

Topic: Symbols, Formulae, and Equations II

Subtopics Covered:

1. Law of Constant Composition
 2. Law of Multiple Proportions
 3. Writing and Balancing Chemical Equations
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Lesson Objectives:

By the end of the lesson, students should be able to:

- State and explain the **Law of Constant Composition**.
 - State and explain the **Law of Multiple Proportions**.
 - Write and balance **chemical equations** properly.
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1. Law of Constant Composition (Law of Definite Proportions)

Statement:

"A chemical compound always contains the same elements combined in the same proportion by mass, regardless of its source or the method of preparation."

Explanation:

- The composition of a **pure compound** is **fixed**.
 - The elements combine in **definite, fixed ratios**.
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Examples:

Water (H₂O):

Element	Mass of 1 mole
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Hydrogen	2g
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Element Mass of 1 mole

Oxygen 16g

Total 18g

Mass Ratio:

$$2:16 = 1:8 \quad \frac{2}{16} : \frac{16}{16} = 1 : 8 \quad 2:16 = 1:8$$

So, water is always **1 part hydrogen** and **8 parts oxygen** by mass, no matter the source.

Carbon Dioxide (CO₂):

Element Mass of 1 mole

Carbon 12g

Oxygen 32g

Total 44g

Mass Ratio:

$$12:32 = 3:8 \quad \frac{12}{32} : \frac{32}{32} = 3 : 8 \quad 12:32 = 3:8$$

Carbon dioxide is always **3 parts carbon** to **8 parts oxygen** by mass.

2. Law of Multiple Proportions

Statement:

"When two elements combine to form more than one compound, the different masses of one element that combine with a fixed mass of the other are in simple whole-number ratios."

Explanation:

If **element A** combines with **element B** in different ways to form different compounds, the mass of B that combines with a fixed mass of A will be in **simple whole number ratios**.

Examples:

Carbon and Oxygen:

Compound	Formula	Mass of Carbon	Mass of Oxygen
Carbon monoxide	CO	12g	16g
Carbon dioxide	CO ₂	12g	32g

Comparison:

Fix carbon at **12g**. Compare oxygen masses:

- In CO: 16g of oxygen
- In CO₂: 32g of oxygen

Ratio of oxygen = **16 : 32 = 1 : 2**

So, the oxygen masses are in a **simple whole-number ratio of 1:2**, confirming the law.

Another Example: Nitrogen Oxides

Compound	Formula	Mass of N (fixed)	Mass of O
Nitrous oxide	N ₂ O	28g	16g
Nitric oxide	NO	28g	32g
Nitrogen dioxide	NO ₂	28g	64g

Ratio of Oxygen:

16 : 32 : 64 = **1 : 2 : 4**

3. Writing and Balancing Chemical Equations

What is a Chemical Equation?

A **chemical equation** shows the **reactants** and **products** in a chemical reaction, using **symbols and formulae**.

Parts of a Chemical Equation:

Reactants

→

Products

Substances before reaction Arrow (yields) Substances after reaction

Symbols Used in Equations:

Symbol Meaning

+ "and" or "reacts with"

→ "produces" or "yields"

(s) Solid

(l) Liquid

(g) Gas

(aq) Aqueous solution (dissolved in water)

Steps to Balance Chemical Equations:

1. **Write the correct formulae** for all reactants and products.
 2. **Count the number of atoms** of each element on both sides.
 3. Use **coefficients (numbers in front)** to balance the atoms.
 4. **Never change subscripts** (do not alter the formula).
 5. Check your work by **recounting atoms**.
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Examples of Balancing Equations:

Example 1: Combustion of Methane

Unbalanced: $\text{CH}_4 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
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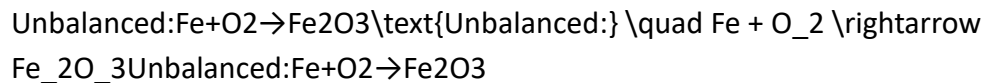
- Carbon: 1 (both sides)
- Hydrogen: 4 (left), 2 (right)
- Oxygen: 2 (left), 3 (right)

Balanced:



- Carbon: 1
- Hydrogen: 4
- Oxygen: 4 (both sides)

Example 2: Reaction of Iron and Oxygen

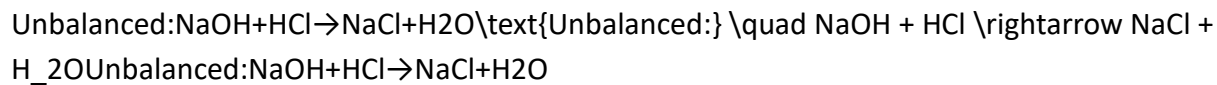


- Iron: 2 on right, so put **2 Fe** on left.
- Oxygen: 3 on right, 2 on left. Use LCM of 6.

Balanced:



Example 3: Neutralization Reaction



- All elements are already balanced.
- **Final equation:**



Additional Examples for Practice:

Reaction	Balanced Equation
Combustion of hydrogen	$2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$
Formation of ammonia	$\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$
Decomposition of water	$2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2$
Reaction of sodium with chlorine	$2\text{Na} + \text{Cl}_2 \rightarrow 2\text{NaCl}$
Calcium carbonate decomposition	$\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$

Summary of Key Points:

Concept	Meaning
Law of Constant Composition	A compound always has elements in a fixed ratio by mass.
Law of Multiple Proportions	Elements can combine in different ratios to form different compounds.
Chemical Equation	Symbolic representation of a chemical reaction.
Balancing Equations	Ensuring same number of atoms on both sides.

Conclusion

The **laws of composition** help explain how elements combine in nature.

Balanced chemical equations show how matter is conserved and reactions happen according to fixed rules.