# Balancing Chemical Reactions

Chemical reactions are like recipes in that the quantity and types of ingredients, or **reactants**, can be related to the quantity and type of cooked food, or **product(s)** formed. Balancing chemical reactions then allows one to determine stoichiometry calculations by understanding the ratio between reactants and/or products. This worksheet includes some rules and guidelines to help you balance chemical equations.

## Rules

1.) The formulas of the reactants and products **cannot** be changed, do not alter subscripts or charges.
2.) The **only** numbers that can be changed are the numbers indicating how many molecules or atoms, which are called **coefficients**.
3.) A coefficient is assumed to be **one** if there is not a number in front of the molecule or atom.
4.) In order to be balanced, there must be an equal number of each type of atom on both the reactant and product side of the reaction.
5.) It is generally required that the coefficients are **whole numbers**.

## Guidelines

1.) In reactions dealing solely with ions, one can leave the polyatomic ions as groups for ease of balancing.
2.) In reactions dealing with only ions and water, water can be considered as a combination of a **hydrogen ion and hydroxide ion**.
3.) If given a reaction with polyatomic ions that are broken down, one **cannot** leave the polyatomic ions as groups.
4.) "Atom accounting" makes this easier by using a table, and is detailed in the following guideline points and examples.
5.) Start with all coefficients of one and total the number of each type of atom or species.
6.) The more atoms in a given molecule, the **larger** the effect it has on balancing, so begin with these.
7.) End with molecules or atoms that consist of only one type, since the number can be changed **independently** of the other atom types.
8.) If a coefficient comes out to a fraction, multiply all coefficients by the fraction denominator to result in all whole number coefficients.

# Atom Accounting

How many nitrogen atoms are in 1 $N_2O_5$ molecule?

In one molecule, there are two nitrogen atoms, as notated by the subscript $_2$.

How many nitrogen atoms are in 2 N2O5 molecules?

2 molecules · 2 nitrogen = 4 nitrogen atoms

How many phosphate groups and oxygen atoms are in 1 formula unit of $Cu_3(PO_4)_2$?

1 formula unit · 2 phosphate groups · 4 oxygen atoms = 8 oxygen atoms

How many oxygen atoms are in 3 formula units of $Cu_3(PO_4)_2$?

3 formula units · 2 phosphate groups · 4 oxygen atoms = 24 oxygen atoms

How many oxygen atoms are in 1 molecule of $CO_2$ and 1 molecule of H2O?

(1 molecule $CO_2$ · 2 oxygen atoms) + (1 molecule $H_2O$ · 1 oxygen atom) = 3 oxygen atoms

How many oxygen atoms are in 4 molecules of $CO_2$ and 7 molecules of $H_2O$?

(4 molecules $CO_2$ · 2 oxygen atoms) + (7 molecule $H_2O$ · 1 oxygen atom) = 15 oxygen atoms

How many oxygen atoms are in 7 formula units of $Cu_3(PO_4)_2$ and 4 formula units of $Na_2SO_4$?

(7 formula units · 2 phosphate groups · 4 oxygen atoms) + (4 formula units · 4 oxygen atoms) = 72 oxygen atoms

**Example**: Hydrogen gas and oxygen gas yields water

$$\_\_\_H_2 \quad + \quad \_\_\_O_2 \quad \rightarrow \quad \_\_\_H_2O$$

| Reactants | Products |
|---|---|
| H = 2 | H = 2 |
| O = 2 | O = 1 |

The oxygen atoms are unbalanced on the right side, so the coefficient of water has to be increased. Let's try 2 molecules. Do not forget to recalculate the count of each atom type in the molecule(s) you're increasing.

$$\_\_\_H_2 \quad + \quad \_\_\_O_2 \quad \rightarrow \quad \_2\_H_2O$$

| Reactants | Products |
|---|---|
| H = 2 | H = 4 |
| O = 2 | O = 2 |

Now oxygen is balanced but hydrogen is not. However, since it is in a molecule on the reactant side by itself, this is easily remedied.

$$\_2\_H_2 \quad + \quad \_1\_O_2 \quad \rightarrow \quad \_2\_H_2O$$

| Reactants | Products |
|---|---|
| H = 4 | H = 4 |
| O = 2 | O = 2 |

Every atom type is equal on both sides, and the coefficients are as shown.

## Practice Problems

Balance the following chemical equations:

1.) ___$N_2O_5$ → ___$N_2$ + ___$O_2$

2.) ___$C_5H_{12}$ + ___$O_2$ → ___$CO_2$ + ___$H_2O$

3.) ___$C_8H_{18}$ + ___$O_2$ → ___$CO_2$ + ___$H_2O$

4.) ___$HC_2H_3O_2$ + ___$KNO_2$ → ___$KC_2H_3O_2$ + ___$HNO_2$

5.) ___$Fe(NO_3)_3$ + ___$MgO$ → ___$Fe_2O_3$ + ___$Mg(NO_3)_2$

6.) ___$(NH_4)_3N$ + ___$Cr(CrO_4)_2$ → ___$(NH_4)_2CrO_4$ + ___$Cr_3N_4$

7.) ___$Cu_3(PO_4)_2$ + ___$Na_2SO_4$ → ___$Na_3PO_4$ + ___$CuSO_4$

8.) ___$AlCl_3$ + ___$H_2O$ → ___$Al(OH)_3$ + ___$HCl$

9.) ___$Al(HCO_3)_3$ + ___$AlPO_4$ → ___$Al_2(CO_3)_3$ + ___$H_3PO_4$

10.) ___$HOCl$ + ___$C$ → ___$H_2O$ + ___$CO_2$ + ___$Cl_2$

## Balancing Chemical Equations Answers

1.) 2, 2, 5
2.) 1, 8, 5, 6
3.) 2, 25, 16, 18
4.) 1, 1, 1, 1
5.) 2, 3, 1, 3
6.) 4, 3, 6, 1
7.) 1, 3, 2, 3
8.) 1, 3, 1, 3
9.) 1, 1, 1, 1

10) 4,1,2,1,2