Name ___________________________

Balancing Chemical Equations

Antoine Lavoisier discovered the **law of conservation of mass**, which states that in chemical reactions, **mass is never lost or gained**. On the atomic level, this means that we never gain or lose atoms of any particular element in a chemical reaction. In other words, in every chemical reaction, **we must end with the same number of atoms of each element with which we started.**

Set-up:

1. Go to phet.colorado.edu and open the simulation *Balancing Chemical Equations*.
2. Click on the Introduction tab.
3. From the top right drop-down Tools menu, select the bar graph.

We are going to methodically balance the equation for the creation of ammonia. Remember, the goal is to have the same number of each type of atom on both sides of the equation. First, add 1 N_2, 1 H_2, and 1 NH_3. Below the current chemical equation, count how many atoms you have of each element and tally them below each element's symbol.

$$N_2 + H_2 \rightarrow NH_3$$

N	H		N	H
		|		

Why is our chemical equation unbalanced?

We do not have the same amount of atoms on either side.

Add a molecule of H_2 to the reactants. How many atoms of each element do we have now?

$$N_2 + 2H_2 \rightarrow NH_3$$

N	H		N	H
		|		

Since we now have too many hydrogen atoms on the reactants side, add another NH_3 molecule. Take another atomic inventory.

$$N_2 + 2H_2 \rightarrow 2NH_3$$

N	H		N	H
		|		

Ok, this is starting to look hopeless. Let's add one more H_2 molecule to the reactants side and take another atomic inventory.

$$N_2 + 3H_2 \rightarrow 2NH_3$$

N	H		N	H

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Finally, we have the same number of nitrogen atoms on each side of the equation and the same number of hydrogen atoms on each side of the equation! The equation is now balanced. This trial and error is an effective method for balancing chemical equations. Adding just one molecule at a time with the elements you need will lead you to success.

Next, we will investigate the combustion of methane. If you are wondering “where do I start?”, recall how we balanced the separation of water equation. The steps we followed were:

1. Start with one of each molecule in the equation.
2. Find out which element you lack, and on which side of the equation you need more.
3. Add another molecule with that element.
4. Check the other side of the equation. If you now have too few atoms of an element on that side, add a molecule to that side.
5. Repeat step 4, jumping from one side of the equation to the other, until your atomic inventory is balanced.

Write in the appropriate coefficients to the chemical equation below in order to balance the equation:

$$\_\_\_\ CH_4 + \_\_\_\ O_2 \rightarrow \_\_\_\ CO_2 + \_\_\_\ H_2O$$

Click the “Separate Water” button. Add 1 molecule of H_2O, H_2, and O_2, then add molecules until the equation is balanced. Use the bar graphs near the top of the screen to take inventories as you try, fail, try again, and succeed.

Write in the appropriate coefficients to the chemical equation below in order to balance the equation:

$$\_\_\_\ H_2O \rightarrow \_\_\_\ H_2 + \_\_\_\ O_2$$

Time to get your game face on. Click the “Game” tab near the bottom of the screen. You must earn a score of **9 out of 10 on Level 1** and **8 out of 10 on Level 2**. ***Before beginning Level 2, you must click the red squares in the top right corner of the two large boxes. This will hide the molecular models, requiring you to take the atomic inventory using good ol’ fashioned math. Use the rules on the next page to count the atoms of each element.

Remember, the steps to balancing equations are:

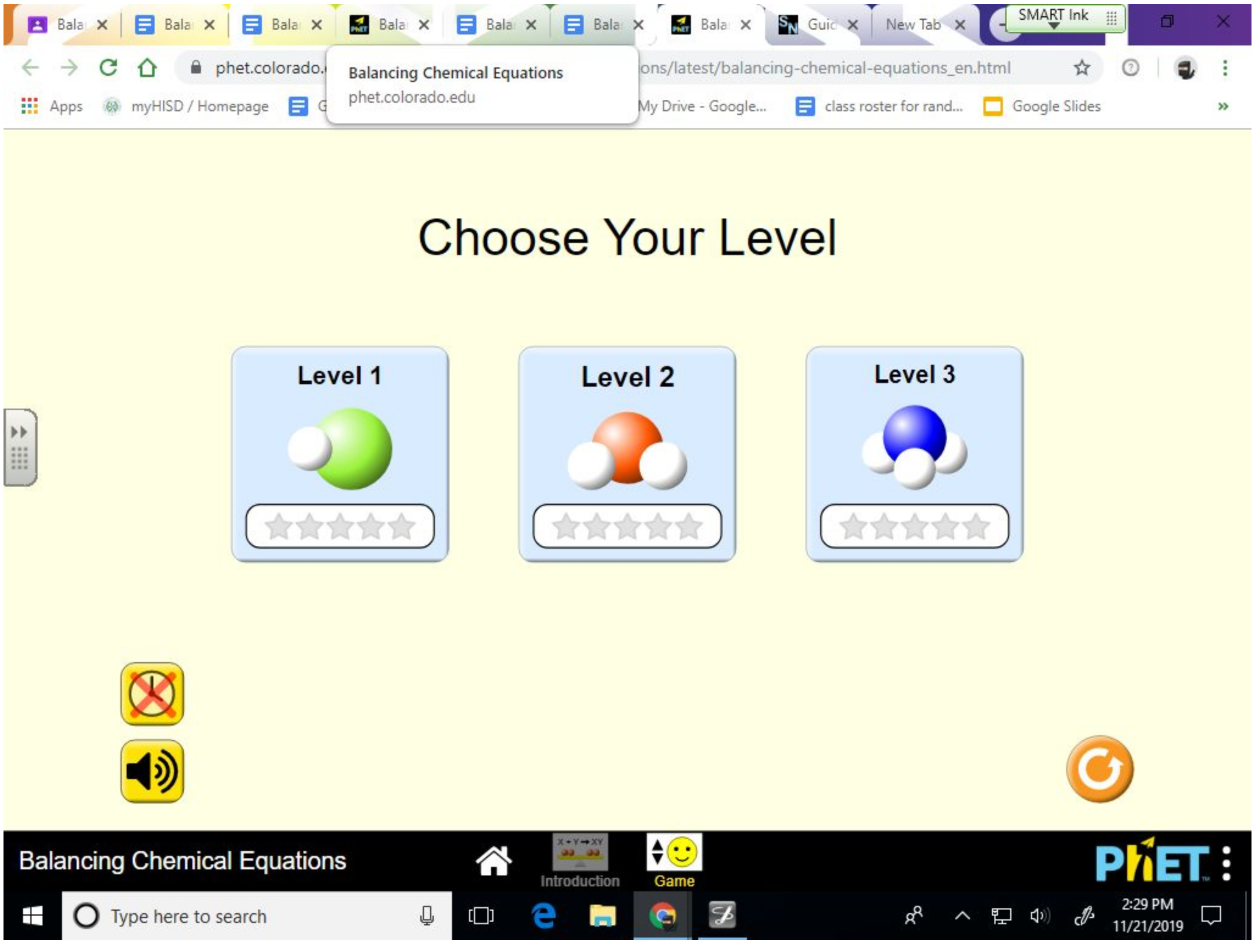
1. Start with one of each molecule in the equation.
2. Find out which element you lack, and on which side of the equation you need more.
3. Add another molecule with that element.
4. Check the other side of the equation. If you now have too few atoms of an element on that side, add a molecule to that side.
5. Repeat step 4, jumping from one side of the equation to the other, until your atomic inventory is balanced.

To count the atoms of each element without the pictures (when you play Level 2), follow the guidelines below.

Rules for counting atoms:

1. Coefficients (the large numbers in front of molecules) apply to every element in that molecule. In other words, **coefficients tell us how many molecules we have.**
2. Subscripts (the little numbers below the symbols) apply only to the preceding element. **Subscripts tell us how many atoms of a particular element are in each molecule.**
3. If no coefficient and/or subscript is written for a particular molecule/element, the coefficient and/or subscript is 1.
4. To find out how many atoms of each element we have, multiply the coefficient in front of the molecule by the subscript below the element. For example, when we have $2H_2O$ on the reactants side, we have **(2 x $_2$) = 4 hydrogen atoms** and **(2 x $_1$) = 2 oxygen atoms**. Again, since oxygen has no subscript, there is 1 atom of oxygen in each molecule of H_2O.

After you successfully earn these scores, try to earn bonus points by completing Level 3. Each star in Level 3 is worth one bonus point. When you have completed the game, paste down below the screen with all of your stars illuminated.



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