Structure of the Atom

The Atomic Theory: History up to John Dalton

Chemistry Timeline

Democritus — Fifth century B.C.

- Matter is composed of individual particles called "atomos"

Alchemists — 100–1600 A.D.

- developed many experimental methods and an extensive body of chemical data during their metaphysical pursuits.

Chemistry Timeline

Robert Boyle — 17th century

- Quantitative measurements of properties of gases

constant n, constant T

$$P = k(1/V)$$

Chemistry Timeline

Joseph Priestley and Antoine–Laurent Lavoisier — 18th century

- Demonstrated that combustion is a reaction between matter and oxygen

Law of Conservation of Mass

- matter can neither be created nor destroyed

Chemistry Timeline

Joseph Proust — 18th century

Law of Definite Proportions

- different samples of the same compound always contain its constituent elements in the same proportions by mass

Example

Proust found that the substance copper carbonate is always

5.3 parts copper

4 parts oxygen

1 part carbon

by mass

Chemistry Timeline

John Dalton — 19th century

- Atomic theory

Law of Multiple Proportions

- if two elements can combine to form more than one compound, the masses of one element that combine with a fixed mass of the other elements are in ratios of small whole numbers

Example

Mass of nitrogen that combines with 1g of oxygen

Whole number ratios

Compound 1

$$\frac{1.750\text{g}}{0.4375\text{g}} = 4$$

Compound 2

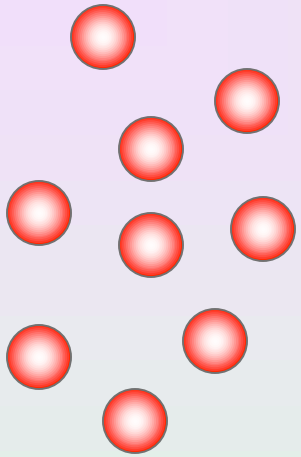
$$\frac{0.8750\text{g}}{0.4375\text{g}} = 2$$

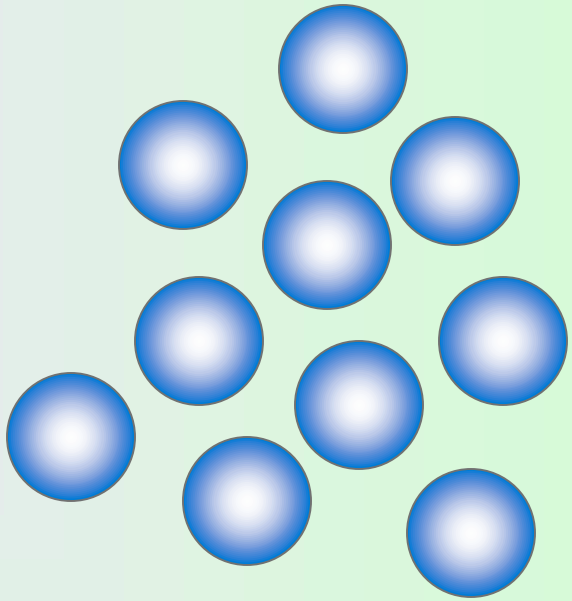
Compound 3

$$\frac{0.4375\text{g}}{0.4375\text{g}} = 1$$

Dalton's Atomic Theory—1808

1. Elements are composed of extremely small particles called atoms. All atoms of a given element are identical, having the same size, mass and chemical properties. The atoms of one element are different from the atoms of all other elements.





Atoms of Element X **Atoms of Element Y**

According to Dalton's atomic theory, atoms of the same element are identical, but atoms of one element are different from atoms of other elements.

Dalton's Atomic Theory—1808

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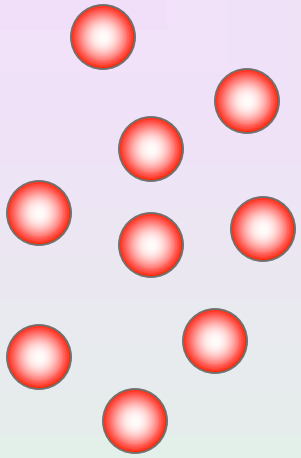
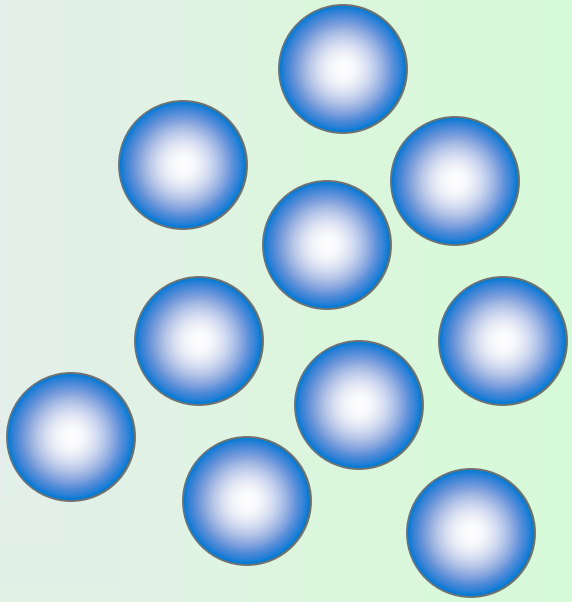
2. Compounds are composed of atoms of more than one element. In any compound, the ratio of the numbers of atoms of any two of the elements present is either an integer or a simple fraction.





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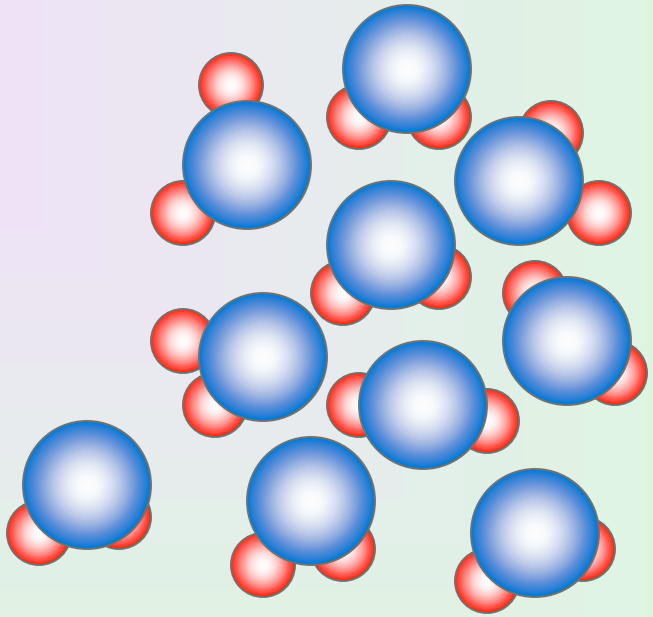

Compound of Elements X and Y

In this example, the ratio of the atoms from element X to the atoms from element Y is 2:1.

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incorporates laws of definite proportions
and multiple proportions

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3. A chemical reaction involves only the separation, combination or rearrangement of atoms; it does not result in their creation or destruction.

Fundamental Chemical Laws

Law of Definite Proportions

- different samples of the same compound always contain its constituent elements in the same proportions by mass

Law of Multiple Proportions

- if two elements can combine to form more than one compound, the masses of one element that combine with a fixed mass of the other elements are in ratios of small whole numbers

Law of Conservation of Mass

- matter can neither be created nor destroyed

Atomic Mass

relative masses of the atoms determined by comparison to a standard mass

Chemistry Timeline

Joseph Gay-Lussac and Amedeo Avogadro— 18th century

- experimental work which produced the first absolute formulas for compounds

Avogadro's hypothesis

at constant temperature and pressure, the volume of a gas is directly proportional to the number moles

constant T, constant P

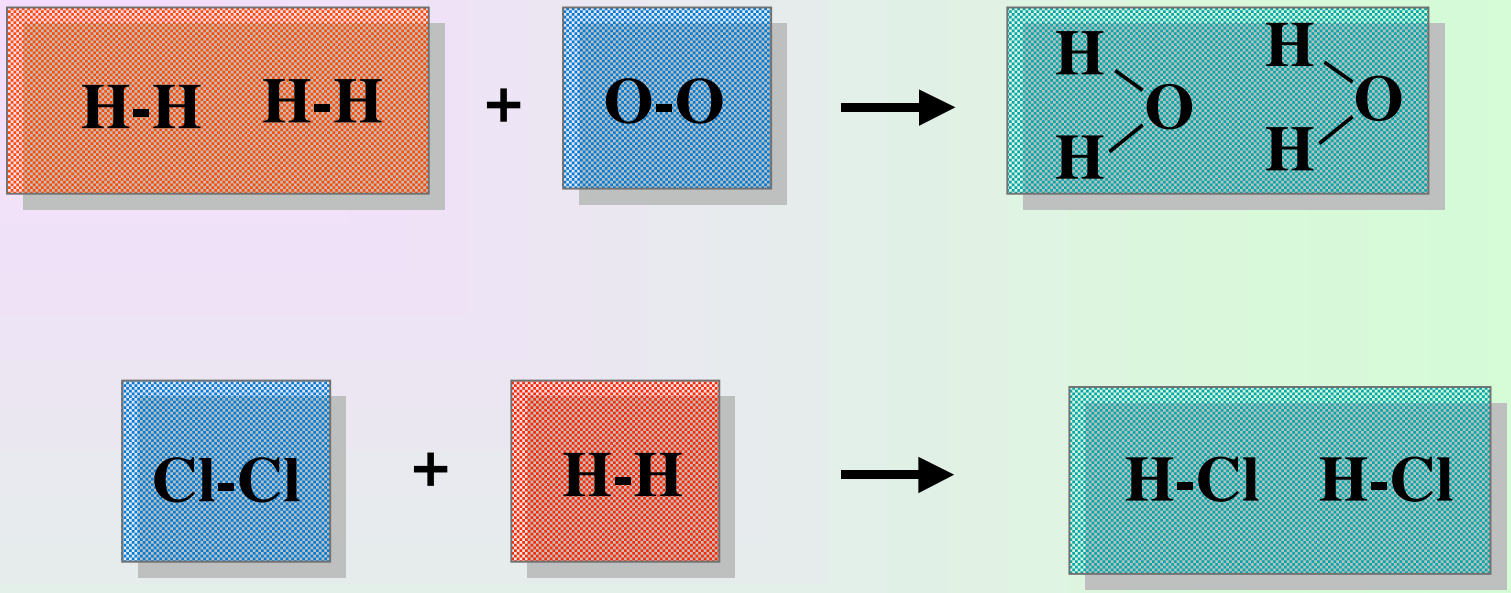
$$V = kn$$

equal volumes of different gases contain equal numbers of molecules

Joseph Gay-Lussac

Two volumes of hydrogen react with one volume oxygen to form two volumes of water

one volume of hydrogen react with one volume chlorine to form two volumes of hydrogen chloride



These observations can best be explained by assuming hydrogen oxygen and chlorine are diatomic (two-atom)molecules.

Chemistry Timeline

Stanislao Cannizzaro — 19th century

- worked out approximate values of relative atomic masses