Lesson: Counting Atoms & Balancing Equations

FOR THE TEACHER

Summary
In this lesson, students will learn how to count atoms and how to balance chemical equations using videos, simulations and games.

Grade Level
Middle and High School

Objectives
By the end of this lesson, students should be able to
- Count atoms in a given chemical formula.
- Identify and differentiate between a coefficient and a subscript.
- Read and understand a balanced chemical equation.
- Identify what substances are the reactants and what substances are the products in a chemical reaction.
- Explain the law of conservation of mass.

Chemistry Topics
This lesson supports students’ understanding of
- Chemical reactions
- Balancing Equations
- Reactants
- Products.
- Conservation of Matter
- Chemical formula
- Coefficients
- Subscripts

Time
Teacher Preparation: 30 minutes
Lesson: Three 45 minute class meetings

Materials
- Computer, tablet or Chrome book
- List of balancing chemical equations web sites and You Tube videos (see teacher notes)
- Student worksheet

Safety
- No specific safety precautions need to be observed for this activity.

Teacher Notes
- I suggest that students work individually, and at their own pace through this lesson.
- Background:
  - Chemical reaction: a process where atoms of the reactant(s) will rearrange themselves to create a new arrangement of atoms, called the product(s).
  - Reactant: A substance or substances present at the start of the reaction.
  - Product: A resulting substance or substances formed by a chemical reaction.
  - Chemical equation: Shorthand form for writing what reactants are used and what
products are formed in a chemical reaction; sometimes shows whether energy is produced or absorbed.

- Chemical formula: Combination of chemical symbols and numbers that indicates which elements and how many atoms of each element are present in a molecule.
- Subscripts: The small numbers written to the right of the atoms. For example, the subscript 2 in H₂O means that each molecule of water has two atoms of hydrogen. A subscript outside a parenthesis multiplies all the elements inside the parenthesis. For example, Ba₃(PO₄)₂, indicates there are 3 atoms of Ba, 2 (2 x 1) atoms of P, and 8 (2 x 4) atoms of O.
- Coefficients: The numbers in front of a chemical formula. For example, 2H₂O means two molecules of water.
- Law of conservation of mass: The mass of the reactants must equal the mass of the products. All the atoms on the reactant side of an equation are also on the product side. Atoms are not lost, but rearranged.

- Rules for balancing chemical equations:
  - Write the correct chemical formulas of reactants and products.
  - Count the number of atoms of each type in the reactants and in the products.
  - Look at the equation and see which elements are not balanced.
  - Balance the elements one at a time by adding coefficients.
  - Count the number of atoms to make sure the equation is balanced.
  - Finally, all coefficients are converted into the lowest possible whole number.
  - Show the students the Fig. 1, to illustrate coefficients and subscripts:

![3B₂O₃](image)

**Coefficient X Subscripts**

Multiply coefficients by the subscripts, e.g., 3x2 = 6 atoms of Boron; 3x3 = 9 atoms of Oxygen

**Fig. 1: Illustration of coefficients and subscripts**

- Never:
  - Change a subscript to balance a chemical equation. If you change the formula, you are describing a different chemical reaction: H₂O is a different compound than H₂O₂.
  - Put a coefficient in the middle of a chemical formula. 2KCl is alright, K₂Cl is not.

- To explain to students how to balance chemical equations, show them the following YouTube videos:
  1. [https://www.youtube.com/watch?v=yA3TZJ2em6g](https://www.youtube.com/watch?v=yA3TZJ2em6g)
  2. [https://www.youtube.com/watch?v=eNsVaUCzvLA](https://www.youtube.com/watch?v=eNsVaUCzvLA)

After watching videos 1 and 2, the students should answer the attached worksheet. If students show at least 80% proficiency they can skip videos 3 – 6, and move on to the simulations and games. Students who display difficulty understanding the concepts should watch videos 3 and
4, and then answer the attached worksheet. Students who still display difficulty may need to watch videos 5 and 6. The teacher should evaluate these students for understanding.

4. https://www.youtube.com/watch?v=E7dUmdY_aNk
5. https://www.youtube.com/watch?v=Oj8HzS8RT0
6. https://www.youtube.com/watch?v=tz5SAGQZDj8

- The following links are simulations and games for students to understand how to balance chemical equations. The PHET simulations and games have different levels of difficulty. Students should be able to balance the most advanced equations, before they are allowed to play the Rags to Riches and Battleship games:
  - Balancing chemical equations simulations and games suggestions:
    - https://teachchemistry.org/periodical/issues/september-2014/balancing-chemical-equations
    - http://www.sciencegeek.net/Chemistry/taters/EquationBalancing.htm
  - Teachers should assign students to use specific simulations and/or games depending on the time available and level.

FOR THE STUDENT

Lesson

Balancing Chemical Equations

Background

- **Chemical reaction**: a process where atoms of the reactant(s) will rearrange themselves to create a new arrangement of atoms, called the product(s).
- **Reactant**: A substance or substances present at the start of the reaction.
- **Product**: A resulting substance or substances formed by a chemical reaction.
- **Chemical equation**: Shorthand form for writing what reactants are used and what products are formed in a chemical reaction; sometimes shows whether energy is produced or absorbed.
- **Chemical formula**: Combination of chemical symbols and numbers that indicates which elements and how many atoms of each element are present in a molecule.
- **Subscripts**: The small numbers written to the right of the atoms. For examples, the subscript 2 in H₂O means that each molecule of water has two atoms of hydrogen. A subscript outside a parenthesis multiplies all the elements inside the parenthesis. For example, Ba₃(PO₄)₂, indicates there are 3 atoms of Ba, 2 (2 x 1) atoms of P, and 8 (2 x 4) atoms of O.
- **Coefficients**: The numbers in front of a chemical formula. For example, 2H₂O means two molecules of water.
- **Law of conservation of mass**: The mass of the reactants must equal the mass of the products. All the atoms on the reactant side of an equation are also on the product side. Atoms are not lost, but rearranged.

Pre-lesson Questions

1. What is a chemical equation? Give an example.
2. What is a coefficient?
3. What is a subscript?

Procedure
Rules for balancing chemical equations:
- Write the correct chemical formulas of reactants and products.
- Count the number of atoms of each type in the reactants and in the products.
- Look at the equation and see which elements are not balanced.
- Balance the elements one at a time by adding coefficients.
- Count the number of atoms to make sure the equation is balanced.
- Finally, all coefficients are converted into the lowest possible whole numbers.
- *Never* change a subscript to balance a chemical equation. If you change the formula, you are describing a different chemical reaction: $\text{H}_2\text{O}$ is a different compound than $\text{H}_2\text{O}_2$.
- Never put a coefficient in the middle of a chemical formula. $2\text{KCl}$ is correct, but $\text{K}_2\text{Cl}$ is not.

\[3\text{B}_2\text{O}_3\]

**Fig. 1: Illustration of coefficients and subscripts**

Multiply coefficients by the subscripts, e.g., $3 \times 2 = 6$ atoms of Boron; $3 \times 3 = 9$ atoms of Oxygen

**Part 1: Videos:**
- To learn how to balance chemical equations, watch YouTube videos 1 & 2. Record any important notes in the space provided below.
  1. [https://www.youtube.com/watch?v=yA3TZJ2em6g](https://www.youtube.com/watch?v=yA3TZJ2em6g)
  2. [https://www.youtube.com/watch?v=eNsVaUCzvLA](https://www.youtube.com/watch?v=eNsVaUCzvLA)

**Video Notes:**

*If you have a strong understanding of how to balance an equation, move on and complete the worksheet.
- If you feel like you need additional practice and explanation, continue to watch the
following videos:
4. https://www.youtube.com/watch?v=E7dUmdY_aNk

Video Notes:

Part 2: Simulations & Games:
- Your teacher will direct you to interact with a particular simulation and/or game for this part of the lesson.