Name: _____ **Date:** _____ **Period:** _____

Counting Atoms and Molecules in Chemical Formulas

Chemical equations are combinations of letters and numbers. Scientists must understand the meaning behind these numbers and symbols to conduct experiments.

Remember that a **chemical symbol** is a shorthand way of writing an element's name. Symbols have one or two letters. The first letter is always capitalized and, if present, the second is always lowercase. **Ex:** H, Li, O, Cl.

One element listed by itself represents one atom. So H is one atom of hydrogen and Cl is one atom of chlorine. However, in nature, most atoms are found bonded to other atoms. When two or more atoms are bonded together, they are called **compounds**. One unit of that compound is called a **molecule**. **Ex:** Na and Cl combine to make NaCl; H and O combine to make H_2O. This combination of symbols is called a chemical formula. NaCl is the chemical formula for sodium chloride. H_2O is the chemical formula for water.

Subscripts

Look at the examples above. Notice that in H_2O, there is a 2 after the H. This is called a **subscript**. The subscript applies to the element listed just before it and tells how many atoms of that element are in the compound. If there is not a subscript, it is assumed to be 1. So, H_2O means that each water molecule is made up of 2 hydrogen atoms bonded to 1 oxygen atom. In the case of NaCl, since there are no subscripts, it means that 1 sodium atom is bonded to 1 chlorine atom to make up a molecule of sodium chloride.

Some molecules are more complex and their formulas contain parentheses. $Al_2(SO_4)_3$, aluminum sulfate, is one example. If there is a subscript outside of the parentheses, it applies to each element inside that parenthesis and multiplies their subscripts. In $Al_2(SO_4)_3$,there are 2 Al atoms, 3 S atoms, and 12 O atoms. Notice that since aluminum (Al) is OUTSIDE the parentheses, the subscript of 3 does not affect it. It only multiplies the subscripts of sulfur (S) and oxygen (O), which are INSIDE the parentheses.

Coefficients

Chemical reactions often involve the combination of a certain number of one molecule with a different number of another. To indicate this, scientists put a number in front of the chemical formula indicating how many molecules of that substance are involved in the reaction. This number is called a **coefficient**. Like with subscripts, if there is no number, it is assumed to be 1. Look at the equation for photosynthesis shown below:

$$6\ CO_2 + 6\ H_2O + \text{light energy} \rightarrow 6\ O_2 + C_6H_{12}O_6$$

The numbers in front of each molecule above indicate that 6 molecules of CO_2 (carbon dioxide) and 6 molecules of H_2O (water) combine with light energy to make 6 molecules of O_2 (oxygen) and 1 molecule of $C_6H_{12}O_6$ (glucose).

What if we wanted to know how many carbon atoms and oxygen atoms were in 6 molecules of CO_2? We could list out CO_2 six times and count them all. However, an easier, less time consuming way would be to use multiplication.

To count the atoms in a molecule with a coefficient, multiply the coefficient by each subscript in the chemical formula. In the case of 6 CO_2, carbon (C) has a subscript of 1. Since 6 X 1 = 6, there are a total of 6 carbon atoms. Oxygen (O) has a subscript of 2. Since 6 X 2 = 12, there are a total of 12 oxygen atoms.

A. Use your knowledge of subscripts to indicate how many atoms of each element are in the molecules shown below.

1. H_2 H _____
2. LiO Li _____ O _____
3. H_2SO_4 H _____ S _____ O _____
4. HCl H _____ Cl _____
5. H_2O_2 H _____ O _____
6. NH_3 N _____ H _____
7. C_2H_5OH C _____ H _____ O _____
8. $KClO_3$ K _____ Cl _____ O _____
9. $NaNO_3$ Na _____ N _____ O _____
10. $Al_2(CO_3)_3$ Al _____ C _____ O _____

B. Use your knowledge of coefficients to indicate how many of each molecule is shown below.

11. O_2 O_2 _____
12. 2 H_2 H_2 _____
13. 4 $KClO_3$ $KClO_3$ _____
14. 2 $Al_2(CO_3)_3$ $Al_2(CO_3)_3$ _____
15. $N_2 + 3\ H_2 \rightarrow 2\ NH_3$ N_2 _____ H_2 _____ NH_3 _____
16. $4\ Li + O_2 \rightarrow 2\ Li_2O$ Li _____ O_2 _____ Li_2O _____
17. $4\ Fe + 3\ O_2 \rightarrow 2\ Fe_2O_3$ Fe _____ O_2 _____ Fe_2O_3 _____
18. $6\ Ag + N_2 \rightarrow 2\ Ag_3N$ Ag _____ N_2 _____ Ag_3N _____
19. $H_2CO_3 \rightarrow H_2O + CO_2$ H_2CO_3 _____ H_2O _____ CO_2 _____
20. $C_2H_5OH + 3\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$ C_2H_5OH _____ O_2 _____ CO_2 _____ H_2O _____

C. For each molecule shown, indicate how many atoms of each element can be found. For each reaction, indicate how many atoms of each element can be found on each side of the equation.

21. O_2 O _____
22. 2 H_2 H _____
23. 4 $KClO_3$ K _____ Cl _____ O _____
24. 2 $Al_2(CO_3)_3$ Al _____ C _____ O _____
25. $N_2 + 3\ H_2 \rightarrow 2\ NH_3$ N _____ H _____ → N _____ H _____
26. $4\ Li + O_2 \rightarrow 2\ Li_2O$ Li _____ O _____ → Li _____ O _____
27. $4\ Fe + 3\ O_2 \rightarrow 2\ Fe_2O_3$ Fe _____ O _____ → Fe _____ O _____
28. $6\ Ag + N_2 \rightarrow 2\ Ag_3N$ Ag _____ N _____ → Ag _____ N _____
29. $H_2CO_3 \rightarrow H_2O + CO_2$ H _____ C _____ O _____ → H _____ C _____ O _____
30. $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ C _____ H _____ O _____ → C _____ H _____ O _____