

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 N₂O₅ molecule?

In one molecule, there are two nitrogen atoms, as notated by the subscript 2.

How many nitrogen atoms are in 2 N₂O₅ molecules?

$$2 \text{ molecules} \cdot 2 \text{ nitrogen} = 4 \text{ nitrogen atoms}$$

How many phosphate groups and oxygen atoms are in 1 formula unit of Cu₃(PO₄)₂?

$$1 \text{ formula unit} \cdot 2 \text{ phosphate groups} \cdot 4 \text{ oxygen atoms} = 8 \text{ oxygen atoms}$$

How many oxygen atoms are in 3 formula units of Cu₃(PO₄)₂?

$$3 \text{ formula units} \cdot 2 \text{ phosphate groups} \cdot 4 \text{ oxygen atoms} = 24 \text{ oxygen atoms}$$

How many oxygen atoms are in 1 molecule of CO₂ and 1 molecule of H₂O?

$$(1 \text{ molecule CO}_2 \cdot 2 \text{ oxygen atoms}) + (1 \text{ molecule H}_2\text{O} \cdot 1 \text{ oxygen atom}) = 3 \text{ oxygen atoms}$$

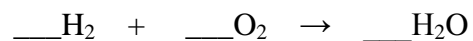
How many oxygen atoms are in 4 molecules of CO₂ and 7 molecules of H₂O?

$$(4 \text{ molecules CO}_2 \cdot 2 \text{ oxygen atoms}) + (7 \text{ molecule H}_2\text{O} \cdot 1 \text{ oxygen atom}) = 15 \text{ oxygen atoms}$$

How many oxygen atoms are in 7 formula units of Cu₃(PO₄)₂ and 4 formula units of Na₂SO₄?

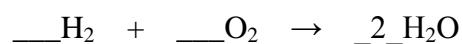
$$(7 \text{ formula units} \cdot 2 \text{ phosphate groups} \cdot 4 \text{ oxygen atoms}) + (4 \text{ formula units} \cdot 4 \text{ oxygen atoms}) = 72 \text{ oxygen atoms}$$

Example: Hydrogen gas and oxygen gas yields water



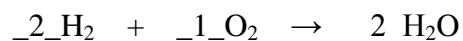
Reactants	Products
H = 2	H = 2
O = 2	O = 1

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.



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.

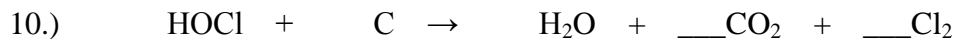
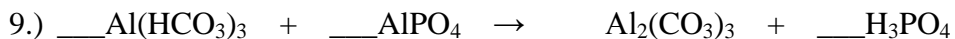
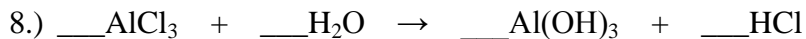
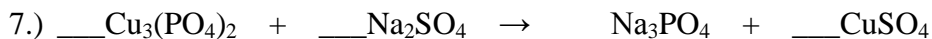
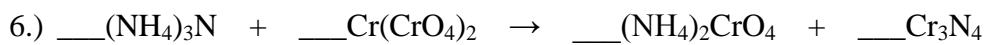
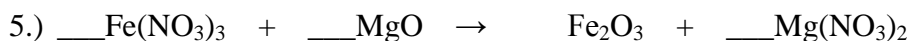
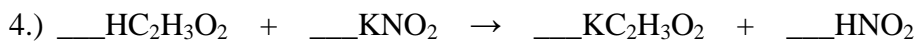
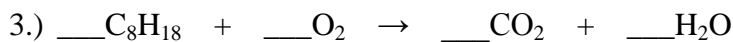
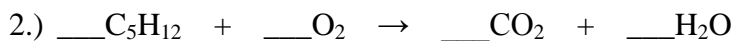


Reactants	Products
H = 4	H = 4
O = 2	O = 2

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

Practice Problems

Balance the following chemical equations:



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