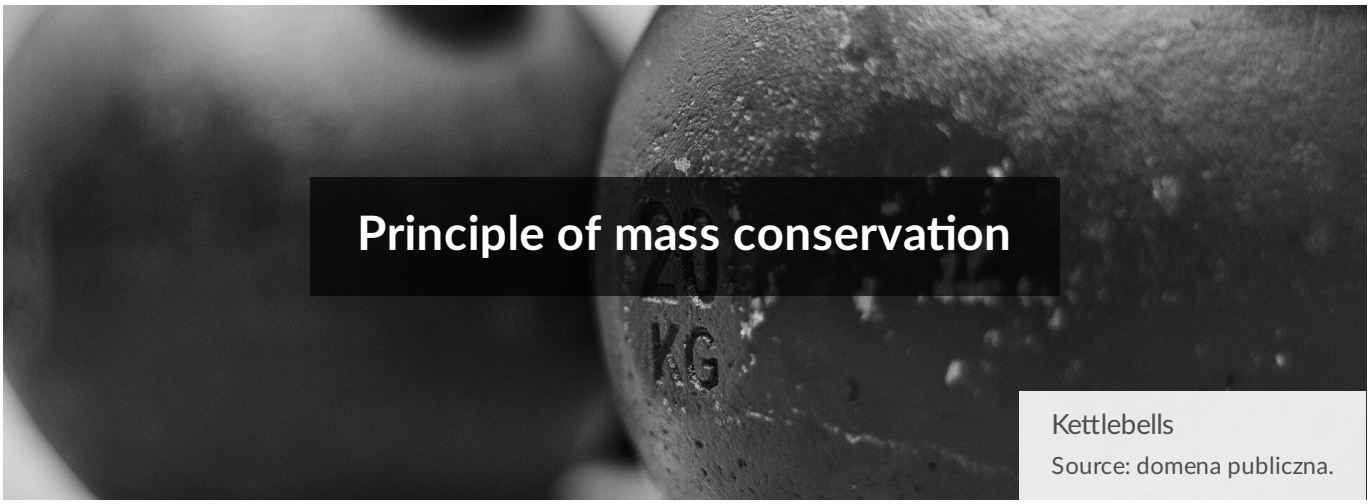
Principle of mass conservation

- Principle of mass conservation
- Lesson plan (Polish)
- Lesson plan (English)



Kettlebells
Source: domena publiczna.

Link to the lesson

Before you start you should know

- that chemical reactions involve changes resulting in new substances;
- that chemical equation reflects chemical changes using symbols of elements and formulas of chemical compounds;
- that substrates are substances involved in a chemical reaction and that products are substances obtained as a result of chemical reaction;
- how to determine mass ratio in a chemical compound based on its formula.

You will learn

- to state the principle of mass conservation and interpret it;
- to solve tasks using the principle of mass conservation.

Nagranie dostępne na portalu epodreczniki.pl

Nagranie dźwiękowe abstraktu. Czy masa i energia substratów zmienia się podczas reakcji chemicznej?

Does the mass and energy of substrates change during a chemical reaction?

While observing the course of chemical reactions, we can describe effects that occur during it, for example changes in colour, sounds, light emission. Sometimes one can also get impression that the quantity of substances involved in the reaction is decreasing or increasing.

Masses of substrates and products were compared already in the 18th century. Due to these studies, conducted independently by two chemists, Mikhail Lomonosov from Russia (1756)

and Antoine Lavoisier from France (1785), a general law of nature was formulated. It was called principle of mass conservation. In line with this law, total mass of substrates is equal to total mass of products in an isolated system (in which reaction products and energy does not leave this system). This means that the same mass of substrates produces the same mass of products; that is mass of substances involved in chemical reaction does not change.
The need to balance chemical equations results in fact from the principle of mass conservation. If the total mass of substrates is to be equal to the total mass of products, numbers of atoms of the same type on both sides of the equation have to be identical.

Nowadays the law of mass conservation is extended by the energy of ingredients. Reagents are characterized by their own internal energy called the resting mass. However, due to the fact that the resting mass of the system or chemical reaction contributes not only to the rest masses of the components, but also all forms of internal energy related to the movement of elemental atoms in space and their mutual interactions, the rest mass of the system is equal to the sum of masses its components and their energy.

During chemical reactions, the structure of the resting mass of the system may change, eg by reducing the sum of the rest masses of its components, and increasing the sum of their energy.

For closed systems but not insulated, the right to maintain the rest mass is not satisfied, because there is a flow of energy between the system and the environment, which results in a change in the rest mass of the system.

However, during chemical reactions, the amounts of energy exchanged are so small that the mass change of the system is not detectable by standard methods, hence the stability of the mass of the reaction system is assumed. In chemical reaction, the sum of the masses of products and substrates are the same.

Task 1

Before you watch the video “How to control mass of substances involved in the reaction of baking soda with vinegar”, write down a research question and a hypothesis.

Analysis of the experiment „How to control mass of substances involved in the reaction of baking soda with vinegar”

Research question

Hypothesis

Film dostępny na portalu epodreczniki.pl

Nagranie filmowe przedstawiające eksperyment- kontrola masy substancji podczas reakcji sody oczyszczonej z octem. Do przeprowadzenia eksperymentu potrzebne są: waga laboratoryjna, proszek do pieczenia, ocet winny, mała kolba pomiarowa, balon, łyżeczka. Przebieg

doświadczenia: dodaj 2–3 łyżeczki sody oczyszczonej do balonu, następnie do kolby miarowej wlej 20–30 cm3 octu, później umieść balon na szyjce kolby, upewnij się, że soda nie dostanie się do kolby, następnie umieść zestaw na wadze laboratoryjnej, gdy masa kolby zostanie ustawiona na wadze, podnieś balon i dodaj sodę do octu. Ponownie sprawdź wskazanie wagi.

Experiment 1

Research problem

Is mass of products greater, smaller than or the same as the mass of its substrates?

Hypothesis

Mass of products is equal to mass of the substrates used.

You will need

- laboratory scale,
- baking soda,
- vinegar,
- small measuring flask,
- balloon,
- teaspoon.

Instruction

1. Add 2–3 teaspoons of baking soda to the balloon.
2. Pour 20–30 cm^3 of vinegar to the measuring flask.
3. Place the balloon on the flask neck. Make sure that the soda does not get inside the flask.

4. Put the set on the laboratory scale.

5. When weight of the flask is set on the balance, lift the balloon and add soda to vinegar.

6. Observe indications of the laboratory scale.

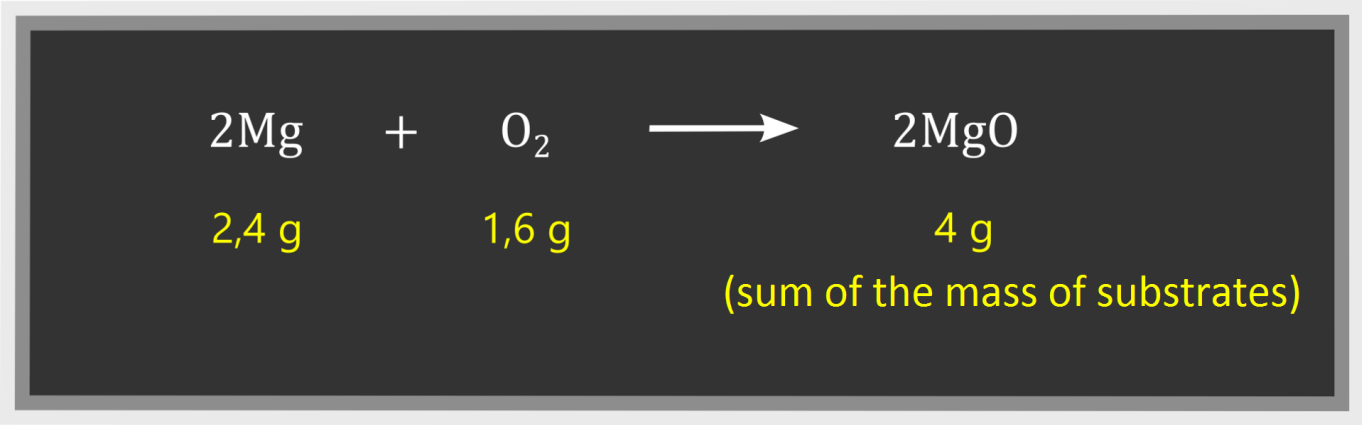
Summary

Observations

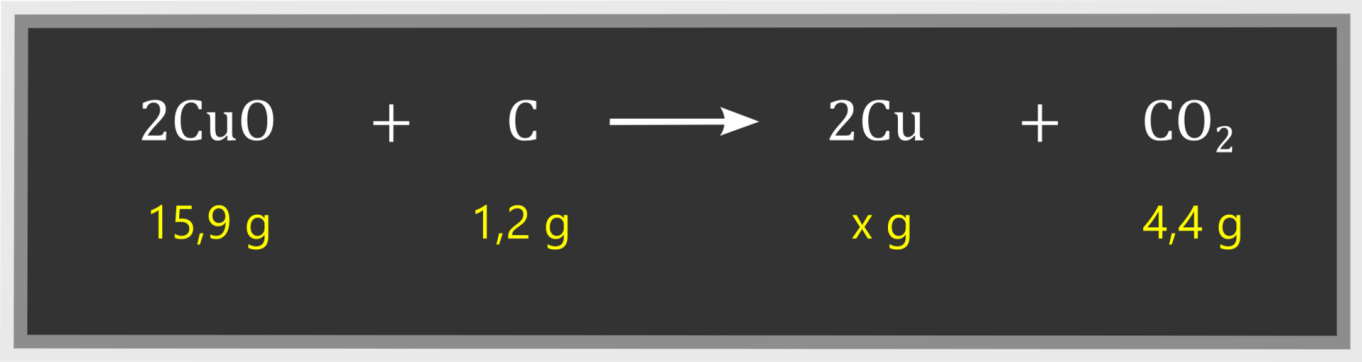
Conclusions

How can the principle of mass conservation be used in chemical calculations?

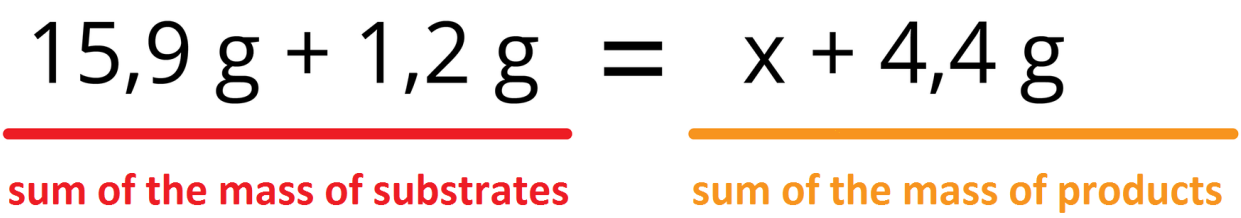
The principle of mass conservation helps determine mass of one substance if we know masses of other substrates and products. If you know this principle, you can calculate for example the quantity of products resulting from a given mass of substrates. For example, if we know that 2.4 g of magnesium and 1.6 of oxygen were involved in the reaction, we can easily determine that $2.4\ \text{g} + 1.6\ \text{g} = 4\ \text{g}$ of magnesium oxide was produced in this chemical reaction:



In case of another reaction – exchange reaction of copper(II) oxide with carbon – we can determine mass of copper if we know masses of substrates and mass of the second product:



In line with the principle of mass conservation, total mass of substrates is to be equal to total mass of products:



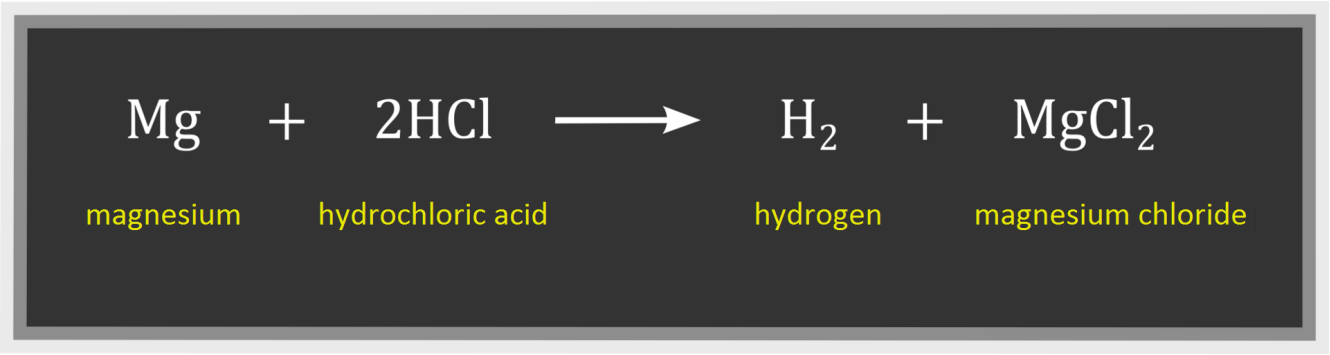
After rearranging the equation and making calculations we will know the mass of copper:

$x = 15.9\ g + 1.2\ g - 4.4\ g = 12.7\ g$

Using the principle of mass conservation, we can conclude that 12.7 g of copper will be produced in a reaction of 15.9 g of copper(II) oxide and 1.2 g of carbon.

Task 2

An experiment was conducted. Hydrogen chloride was added to water and then magnesium chips were added to the mixture. It was observed that a gas was released. It was hydrogen. During the experiment 2.4 g of magnesium and 7.3 of hydrochloric acid reacted with each other. Hydrogen and magnesium chloride were products of this reaction. Mass of magnesium chloride was determined. It amounted to 9.5 g. The reaction is described with the following equation:



Calculate mass of hydrogen produced in this reaction and determine the number of molecules of this gas.

Exercise 1

Mark true statements.

- 252 g of calcium oxide will be produced as a result of thermal decomposition of 450 g of calcium carbonate, during which 198 g of carbon dioxide was obtained.
- According to the principle of mass conservation, total mass of all substrates in a reaction is not equal to total mass of all resulting products.
- According to the principle of mass conservation, an isolated system in which a reaction is carried out is a system that does not exchange mass with environment, but only energy.
- 8.96 dm^3 of oxygen with density of 1.43 g/dm^3 and 0.8 g of hydrogen were obtained as a result of decomposition of 14.4 g of water.

Summary

- According to the principle of mass conservation it is assumed that in each reaction total mass of substrates is equal to total mass of resulting products.
- Mass of each substrate or products can be calculated based on the principle of mass conservation, if you know masses of the other ones.

- According to the law of definite proportion, mass ratio of elements in a chemical compound is always constant and does not depend on its source and method of preparation (each chemical compound always contains its component elements in fixed qualitative and quantitative ratio).
- If you know mass ratio of chemical elements in a compound, you can calculate mass of chemical elements in given amount of this compound.
- Molecular formula of given compound may be determined based on mass ratio of its component elements.

Keywords

Principle of mass conservation, reaction, substance

Glossary

law of definite proportion

Nagranie dostępne na portalu epodreczniki.pl

Nagranie dźwiękowe słówka: prawo określonej proporcji.

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prawo odnoszące się do stosunków masowych w związkach chemicznych, zgodnie z którym stosunek masowy pierwiastków w związku chemicznym jest zawsze stały i niezależny od sposobu oraz miejsca jego otrzymania. Prawo to nie jest spełnione w przypadku bertolidów (związków niestechiometrycznych). Przyczyną zmiennej zawartości różnych pierwiastków w związku mogą być defekty sieci krystalicznej lub występowanie nadmiaru atomów jednego ze składników, nietworzących wiązań chemicznych.

principle of mass conservation

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Nagranie dźwiękowe słówka: prawo zachowania masy.

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prawo zachowania masy – reguła, która mówi, że w układzie zamkniętym w przypadku każdej reakcji chemicznej całkowita masa substratów jest równa łącznej masie produktów.

Lesson plan (Polish)

Temat: Prawo zachowania masy

Adresat

Uczeń szkoły podstawowej (klasy 7. i 8.)

Podstawa programowa:

Szkoła podstawowa. Chemia.

III. Reakcje chemiczne. Uczeń:

7) stosuje do obliczeń prawo stałości składu i prawo zachowania masy (wykonuje obliczenia związane ze stechiometrią wzoru chemicznego i równania reakcji chemicznej).

Ogólny cel kształcenia

Uczeń interpretuje prawo zachowania masy oraz rozwiązuje zadania, wykorzystując prawo zachowania masy.

Kompetencje kluczowe

- porozumiewanie się w języku ojczystym;
- porozumiewanie się w językach obcych;
- kompetencje matematyczne i podstawowe kompetencje naukowo-techniczne;
- kompetencje informatyczne;
- umiejętność uczenia się.

Kryteria sukcesu
Uczeń nauczy się:

- znajomości treści prawa zachowania masy i dokonasz jego interpretacji;
- rozwiązywać zadania, wykorzystując prawo zachowania masy.

Metody/techniki kształcenia

- **podające**
    - pogadanka.
- **eksponujące**
    - film.
- **programowane**
    - z użyciem komputera;
    - z użyciem e-podręcznika.

- **praktyczne**
    - ćwiczeń przedmiotowych.

Formy pracy

- praca indywidualna;
- praca w parach;
- praca całego zespołu klasowego.

Środki dydaktyczne

- e-podręcznik;
- zeszyt i kredki lub pisaki;
- tablica interaktywna, tablety/komputery;
- metodnik lub kartki zielone, żółte i czerwone.

Przebieg lekcji

Faza wstępna

1. Nauczyciel rozdaje uczniom metodniki lub kartki w trzech kolorach: zielonym, żółtym i czerwonym do zastosowania w pracy techniką świateł drogowych. Przedstawia cele lekcji sformułowane w języku ucznia na prezentacji multimedialnej oraz omawia kryteria sukcesu (może przesłać uczniom cele lekcji i kryteria sukcesu pocztą elektroniczną lub zamieścić je np. na Facebooku, dzięki czemu uczniowie będą mogli prowadzić ich portfolio).
2. Prowadzący wspólnie z uczniami ustala – na podstawie wcześniej zaprezentowanych celów lekcji – co będzie jej tematem, po czym zapisuje go na tablicy interaktywnej/tablicy kredowej. Uczniowie przepisują temat do zeszytu.

Faza realizacyjna

1. Prowadzący lekcję zapowiada film pt. „Kontrola masy substancji biorących udział w reakcji sody oczyszczonej z octem". Poleca podopiecznym, żeby w formularzu zamieszczonym w abstrakcie zapisali pytanie badawcze i hipotezę. Następnie wyświetla film, a uczniowie odnotowują swoje obserwacje i wnioski. Nauczyciel, nawiązując do obserwacji i wniosków, zachęca młodzież do dyskusji.
2. Uczniowie czytają fragment pt. „Czy masa substratów zmienia się podczas reakcji chemicznej?". Wyjaśniają, na czym polega prawo zachowania masy i kto je sformułował, nauczyciel uzupełnia informacje wyjaśniając przypadki, w których prawo to nie jest spełnione. Następnie nauczyciel tłumaczy, że w fizyce współczesnej, zgodnie ze szczególną teorią względności obowiązuje prawo zachowania całkowitej masy spoczynkowej układu izolowanego, uwzględniająca energię..
3. Nauczyciel tłumaczy, jak można wykorzystać prawo zachowania masy w obliczeniach chemicznych. Prezentuje i omawia przykłady z abstraktu (reakcja syntezy magnezu

i tlenu w tlenek magnezu; reakcja wymiany tlenku miedzi i węgla w miedź i dwutlenek węgla).

4. Uczniowie, pracując w parach, rozwiazują zadania: a) Ogrzewając 30 g miedzi z tlenem, otrzymano 38 g tlenku miedzi(II). Oblicz, ile zużyto tlenu w tej reakcji; b) Żelazo otrzymuje się z rud żelaza. Do reakcji zużyto 14 g tlenku żelaza(III) z 6, 4 g tlenku węgla(II) i otrzymano 9,2 g żelaza. Oblicz objętość wydzielonego tlenku węgla(IV), jeśli jego gęstość jest równa 1,96 g/dm^3; c) Podczas spalania magnezu zużyto 6,4 g tlenu, otrzymując 16 g tlenku magnezu. Oblicz masę magnezu, jaką użyto w reakcji chemicznej. Ochotnicy przedstawiają rozwiązania, nauczyciel koryguje błędy.
5. Nauczyciel odtwarza nagranie abstraktu dla wszystkich uczniów. Uczestnicy zajęć słuchają uważnie i udzielają informacji zwrotnej dotyczącej trudności wysłuchanego tekstu z wykorzystaniem metody świateł. Uczniowie są wyposażeni w kartki koloru: zielonego, żółtego i czerwonego. Podczas słuchania nagrania pokazują odpowiedni kolor w celu samooceny i poinformowania nauczyciela: zielony – daję sobie świetnie radę, wszystko rozumiem; żółty – mam pewne wątpliwości; czerwony – nic nie rozumiem, proszę o pomoc. Nauczyciel reaguje w zależności od potrzeb uczniów, decydując się na powtórne odtworzenie nagrania, słuchanie nagrania z jednoczesnym śledzeniem tekstu wzrokiem lub tłumaczeniem tekstu.

Faza podsumowująca

1. Nauczyciel prosi uczniów o rozwinięcie zdań:
    - Dziś nauczyłem się...
    - Zrozumiałem, że...
    - Zaskoczyło mnie...
    - Dowiedziałem się...

    W celu przeprowadzenia podsumowania może posłużyć się tablicą interaktywną w abstrakcie lub polecić uczniom pracę z nią

Praca domowa

1. Wykonaj ćwiczenie interaktywne.

W tej lekcji zostaną użyte m.in. następujące pojęcia oraz nagrania

Pojęcia

> **law of definite proportion**
>
> Nagranie dostępne na portalu epodreczniki.pl
>
> Nagranie dźwiękowe słówka: prawo określonej proporcji.

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principle of mass conservation

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Teksty i nagrania

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While observing the course of chemical reactions, we can describe effects that occur during it, for example changes in colour, sounds, light emission. Sometimes one can also get impression that the quantity of substances involved in the reaction is decreasing or increasing.

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The need to balance chemical equations results in fact from the principle of mass

conservation. If the total mass of substrates is to be equal to the total mass of products, numbers of atoms of the same type on both sides of the equation have to be identical.

Nowadays the law of mass conservation is extended by the energy of ingredients. Reagents are characterized by their own internal energy called the resting mass. However, due to the fact that the resting mass of the system or chemical reaction contributes not only to the rest masses of the components, but also all forms of internal energy related to the movement of elemental atoms in space and their mutual interactions, the rest mass of the system is equal to the sum of masses its components and their energy.

During chemical reactions, the structure of the resting mass of the system may change, eg by reducing the sum of the rest masses of its components, and increasing the sum of their energy.

For closed systems but not insulated, the right to maintain the rest mass is not satisfied, because there is a flow of energy between the system and the environment, which results in a change in the rest mass of the system.

However, during chemical reactions, the amounts of energy exchanged are so small that the mass change of the system is not detectable by standard methods, hence the stability of the mass of the reaction system is assumed. In chemical reaction, the sum of the masses of products and substrates are the same.

The principle of mass conservation helps determine mass of one substance if we know masses of other substrates and products. If you know this principle, you can calculate for example the quantity of products resulting from a given mass of substrates. For example, if we know that 2.4 g of magnesium and 1.6 of oxygen were involved in the reaction, we can easily determine that $2.4\ \mathrm{g} + 1.6\ \mathrm{g} = 4\ \mathrm{g}$ of magnesium oxide was produced in this chemical reaction:

In case of another reaction – exchange reaction of copper(II) oxide with carbon – we can determine mass of copper if we know masses of substrates and mass of the second product:

In line with the principle of mass conservation, total mass of substrates is to be equal to total mass of products:

After rearranging the equation and making calculations we will know the mass of copper:

$\mathrm{x} = 15.9\ \mathrm{g} + 1.2\ \mathrm{g} - 4.4\ \mathrm{g} = 12.7\ \mathrm{g}$

Using the principle of mass conservation, we can conclude that 12.7 g of copper will be produced in a reaction of 15.9 g of copper(II) oxide and 1.2 g of carbon.

Calculate mass of hydrogen produced in this reaction and determine the number of molecules of this gas.

- According to the principle of mass conservation it is assumed that in each reaction total mass of substrates is equal to total mass of resulting products.
- Mass of each substrate or products can be calculated based on the principle of mass conservation, if you know masses of the other ones.
- According to the law of definite proportion, mass ratio of elements in a chemical compound is always constant and does not depend on its source and method of preparation (each chemical compound always contains its component elements in fixed qualitative and quantitative ratio).
- If you know mass ratio of chemical elements in a compound, you can calculate mass of chemical elements in given amount of this compound.
- Molecular formula of given compound may be determined based on mass ratio of its component elements.

Lesson plan (English)

Topic: Principle of mass conservation

Target group

Elementary school student (grades 7. and 8.)

Core curriculum:

Elementary school. Chemistry.

III. Chemical reactions. Student:

7) applies the constancy law and mass conservation law to calculations (performs calculations related to the stoichiometry of the chemical formula and the chemical reaction equation).

General aim of education

The student interprets the law of mass preservation and solves tasks using the law of mass preservation.

Key competences

- communication in the mother tongue;
- communication in foreign languages;
- mathematical competence and basic competences in science and technology;
- digital competence;
- learning to learn.

Criteria for success
The student will learn:

- knowledge of the content of the law of mass conservation and its interpretation;
- solve tasks using the law of mass conservation.

Methods/techniques

- **expository**
    - talk.
- **exposing**
    - film.
- **programmed**
    - with computer;

    - with e-textbook.
- **practical**
    - exercices concerned.

Forms of work

- individual activity;
- activity in pairs;
- collective activity.

Teaching aids

- e-textbook;
- notebook and crayons/felt-tip pens;
- interactive whiteboard, tablets/computers;
- methodician or green, yellow and red cards.

Lesson plan overview

Introduction

1. The teacher hands out Methodology Guide or green, yellow and red sheets of paper to the students to be used during the work based on a traffic light technique. He presents the aims of the lesson in the student's language on a multimedia presentation and discusses the criteria of success (aims of the lesson and success criteria can be send to students via e-mail or posted on Facebook, so that students will be able to manage their portfolio).
2. The teacher together with the students determines the topic – based on the previously presented lesson aims – and then writes it on the interactive whiteboard/blackboard. Students write the topic in the notebook.

Realization

1. Students read the fragment titled „Does the mass of substrates change during a chemical reaction?" They explain what the principle of mass conservation is and who formulated it, the teacher completes the information explaining cases in which this principle is not preserved. Next, the teacher explains that in modern physics, according to the special theory of relativity, the law of preserving the total resting mass of the isolated system takes energy into account.
2. The teacher announces a movie titled "How to control mass of substances involved in the reaction of baking soda with vinegar". He instructs his pupils to write a research question and a hypothesis in the form provided in the abstract. Then he plays the video and the students note their observations and conclusions. Referring to observations and conclusions, the teacher encourages young people to discuss.

3. The teacher explains how can the principle of mass conservation be used in chemical calculations. He presents and discusses examples from the abstract (the reaction of the synthesis of magnesium and oxygen in magnesium oxide, the reaction of exchanging copper oxide and carbon in copper and carbon dioxide).
4. The students, working in pairs, solve the tasks: a) Heating 30 g of copper with oxygen, 38 g of copper(II) oxide were obtained. Calculate how much oxygen was used in this reaction; b) The iron is obtained from iron ore. 14 g of iron(III) oxide were used for the reaction with 6.4 g of carbon monoxide and 9.2 g of iron was obtained. Calculate the volume of the separated carbon dioxide, if its density is equal to 1.96 g / dm^3; c) 6.4 grams of oxygen were consumed when magnesium was burned, yielding 16 grams of magnesium oxide. Calculate the mass of magnesium used in the chemical reaction.
5. The teacher plays the abstract recording for all students. Participants listen carefully and give feedback on the difficulty of the text being heard using the traffic light method. Students are provided with green, yellow and red cards. While listening to the recording, they display the appropriate color for self-assessment and to inform the teacher: green - I'm fine, I understand everything; yellow - I have some doubts; red - I do not understand anything, please help. The teacher responds depending on the needs of the students, deciding to repeat the recording, listen to the recording while following the text or translate the text.

Summary

1. The teacher asks the students to finish the following sentences:
    - Today I learned ...
    - I understood that ...
    - It surprised me ...
    - I found out ...

    The teacher can use the interactive whiteboard in the abstract or instruct students to work with it

Homework

1. Carry out interactive exercise.

The following terms and recordings will be used during this lesson

Terms

> **law of definite proportion**
>
> Nagranie dostępne na portalu epodreczniki.pl

Nagranie dźwiękowe słówka: prawo określonej proporcji.

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principle of mass conservation

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Nagranie dźwiękowe słówka: prawo zachowania masy.

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prawo zachowania masy – reguła, która mówi, że w układzie zamkniętym w przypadku każdej reakcji chemicznej całkowita masa substratów jest równa łącznej masie produktów.

Texts and recordings

Nagranie dostępne na portalu epodreczniki.pl

Nagranie dźwiękowe abstraktu. Czy masa i energia substratów zmienia się podczas reakcji chemicznej?

Principle of mass conservation

While observing the course of chemical reactions, we can describe effects that occur during it, for example changes in colour, sounds, light emission. Sometimes one can also get impression that the quantity of substances involved in the reaction is decreasing or increasing.

Masses of substrates and products were compared already in the 18th century. Due to these studies, conducted independently by two chemists, Mikhail Lomonosov from Russia (1756) and Antoine Lavoisier from France (1785), a general law of nature was formulated. It was called principle of mass conservation. In line with this law, total mass of substrates is equal to total mass of products in an isolated system (in which reaction products and energy does not leave this system). This means that the same mass of substrates produces the same mass of products; that is mass of substances involved in chemical reaction does not change.

The need to balance chemical equations results in fact from the principle of mass conservation. If the total mass of substrates is to be equal to the total mass of products, numbers of atoms of the same type on both sides of the equation have to be identical.

Nowadays the law of mass conservation is extended by the energy of ingredients. Reagents are characterized by their own internal energy called the resting mass. However, due to the fact that the resting mass of the system or chemical reaction contributes not only to the rest masses of the components, but also all forms of internal energy related to the movement of elemental atoms in space and their mutual interactions, the rest mass of the system is equal to the sum of masses its components and their energy.

During chemical reactions, the structure of the resting mass of the system may change, eg by reducing the sum of the rest masses of its components, and increasing the sum of their energy.

For closed systems but not insulated, the right to maintain the rest mass is not satisfied, because there is a flow of energy between the system and the environment, which results in a change in the rest mass of the system.

However, during chemical reactions, the amounts of energy exchanged are so small that the mass change of the system is not detectable by standard methods, hence the stability of the mass of the reaction system is assumed. In chemical reaction, the sum of the masses of products and substrates are the same.

The principle of mass conservation helps determine mass of one substance if we know masses of other substrates and products. If you know this principle, you can calculate for example the quantity of products resulting from a given mass of substrates. For example, if we know that 2.4 g of magnesium and 1.6 of oxygen were involved in the reaction, we can easily determine that $2.4\ \mathrm{g} + 1.6\ \mathrm{g} = 4\ \mathrm{g}$ of magnesium oxide was produced in this chemical reaction:

In case of another reaction – exchange reaction of copper(II) oxide with carbon – we can determine mass of copper if we know masses of substrates and mass of the second product:

In line with the principle of mass conservation, total mass of substrates is to be equal to total mass of products:

After rearranging the equation and making calculations we will know the mass of copper:

$\mathrm{x} = 15.9\ \mathrm{g} + 1.2\ \mathrm{g} - 4.4\ \mathrm{g} = 12.7\ \mathrm{g}$

Using the principle of mass conservation, we can conclude that 12.7 g of copper will be produced in a reaction of 15.9 g of copper(II) oxide and 1.2 g of carbon.

Calculate mass of hydrogen produced in this reaction and determine the number of molecules of this gas.

- According to the principle of mass conservation it is assumed that in each reaction total mass of substrates is equal to total mass of resulting products.
- Mass of each substrate or products can be calculated based on the principle of mass conservation, if you know masses of the other ones.
- According to the law of definite proportion, mass ratio of elements in a chemical compound is always constant and does not depend on its source and method of preparation (each chemical compound always contains its component elements in fixed qualitative and quantitative ratio).
- If you know mass ratio of chemical elements in a compound, you can calculate mass of chemical elements in given amount of this compound.
- Molecular formula of given compound may be determined based on mass ratio of its component elements.