SECTION 3

Gas Volumes and the Ideal Gas Law

OBJECTIVES

- State the law of combining volumes.
- State Avogadro's law and explain its significance.
- Define *standard molar volume of a gas* and use it to calculate gas masses and volumes.
- State the ideal gas law.
- Using the ideal gas law, calculate pressure, volume, temperature, or amount of gas when the other three quantities are known.

In this section, you will study the relationships between the volumes of gases that react with each other. You will also learn about the relationship between molar amount of gas and volume, and a single gas law that unifies all the basic gas laws into a single equation.

Measuring and Comparing the Volumes of Reacting Gases

In the early 1800s, French chemist Joseph Gay-Lussac studied gas volume relationships involving a chemical reaction between hydrogen and oxygen. He observed that 2 L of hydrogen can react with 1 L of oxygen to form 2 L of water vapor at constant temperature and pressure.

hydrogen gas	+	oxygen gas	⟶	water vapor
2 L (2 volumes)		1 L (1 volume)		2 L (2 volumes)

In other words, this reaction shows a simple and definite 2:1:2 relationship between the volumes of the reactants and the product. Two volumes of hydrogen react with 1 volume of oxygen to produce 2 volumes of water vapor. The 2:1:2 relationship for this reaction applies to any proportions for volume—for example, 2 mL, 1 mL, and 2 mL; 600 L, 300 L, and 600 L; or 400 cm^3, 200 cm^3, and 400 cm^3.

Gay-Lussac also noticed simple and definite proportions by volume in other reactions of gases, such as in the reaction between hydrogen gas and chlorine gas.

hydrogen gas	+	chlorine gas	⟶	hydrogen choloride gas
1 L (1 volume)		1 L (1 volume)		2 L (2 volumes)

In 1808, Gay-Lussac summarized the results of his experiments in a statement known today as **Gay-Lussac's law of combining volumes of gases.** The law states that *at constant temperature and pressure, the volumes of gaseous reactants and products can be expressed as ratios of small whole numbers.* This simple observation, combined with the insight of Avogadro, provided more understanding of how gases react and combine with each other.