Step 2: Add coefficients to balance the equation. In this case, a coefficient of 2 in front of HCl will balance the equation. The rest of the coefficients are 1.

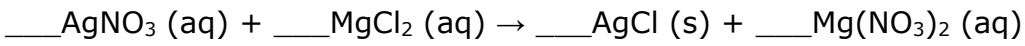
1 Mg (s) + **2** HCl (aq) → **1** H_2 (g) + **1** $MgCl_2$ (aq)

Reactant	Atom	Product
1	Mg	1
2	H	2
2	Cl	2

All atoms are balanced.
The equations is balanced.

Example 2

Step 1: Determine the number of each type of atom that are on the reactant and the product side of the equation:



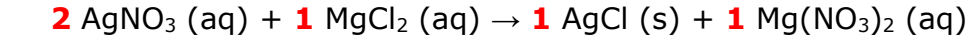
$$\_\_\_AgNO_3\ (aq) + \_\_\_MgCl_2\ (aq) \rightarrow \_\_\_AgCl\ (s) + \_\_\_Mg(NO_3)_2\ (aq)$$

Reactant	Atom or Unit	Product
1	Ag	1
1*	NO_3	**2***
1	Mg	1
2*	Cl	**1***

Ag and Mg are balanced but NO_3 and Cl are not. Start with the NO_3.

(*) indicates that the atoms are not balanced in the equation. Coefficients must be used.

Step 2: Add coefficients to balance the equation. In this case, add a coefficient of 2 to balance the NO_3 and add a coefficient of 1 to the others at this point. The number of atoms have changed, updated values appear in the table.



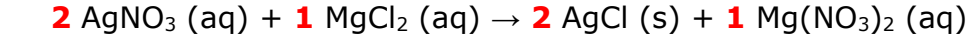
$$\mathbf{2}\ AgNO_3\ (aq) + \mathbf{1}\ MgCl_2\ (aq) \rightarrow \mathbf{1}\ AgCl\ (s) + \mathbf{1}\ Mg(NO_3)_2\ (aq)$$

Reactant	Atom or Unit	Product
2*	Ag	**1***
2	NO_3	2
1	Mg	1
2*	Cl	**1***

NO_3 and Mg are balanced but Ag and Cl are not. There are twice as many reactants as product for both Ag and Cl.

(*) indicates that the atoms are not balanced in the equation. Coefficients must be changed.

Step 3: Change the coefficient for AgCl to 2 to balance the equation. The number of atoms have again changed, the updated values appear in the table.



$$\mathbf{2}\ AgNO_3\ (aq) + \mathbf{1}\ MgCl_2\ (aq) \rightarrow \mathbf{2}\ AgCl\ (s) + \mathbf{1}\ Mg(NO_3)_2\ (aq)$$

Reactant	Atom or Unit	Product
2	Ag	2
2	NO_3	2
1	Mg	1
2	Cl	2

All atoms are balanced. The equation is balanced.

Pre-Activity Questions:

1. Write the name and then determine the number of atoms of each element in the following chemical formulas:

H_3PO_4	N_5O_3	$Al_2(SO_3)_3$
Name:	Name:	Name:
No. of H _____	No. of N _____	No. of Al _____
No. of P _____	No. of O _____	No. of S _____
No. of O _____		No. of O _____

2. Use this equation to answer the following questions:

1 Ca (s) + 2 HF (aq) → 1 CaF_2 (s) +1 H_2 (g)

Write a word equation for this reaction.	
Is the reaction balanced?	
Identify the coefficient(s).	
Identify the subscript(s).	
What is the state of each of the reactants?	
What will serve as evidence that a reaction has occurred?	

Simulation

1. Log onto the simulation: http://bit.ly/BalancingEquationsPhET
2. Select "Introduction".
3. Select "Make Ammonia" and then select the balance "Tool". Complete the table to count the number of each type of atom in the space provided below. Write the balanced equation next to the table.

Reaction 1 Make Ammonia	Total Number of Atoms	
	Reactants	Products
H		
N		

4.  Reset the simulation.
5. Select "Separate Water" and then select the bar graph "Tool".
6. Add coefficients until the equation is balanced. Complete the table to count the number of each type of atom in the space provided below. Write the balanced equation next to the table.

Reaction 2 Separate Water	Total Number of Atoms	
	Reactants	Products
H		
O		

7.  Reset the simulation.
8. Select "Combust Methane" and then select "None" for "Tools".
9. Add coefficients until the equation is balanced. Complete the table to count the number of each type of atom in the space provided below. Write the balanced equation next to the table.

Reaction 3 Combust Methane	Total Number of Atoms	
	Reactants	Products
C		
H		
O		

10. Select "Game" at the bottom of the page and then select "Level 1".
11. Balance the first equation, and then use the "Check" button to see if your equation is balanced.
    a. If it is, move onto the next equation.
    b. If not, use the "Show Why" button to see the number of each type of atom and then "Try Again".
    c. Show all of your work and write your final equation in the space provided below.

12. Continue on to Level 2 and follow the directions given for Level 1. Show all of your work and write your final equation in the space provided below.

1
2
3
4
5

13. Continue on to Level 3 and follow the directions given for Level 1. Show all of your work and write your final equation in the space provided below.

1
2
3

4
5