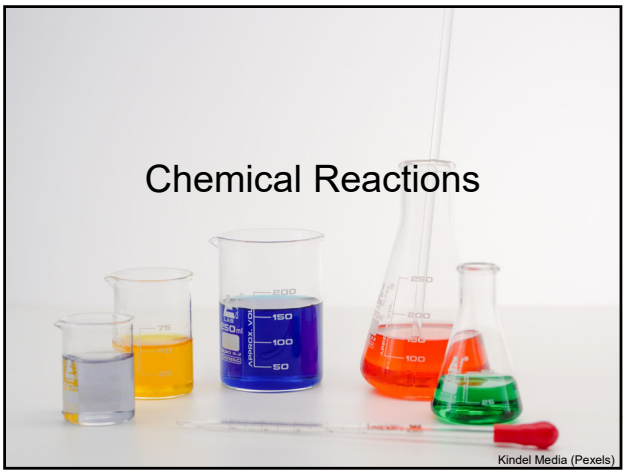
Chemical Reactions



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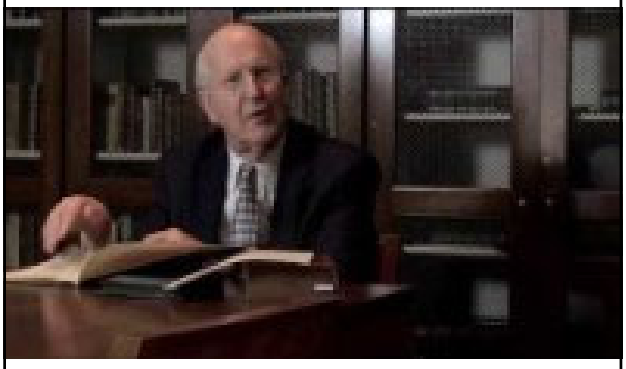
- Antoine-Laurent Lavoisier (French) 1789
  - During a chemical reaction, the total mass of the reacting substances, the **reactants**, is always equal to the total mass of the resulting substances, the **products**.
  - This is known as the “Law of Conservation of Mass.”

Modification of Antoine Laurent Lavoisier (1743–1794) and Marie Anne Lavoisier (Marie Anne Pierrette Paulze, 1758–1836) – Jacques Louis David (Public Domain)

https://youtu.be/nWdK1L7GXys

- John Dalton (British) 1804
  - Compounds are formed when atoms of different elements combine in **fixed proportions**.
    - For example, when Na combines with O it is always 2 Na for 1 O.

Dalton – Charles Turner, Library of Congress Print and Photograph Division, digital ID: cph.3b12511, Public Domain



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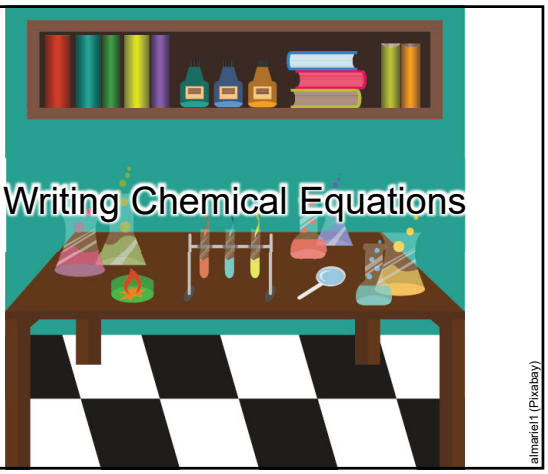
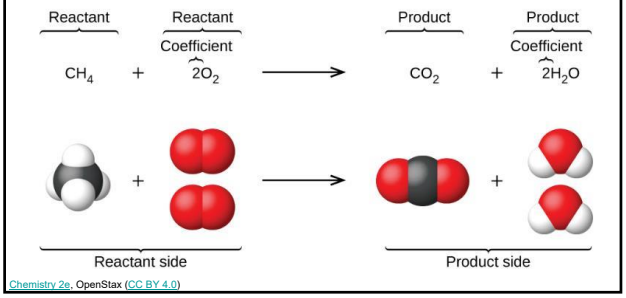


- A chemical equation is used to represent a chemical reaction.
  - The chemical equation indicates what compounds are involved in the reaction.
  - It also shows how many of each compound is involved in the reaction.

$$CaCl_2 + 2AgNO_3 \longrightarrow Ca(NO_3)_2 + 2AgCl$$

- A chemical equation has the following fundamental aspects:
  1. The substances undergoing reaction are called **reactants**, and their formulas are placed on the left side of the equation.
  2. The substances generated by the reaction are called **products**, and their formulas are placed on the right side of the equation.
  3. Plus signs (+) separate individual reactant and product formulas, and an arrow (⟶) separates the reactant and product (left and right) sides of the equation.

4. The relative numbers of reactant and product species are represented by coefficients (numbers placed immediately to the left of each formula). A coefficient of 1 is typically omitted.



Chemistry 2e, OpenStax (CC BY 4.0)

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- The chemical equation

  $$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

  is balanced, meaning that equal numbers of atoms for each element involved in the reaction are represented on the reactant and product sides.
- This is a requirement the equation must satisfy to be consistent with the law of conservation of matter.

Method 1

1. Write down how many atoms of each element there are on each side of the reaction arrow.
2. Add coefficients so the number of atoms of each element is the same on both sides of the equation. It's easiest to balance the hydrogen and oxygen atoms last.
3. Check your work.

$$4\,Fe + 3\,O_2 \rightarrow 2\,Fe_2O_3$$

4 2 Fe 1 2 4 | 2 Fe 2 4 ✗

3 O 2 6 | O 3 6 ✗

Method 2

1. Assign a letter to each compound.
2. Check the number of each element found on both sides and set those equal to each other.
3. Set the first variable to 1.
4. Solve for the remaining variables.

$a\,PCl_5 + b\,H_2O \rightarrow c\,H_3PO_4 + d\,HCl$

P: $1a = 1c$

Cl: $5a = 1d$

H: $2b = 3c + 1d$

O: $1b = 4c$

$a\,PCl_5 + 4\,H_2O \rightarrow c\,H_3PO_4 + 5\,HCl$

$a = 1$

P: $1a = 1c$

Cl: $5a = 1d$

H: $2b = 3c + 1d$

O: $1b = 4c$

$1a = 1c$

$1(1) = 1c$

$c = 1$

$5a = 1d$

$5(1) = 1d$

$d = 5$

$2b = 3c + 1d$

$2b = 3(1) + 1(5)$

$2b = 8$

$b = 4$

Additional Information

- The physical states of reactants and products in chemical equations very often are indicated with an abbreviation following the formulas.
  - (s) – solid
  - (l) – liquid
  - (g) – gas
  - (aq) – aqueous solution

$2Na(s) + 2H_2O(l) \longrightarrow 2NaOH(aq) + H_2(g)$

- This equation represents the reaction that takes place when sodium metal is placed in water.
- The solid sodium reacts with liquid water to produce hydrogen gas and the ionic compound sodium hydroxide (a solid in pure form, but readily dissolved in water).