

The Gas Laws—Preface

Applications of the gas laws are important in physiology, meteorology, scuba diving, even hot-air ballooning. Boyle's law is demonstrated with every breath we take. Charles's law is illustrated in the ascent and landing of a hot-air balloon. The purpose of *The Gas Laws*, Volume 9 in the Flinn ChemTopic™ Labs series, is to provide high school chemistry teachers with laboratory activities that will help students investigate, apply, and explain the relationships among the four measurable gas properties—pressure, temperature, volume, and number of moles of gas. Five experiments and six demonstrations allow students to measure the gas properties, derive their mathematical relationships, and explain the behavior of gases under different conditions.

Pressure and Volume

The study of the gas laws begins with pressure. Take yourself back more than 350 years ago and imagine the surprise that greeted Torricelli's demonstration that the pressure of air would support a column of mercury more than 29 inches high. A few years later, Robert Boyle would compare the pressure of air to the force stored in a spring. Use "The Collapsing Can" demonstration to show your students that air pressure is indeed a force to be reckoned with! Afterwards, challenge your students with "Life on Planet V" to describe how their lives would be different if there were no air pressure. Once students understand the concept of pressure, they will be ready to investigate the first gas law, the effect of pressure on the volume of a gas, in "Boyle's Law in a Bottle." Students need only a syringe and a pressurized soda bottle to recreate Boyle's classic measurements and derive the mathematical relationship between pressure and volume. After students have finished the calculations and the graphing, they will enjoy playing with "Cartesian Divers," a classic toy that demonstrates how Boyle's law affects the density and buoyancy of a gas.

Temperature and Kinetic Energy

The temperature of a gas affects both its volume and its pressure. In "Charles's Law and Absolute Zero," students measure how the volume of a fixed amount of gas changes as the gas is heated or cooled in a flexible container at constant pressure. Graphing the results will lead students to the concept of absolute zero and to the most fundamental concept describing the behavior of matter—the kinetic-molecular theory. Alternatively, in "Technology and the Forgotten Gas Law," students use a pressure sensor and a temperature sensor to determine how the temperature of a gas affects its pressure if the volume is held constant. The resulting mathematical relationship between temperature and pressure also leads to the definition of absolute zero. In both experiments,

the results can only be explained in terms of the kinetic energy of moving molecules. Use the "Diffusion of Gases" demonstration to show your students that molecules really do move and that their kinetic energy depends on temperature.



Avogadro's Law and the Number of Moles of Gas

Avogadro's law introduces the number of moles of gas as an independent variable and leads to the ideal gas law, which ties together all the measurable gas properties. According to Avogadro's law, the volume of a gas is directly proportional to the number of moles of gas if the temperature and pressure are held constant. In the microscale experiment "Molar Volume of Hydrogen," students use Avogadro's law and the ideal gas law to determine the molar volume of an ideal gas at standard temperature and pressure. Two demonstrations, "Massing Gases" and "Molar Mass of Butane" illustrate how Avogadro's law and the ideal gas law are also used to determine the molar mass of a gas. As a culminating activity, consider using "Construction of Gas Volume Cubes" to assess students understanding of the gas laws and their ability to perform ideal gas law calculations. Given an assigned number of moles of an ideal gas, students must calculate the volume of the gas at standard temperature and pressure and then construct a cube to match the volume. Assign different groups of students different numbers of moles, and the result will be a classroom exhibit of Avogadro's law!

Chemistry is an experimental science!

The overlapping selection of experiments and demonstrations in *The Gas Laws* gives you the ability to cover the topics you feel are important in the safest, most effective way possible. Depend on Flinn Scientific to provide you with up-to-date, modern variations of classic experiments and demonstrations. Remember, chemistry is an experimental science, and nowhere is this more evident than in the relationship between experiment, theory, and applications in the study of gases. Finally, no matter what experiments and demonstrations you choose, your students are assured of success. Each experiment and demonstration in *The Gas Laws* has been thoroughly tested and retested. You know they will work! Use the experiment summaries and concepts on the following pages to locate the concepts you want to teach and to choose activities that will help you meet your goals.

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