TOPIC: Lavoisier's law: Conservation of mass

SUBJECT: CHEMISTRY

LEVEL/AGE: 14-15 YEARS OLD

FOREKNOWLEDGE: Knowledge of chemical elements, atoms and molecules.

LENGTH: 6 PAGES (DURATION: 45 MINUTES)

LEARNING OUTCOMES

By the end of the lesson, students will know what the law of conservation of mass (or Lavoisier's law) is and how to apply it in chemical equations.

RESOURCES

Periodic table of elements, worksheets, video projector, lab elements (optional)

TEACHING METHODS

Explanatory videos

Repetition of exercises

Visual experiments

Exercise sheets

Games

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ACTIVITIES

INTRODUCTION (3 minutes)

When we are burning wood, we can observe its entire body transforming to ashes, soot, and gases.

But what if I say the total mass of the wood before burning and the total mass of the ashes, soot, and gases are equal? Would you believe it?

REVISION (10 minutes)

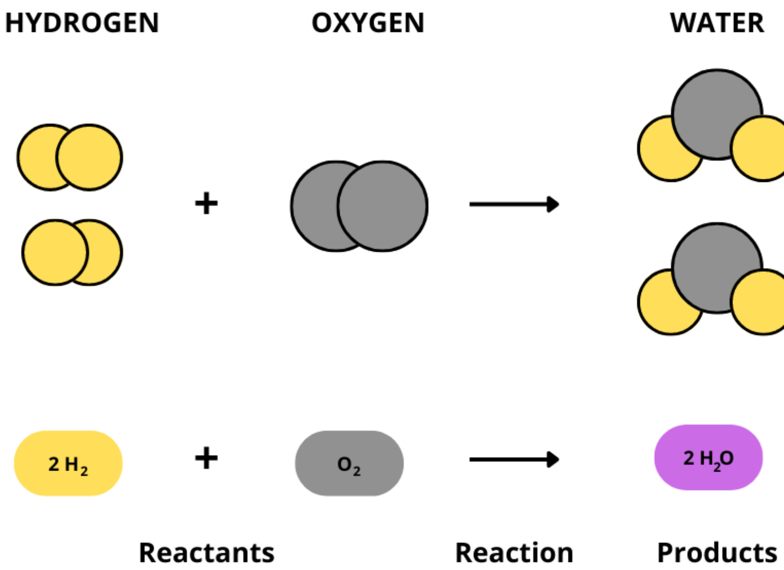
Before tackling the explanation and subsequent exercises on Lavoisier's law, it would be useful to review previous knowledge on the composition of molecules, both elements and chemical compounds. To do this, students can do a simple task such as decomposing the following common molecules into their constituent elements:

- Water: H_2O (Solution: Two atoms of hydrogen and one of oxygen)
- Oxygen: O_2
- Carbon dioxide: CO_2
- Hydrochloric acid: HCl
- Sulphuric acid: H_2SO_4
- Ethanol: C_2H_5OH
- Glucose: $C_6H_{12}O_6$
- Silver nitrate: $AgNO_3$
- Ammonia: NH_3
- Acetone: C_3H_6O

THEORY PART (5 minutes)

The law of conservation of mass is a fundamental principle of physics. According to this law, matter can be neither created nor destroyed. In other words, the mass of an object or collection of objects never changes, no matter how the parts are rearranged. For example, the carbon atom in coal becomes carbon dioxide when it is burned. The carbon atom changes from a solid structure to a gas, but its mass does not change.

During a chemical reaction, one or more substances react with each other to produce one or more other substances. The first ones are called 'reactants', while the ones formed after the reaction are called 'products'. Here we can see the combination of hydrogen (H) and oxygen (O) to form water (H_2O).



HANDS-ON PART (15 MINUTES)

A simple experiment can be carried out to give students a better understanding of the concept, always under the supervision of an adult. To do this, we will need the following:

- Bicarbonate of soda (4gr)
- Vinegar (10 ml)
- A weighing scale
- A jar with a lid (hermetic seal)
- Test tubes

1.- On a balance, place a wide-mouthed bottle with 2 grams of sodium bicarbonate and inside it a test tube with 5 ml of vinegar. We weigh and note the value. Then pour the contents of the test tube into the bottle. When the bubbles are gone, write down the new weight value.

2.- On the same balance, we place a wide-mouth bottle with 2 grams of sodium bicarbonate and inside it a test tube with 5 ml of vinegar, and we close the bottle. Weigh and write down the value. Then take the bottle and pour the contents of the test tube into it. When the bubbles are gone, write down the new weight value.

In the first test, when the vinegar reacts with the sodium bicarbonate, carbon dioxide is released into the atmosphere because the bottle is open. In this case, the weight decreases. In the second, the same carbon dioxide is formed, but as the jar is covered, the weight does not change. This shows that matter does not disappear.

CAUTION: Due to the formation of gas (carbon dioxide), the pressure inside the closed bottle increases. Great care must be taken when opening the bottle, opening it slowly so that the gas is released gradually.

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EXTRA EXERCISE: Vinegar is diluted acetic acid. Acetic acid reacts with sodium bicarbonate to form sodium acetate and carbon dioxide, according to the following equation:

$$CH_3COOH + NaHCO_3 \rightarrow Na + CH_3COO + CO_2 + H_2O$$

You can do the exercise of decomposing this equation into atoms to check that there is no difference between the atoms that make up the reactants and the product.

EXERCISE PART (10 MINUTES)

Check whether, in all cases, the same number of atoms of each element appears in the reactants as in the products, thus fulfilling Lavoisier's law (or the law of conservation of mass). (All the examples below are correct; the teacher may also include some wrong chemical equations):

- **$2\ Mg + O_2 \rightarrow 2\ MgO$**

Explanation: Reactants are composed of two magnesium atoms and two oxygen atoms (in one oxygen molecule), while in the product there are two magnesium oxide units (with one magnesium and one oxygen atom each, so two magnesium and two oxygen atoms).

- **$Ni + 2\ HCl \rightarrow NiCl_2 + H_2$**

Explanation: Reactants are composed of one atom of nickel (Ni), two atoms of hydrogen (H) and two atoms of chlorine (Cl), (each molecule of hydrogen chloride HCl has one H and one Cl atom), while the products are composed by one nickel atom and two chlorine atoms in the nickel chloride ($NiCl_2$) and two hydrogen atoms.

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

Explanation: Reactants are composed of one carbon atom and four hydrogen atoms in the methane (CH_4) molecule and four oxygen atoms (two oxygen atoms for each oxygen molecule). Products are composed of one carbon atom in the carbon dioxide, four hydrogen atoms (two hydrogen atoms in each molecule, of which there are two) and four oxygen atoms (two atoms in the water molecule, of which there are two).

- **$S_8 + 8\ Fe \rightarrow 8\ FeS$**

Explanation: Reactants are composed of eight atoms in the sulphur molecule (S_8) and eight atoms of iron (Fe). Products: in each unit of iron sulphide, there is one iron and one sulphur atom.

SYNTHESIS/SUMMARY (2 MINUTES)

KEEP IN MIND!

- A reaction can be summarised in a symbol equation.
- The total mass of the reactions is the same as the total mass of products in a reaction.
- A symbol equation must be balanced as no atoms are created or destroyed.
- There should be the same number of atoms of each type of element on each side of the equation.
- You can never change a formula when balancing an equation.

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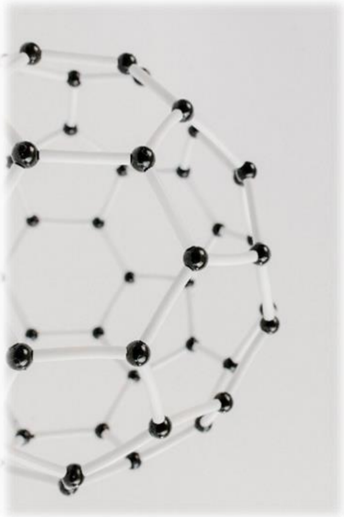
BIBLIOGRAPHY

- TED-Ed. *The law of conservation of mass – Todd Ramsey* (2015). Youtube: https://www.youtube.com/watch?v=2S6e11NBwiw
- MooMooMath and Science. *Law of Conservation of Mass Example* (2019). Youtube: https://www.youtube.com/watch?v=HmzFG_xOeaQ
- PHET. *Reactants, Products and Leftovers* (Game). https://phet.colorado.edu/en/simulations/reactants-products-and-leftovers/translations



TOPIC: Valences and molecular bonding

SUBJECT: Chemistry

LEVEL/AGE: 14-15 years old

FOREKNOWLEDGE: Chemical elements

LENGTH: 5 PAGES (DURATION: 55 MINUTES)

LEARNING OUTCOMES

By the end of this lesson, the students should know what valences are and how they are used to combine chemical elements to make new molecules.

RESOURCES

Periodic table of elements, worksheets, video projector, school supplies (scissors, paper, coloured pencils,...)

TEACHING METHODS

Explanatory videos

Repetition of exercises

Games

Visual experiments

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ACTIVITIES

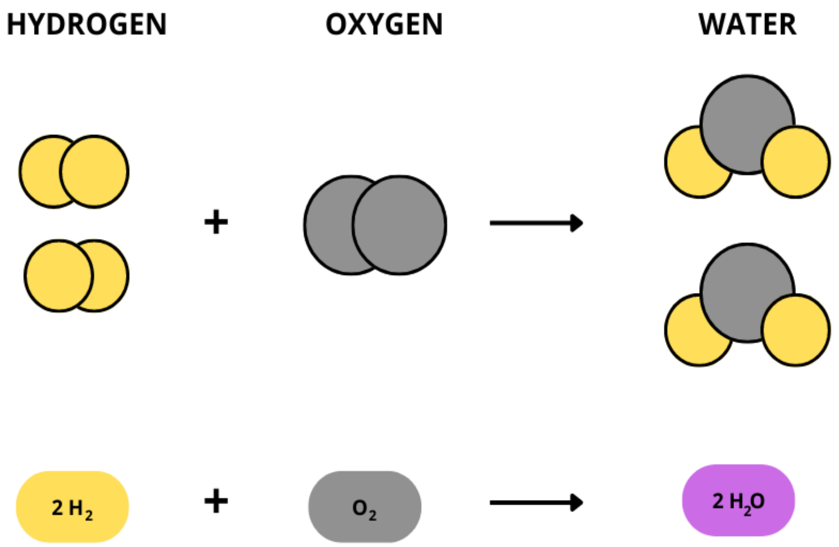
INTRODUCTION (5 minutes)

Give each student a small square of paper and a pair of scissors. Ask: "How many times do you think you can cut this paper in half until you can't cut it any more? Tell your prediction to a partner, try it and do the maths".

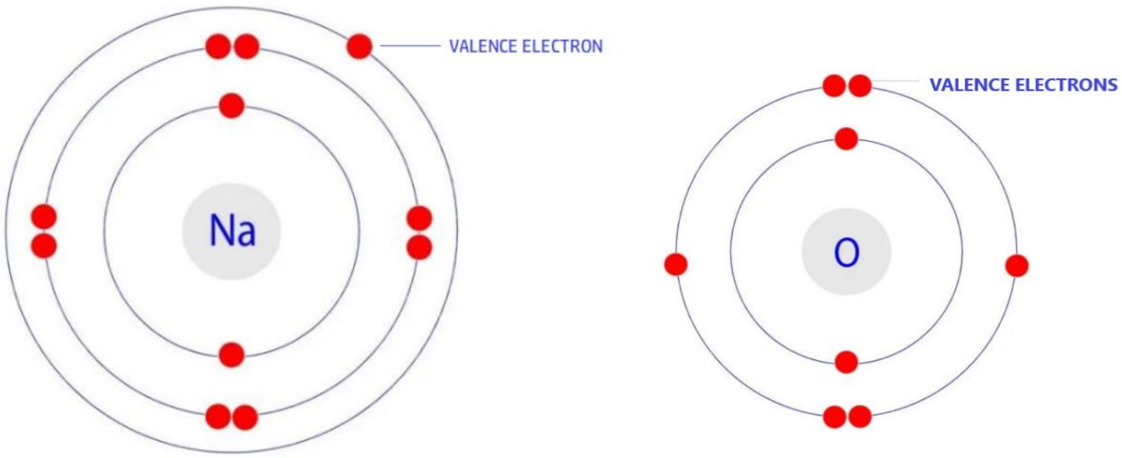
Allow a few minutes for students to tear or cut out their paper square. Ask them to share their results. Then explain that the smallest piece of paper in front of them is more than 100,000 times bigger than an atom. Atoms are so small that they can only be seen with special microscopes. All matter is made up of atoms.

THEORY PART (15 minutes)

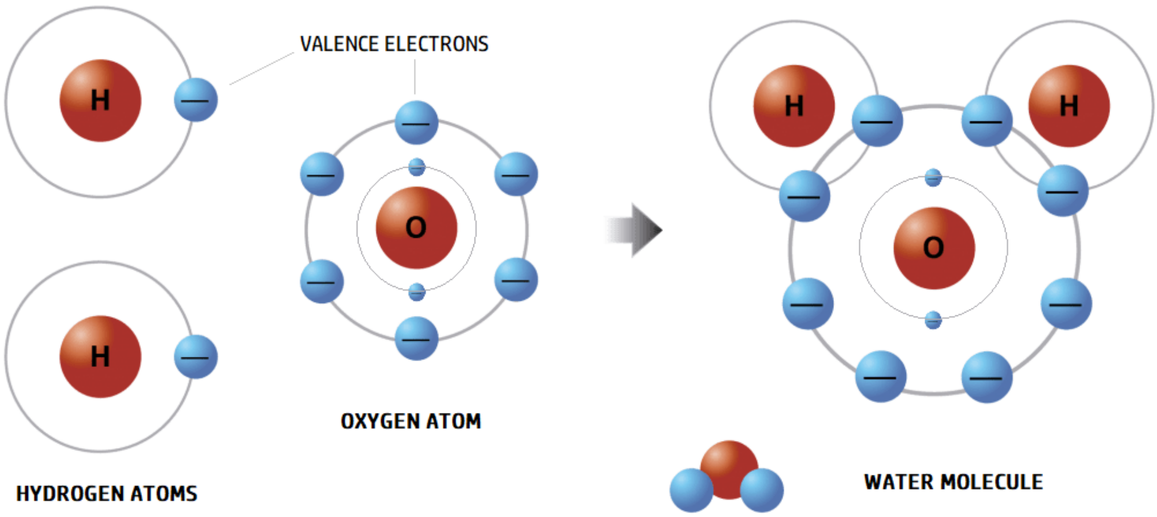
Molecules are any combination of 2 or more atoms. A molecule can be made up of 2 atoms of the same type, such as a molecule of oxygen (O_2), or a molecule can be made up of 2 or more different atoms, such as water (H2O). If there are 2 different types of atoms, this molecule is called a compound. Therefore, water is a molecule and a compound. Oxygen gas (O_2) is a molecule but not a compound.



We have already seen that it is possible to combine different elements to form new molecules, however, it is not possible to put elements together at random. Elements are very picky about what they combine, but we have a clue with their valence electron numbers. But what is this? Quite easily; the valence electrons are the electrons in the last energy level of the atom, and they are the ones that allow bonds to form with other elements:



All atoms have one goal: to have an octect, that is, eight valence electrons (in their outer shell, in the inner shell they will seek to have two electrons); to do this, elements can give, take or share an electron with other elements. We can use this to determine which elements will combine easily with others.

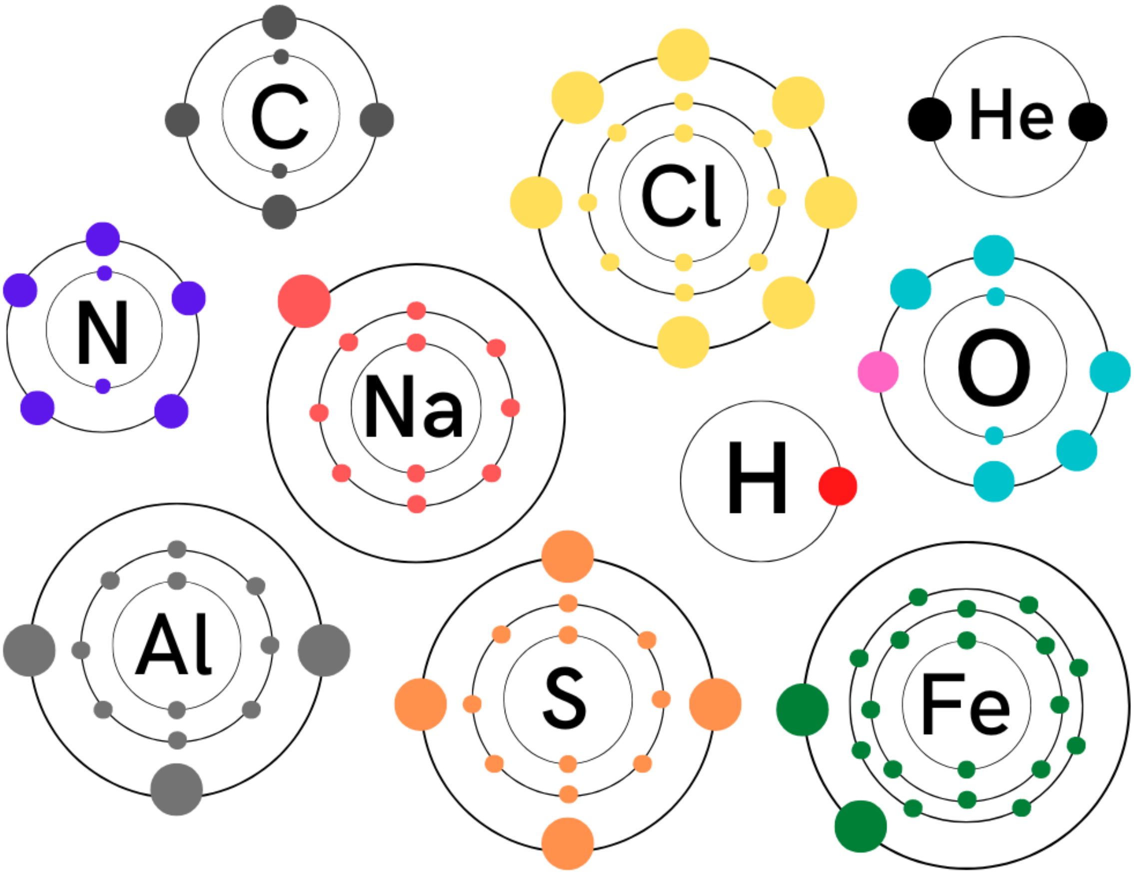


HANDS-ON PART (15 MINUTES)

Students will choose one element (or can assign one) to make a model. They can choose any materials they want, as long as they are prepared to explain what the materials represent. Then ask students to find other atoms to "connect" to their atoms to form molecules. (For example, if 2 students have hydrogen, they could find another student to "connect" to their atoms to form molecules). To help students form molecules, list common molecules on the board, such as CO_2, H_2O, NaCl, O_2 , or N_2.

EXERCISE PART (15 MINUTES)

Now I am going to show you some atoms of different elements of the periodic table, with their corresponding shells and electrons. Take a look because we will do some exercises with them:



Following the octet rule, answer the following questions:

1. According to the infographic above, could an oxygen particle and a chlorine particle get their octets if they combined? Why?

2. How many hydrogen atoms would be necessary for a carbon atom to have its octet?

3. With which of the above elements can helium be bonded?

4. What molecule can we form with sulphur and nitrogen?

- S_2N_3
- S_4N_3
- S_3N_2

5. How many electrons would a nitrogen atom have to share with a nitrogen atom for both to be complete (N_2)?

6. Represent the bonding of atoms in NH_3, NaCl, FeO, CO_2 and CH_4.

7. Try to make as many combinations as possible to create new molecules.

SYNTHESIS/SUMMARY (5 MINUTES)

KEEP IN MIND!

- Valence electrons are the electrons in the last shell of an atom.
- These electrons determine which elements could combine to form new substances.
- The goal of an atom is to have a full electron shell (two electrons in the inner shell or 8 in the outer shell).
- Atoms can give, take or share electrons with other atoms.

BIBLIOGRAPHY

- GENERATION GENIUS. *Atoms & Molecules Activity for Kids.* (2019). https://www.generationgenius.com/activities/atoms-and-molecules-activity-for-kids/
- DON'T MEMORISE. *Concept of Valency | Atoms and Molecules.* (2018). https://www.youtube.com/watch?v=2ugSvI-F__I
- PHET. *Build a molecule* (Game). https://phet.colorado.edu/en/simulations/build-a-molecule/translations

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