# Chemical reactions

**Chemical reactions** are events in which substances of a different composition (products) are formed from starting substances (reactants); chemical reactions are described by a **chemical equation**.

- **reactants** = starting substances entering a chemical reaction
- **products** = newly formed substances arising from a chemical reaction

## Basic chemical laws

1. **Law of conservation of mass** – the mass of all reactants equals the mass of all products
2. **Law of conservation of energy** – the energy of an isolated system is constant during a chemical reaction
3. **The law of constant combining ratios** – the ratio of elements or parts of a given compound is always the same, it does not depend on the method of preparation of compounds

## Types of reactions

1. **Direct** – creation of products
2. **Reverse** – reaction of products to form starting substances
3. **Reversible** – direct and reverse reactions take place mutually

## Types of reactions according to external changes during the reaction

### Synthesis

- combination reaction
- a reaction in which simpler starting substances combine to form more complex substances, e.g. $N_2 + 3\ H_2 \rightarrow 2\ NH_3$

### Analysis

- decomposition reaction
- a reaction in which more complex substances are split into simpler substances, e.g. $CaCO_3 \rightarrow CaO + CO_2$

### Single-Replacement Reactions

- substitution reaction
- a reaction in which one reactant replaces an atom or functional group from another reactant (compound), e.g. $2\ KI + Cl_2 \rightarrow 2\ KCl + I_2$ (chlorine replaced iodine from potassium iodide)

### Double-Replacement Reactions

- conversion
- is formed by the combination of two displacement (substitution) reactions, e.g. $NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$

## Types of reactions according to the reaction mechanism

### Addition

- A reaction in which molecules of another substance (e.g. water, hydrogen halides) are added to an organic compound bearing a multiple bond and the multiple bond disappears, e.g. $CH_2{=}CH_2 + Cl_2 \rightarrow CH_2\ Cl\text{-}CH_2\ Cl$
  - **Electrophilic addition** – an electrophilic reagent (a reagent with an electrophilic deficit) reacts with the π-electrons of multiple bonds, e.g. addition of hydrogen halides and halogens to alkenes or alkynes
  - **Nucleophilic addition** – a nucleophilic reagent (contains a non-bonding electron pair) is added to the carbon in the bond carrying a partial positive charge, the reaction is typical for carbonyl compounds

### Elimination

- A reaction in which a simple inorganic compound is split off and a multiple bond is simultaneously formed, e.g. $CH_3\text{-}CH_2Cl \rightarrow CH_2{=}CH_2 + HCl$
  - **Dehydration** – water molecules are split off
  - **Dehydrogenation** – hydrogen molecules are split off
  - **Dehydrohalogenation** – hydrogen halide molecules are split off

### Substitution

- A reaction in which an atom or group of atoms is exchanged for another atom or group of atoms, the multiplicity of the bonds does not change
  - **Radical substitution** – characteristic of compounds with non-polar covalent bonds (e.g. alkanes), homolytic cleavage of bonds occurs and radicals are formed (very reactive particles with unpaired electron) reacting with the radical of the substituted atom, e.g. chlorination of hydrocarbons
  - **Electrophilic substitution** – a typical reaction of aromatic hydrocarbons in which they react with an electrophilic agent that is formed during the reaction, e.g. nitration of arenes (the nitro group $NO_2$ in the form of a nitronium cation is introduced into the arene molecule)
  - **Nucleophilic substitution** – a nucleophilic reagent reacts with a carbon atom and a partially positive charge, the reaction is typical for alkyl halides

### Permutation

- Isomerization reaction in which the atoms inside the molecule are rearranged

## Types of reactions according to the number of phases

### Homogeneous

- Reactions in which the reactants are in one phase, most often gaseous or liquid, e.g. $H_2$ (g) + $I_2$ (g) → 2 HI (g)

### Heterogeneous

- Reactions in which the reactants are in different phases and the reaction takes place at their phase interface, e.g. 2 HCl (aq) + Zn (s) → $ZnCl_2$ (aq) + $H_2$ (g)

## Types of reactions according to the type of transferred particles

### Oxidation-reduction

- redox
- reactions in which electrons are transferred between reaction components, taking place as two partial reactions - oxidation and reduction; certain atoms give up electrons, thereby becoming oxidized, and at the same time other atoms receive electrons, thereby reducing

### Acid-base

- protolytic
- reactions in which the cation $H^+$ is transferred ; substances that donate $H^+$ cations are called acids, substances that accept $H^+$ cations are called bases (according to the Brönsted-Lowry theory of acids and bases)

### Coordination

- complex forming
- reactions during which whole groups of atoms are transferred and complex compounds are formed

## Types of reactions according to the method of bond cleavage

### Homolytic

- reactions in which the covalent bond formed by atoms with the same (or almost the same) electronegativity splits symmetrically so that each of the resulting particles retains one electron and forms radicals, e.g. Cl – Cl → Cl • + Cl •

### Heterolytic

- the opposite of homolysis
- the bond splits asymmetrically, the bound particles have a large electronegativity difference, the more electronegative particle retains the entire electron pair from the bond and ions are formed, e.g. HCl → $H^+$ + $Cl^-$

## Links

### Related articles

- Chemical equilibrium

### Literature

- SLEZINA, Miroslav. *Biochemie pro studující medicíny.* 2. edition. Karolinum, 2009. 0 pp. ISBN 978-80-246-1414-4.

- BENEŠOVÁ, Marika – SATRAPOVÁ, Hana. *Odmaturuj! z chemie.* 1. edition. Didaktis, 0000. 0 pp. ISBN 80-862-8556-1.