Chapter 10- Chemical Reactions and Equations

10.1- Chemical Formulas

How are the formulas for ionic compounds written?

- The symbols for elements are used to indicate which atoms are included in the compound.
- The number of cations and anions in the compound is indicated by subscripts that follow the symbols for the elements.
- The number of ions in the compound is determined by balancing the charges on the ions.
- If no **subscript** appears after a symbol, it is assumed that only one **ion** of the element is present.
- If possible, the ratio of the subscripts should be reduced to their **empirical formula** for ionic compounds.
- Polyatomic ions consist of groups of two or more atoms that are covalently bonded to one another.

How are empirical and molecular formulas distinguished?

- A **molecular formula** describes the elements and the actual number of atoms of each present in each **molecule** of the compound.
- An empirical formula describes the simplest whole number ratio of the atoms of the elements in a compound.

How are the formulas for molecular compounds written?

- Chemical symbols for the elements are used to describe the components of a molecular compound.
- Frequently, prefixes such as mon-, di-, tri-, and tetra- are used in the names of molecular compounds to indicate the number of atoms of each element in the compound.
- Subscripts are used in the **chemical formula** of a molecular compound to indicate the number of atoms of each element present in the compound.

10.2 Chemical Reactions and Equations

What are five types of chemical reactions?

The five recognized types of chemical reactions are based on how substances change:

- Synthesis reactions form a single **product** from two or more reactants.
- Decomposition reactions form two or more products from a single **reactant**.
- Combustion reactions occur when a substance combines with oxygen to form an oxide, and releases thermal energy.
- Single-displacement reactions occur when an active element replaces a less active element in a compound.
- Double-displacement reactions occur when the ions in two compounds trade places. **Solubility** rules help to determine which product is insoluble and forms a precipitate.

How can you predict the products of each of the five types of chemical reactions?

The products of a reaction are predicted based on how substances change in that type of reaction:

- In a **synthesis reaction**, a metal and a nonmetal react to form a binary ionic compound.
- In a **decomposition reaction**, a binary compound will usually break down into its individual elements. Metal carbonates break down to form a metal oxide and carbon dioxide. Metal hydroxides break down to form a metal oxide and water.
- In a **combustion reaction**, hydrocarbons that burn completely form carbon dioxide and water. The combustion of an element is also a synthesis reaction. Its product is an oxide of that element.
- The **reactivity series** must be checked to predict if a single-displacement reaction will occur. If it does, then the more active element replaces a less active element in a compound. The products are the less active element and a new compound.
- In a double-displacement reaction, switch either the cations or anions of the two compounds. Check the solubility rules to determine which product is insoluble and forms a precipitate.

How can you represent chemical reactions using chemical equations?

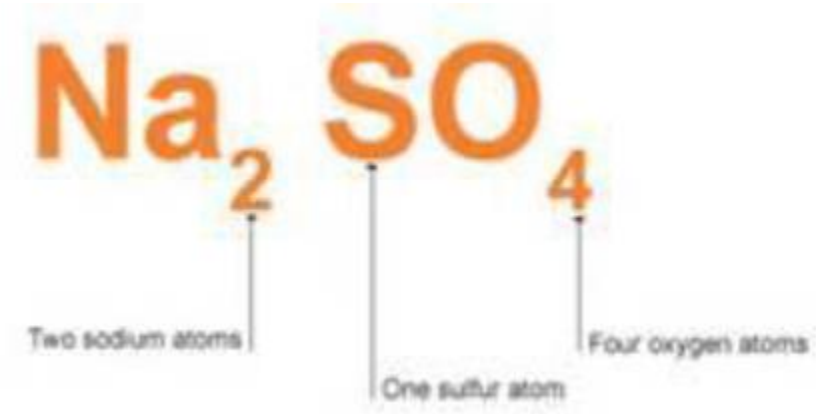
Chemical equations represent chemical reactions in several ways:

- A balanced equation shows that a chemical reaction demonstrates the **law of conservation of matter**.
- The phase state of each substance in a reaction can be shown after the chemical symbol or formula of each substance.
- Net ionic equations show only those substances that actually change during the reaction.

BALANCING SIMPLE EQUATIONS

A chemical equation is a written symbolic representation of a chemical reaction. The reactant chemical(s) are given on the left-hand side and the product chemical(s) on the right-hand side. The law of conservation of mass states that no atoms can be created or destroyed in a chemical reaction, so the number of atoms that are present in the reactants has to balance the number of atoms that are present in the products.

Chemical symbols are used in writing chemical formulas, in which the symbols represent the atoms of the elements present in a compound.



What information can be learned from the chemical formula?

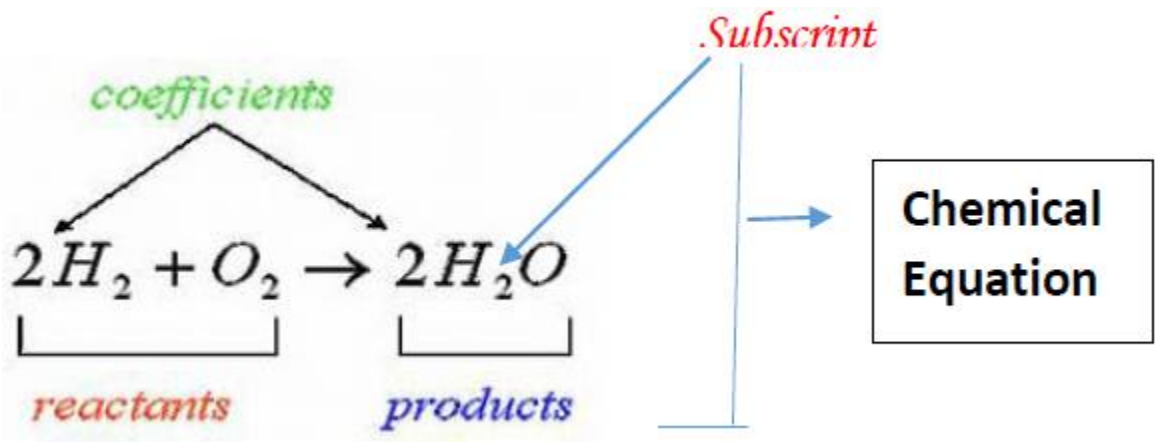
- The elements that are present in the compound
- The ratio of the elements in the compound

Compounds are pure substances that are made up of *two or more elements that are chemically combined* in fixed mass ratios. The elements in the compound are joined together by chemical bonds.

The properties of a compound are unique and differ from the elements that make up the compound.

The arrow usually points toward the right or toward the product side of the equation.

The elements in an equation are represented by their chemical symbols. Coefficients next to the symbols indicate the *number of molecules*. Subscripts are used to indicate the *number of atoms of an element* present in a chemical.



A chemical equation is a *written representation of* the process that occurs in a *chemical reaction*. A chemical equation is written with the *reactants on the left side* of an arrow (yield symbol) and the *products* of the chemical reaction *on the right side* of the equation.

Is it balanced?

$C_3H_8 + 5\,O_2 \rightarrow 4\,H_2O + 3\,CO_2$

	LEFT SIDE	RIGHT SIDE
C	3	3 ✓
H	8	8 ✓
➡ O	10	10 ✓

10.4 Reaction Rate

What factors influence reaction rate and what is their impact?

Reaction rate is affected by qualities of the system and the environment.

- The combination of chemical compounds present in a reaction affects reaction rate.
- Increased **surface area** and temperature increase reaction rate.
- Increased pressure increases reaction rate for gases.
- A **catalyst** increases reaction rate and an **inhibitor** decreases it.

What are rate laws?

A rate law is a mathematical equation that describes the rate of a reaction.

- For the reaction aA +bB → C, the rate law is $r = k[A]^x[B]^y$.
- The values of x and y are the orders of the reactions with respect to the reactants A and B.
- The overall order of the reaction is found by adding the orders with respect to each **reactant**.