

Step 4 Exploring matter

Here is a review of the main concepts of this step!

1 Chemical compounds and reactions: key concepts in chemistry

Two concepts are fundamental in chemistry: chemical compounds and chemical reactions. Scientists have leveraged these concepts to innovate products that serve humanity.

Chemical compounds

Chemical compounds, prevalent in our daily lives, result from the combination of two or more elements in specific ratios through chemical reactions. Unlike mixtures, compounds possess distinct properties. Breaking down compounds requires energy, whereas mixtures can be separated physically. For instance, sodium chloride (NaCl) forms from sodium (Na), a reactive metal, and chlorine (Cl), a toxic gas, to create common table salt.

Chemical reactions

Chemical reactions entail the transformation of initial substances into new products with altered properties. These reactions are not confined to labs but occur in everyday scenarios. Examples encompass burning, decay, fermentation, steel corrosion, and food digestion.

2 Chemical formulae

Chemical formulae are essential tools in chemistry for describing substances. With only 89 elements in nature but millions of compounds, chemical formulae provide a concise way to identify and understand these compounds. They represent the elements present and their quantities.

Understanding valence, the bonding capacity of elements, is crucial for naming compounds and writing formulae. Valence ranges from 1 to 4 for most elements, and atoms are classified based on their bonding capacity as monovalent, divalent, trivalent, or tetravalent.

For example, carbon forms compounds with oxygen, yielding either carbon monoxide (CO) or carbon dioxide (CO₂) depending on their bonding capacities.

3 Chemical reactions

During a chemical reaction, substances transform into others, with the initial substances termed reactants and the resulting substances termed products. Both reactants and products can be elements or compounds. The change in a chemical reaction involves the motion of electrons and the formation or breaking of chemical bonds. If the nucleus is involved, it's termed a nuclear reaction, where an element can change into another. These reactions are represented using chemical equations, which show the reactants and products linked by a unidirectional arrow, indicating the direction of the reaction. The general format is "Reactant → Product". However, some reactions are reversible, represented by double arrows to denote reversibility.

The law of conservation of mass, established by Antoine Lavoisier, says that in a chemical reaction, matter is neither created nor destroyed. Therefore, the mass of the reactants must equal the mass of the products in a balanced chemical equation.

4 Mind the product!

In a chemical reaction, atoms can combine to form compounds with different characteristics. Carbon, for instance, produces two oxides: carbon monoxide (CO) and carbon dioxide (CO₂). These compounds have distinct effects on humans and the environment.

Carbon dioxide, formed when carbon combustion is complete, is essential in nature. It serves as the raw material for photosynthesis, crucial for plant growth and human/animal respiration. CO₂ finds applications in various industries, from food to chemicals, and is utilized in products like life jackets, airgun capsules, and fire extinguishers.

In contrast, carbon monoxide, a byproduct of incomplete carbon combustion due to limited air supply, is highly toxic. It binds strongly to haemoglobin, causing suffocation. Since it's nearly odourless, its presence often goes undetected.

Common sources of CO include cars, gas appliances, and wood stoves. Smokers also inhale CO from cigarettes, leading to elevated blood levels even after smoking cessation.

5 Acids, bases and salts

In everyday life, we encounter acids, bases, and salts, present in common household items like soft drinks, vinegar, baking soda, and table salt.

Acids, such as sulphuric acid and carbonic acid, dissolve in water to produce hydrogen ions and act as proton donors. Bases, like sodium hydroxide and calcium hydroxide, accept protons and yield hydroxide ions in water.

These compounds exhibit various properties: acids taste sour, feel painful on the skin, react with certain metals, and turn litmus paper red; bases taste bitter, feel slippery, react with oils, and turn litmus paper blue.

Salts are formed from neutralization reactions between acids and bases. For example, table salt (sodium chloride) results from the neutralization of hydrogen chloride with sodium hydroxide.

6 The pH scale

The pH scale measures the acidity or alkalinity of a solution on a scale from 0 to 14. The term "pH" stands for "power of hydrogen," with 'p' representing 'power' and 'H' for hydrogen.

A solution with a pH of 7 is considered neutral, like pure water. Solutions with a pH below 7 are acidic, while those above 7 are basic or alkaline. Universal indicator paper changes colour based on pH, offering a visual representation of acidity levels.

pH finds application not only in science and industry but also in daily life, such as in cooking to balance acidity, designing cocktails, cleaning products, and food preservation. It plays vital roles in pool maintenance, water purification, agriculture, medicine, and various scientific fields.