Behavior of Gases

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CHAPTER 1 Behavior of Gases

Lesson Objectives

- Define pressure.
- State the gas laws.

Vocabulary

- Amonton's law
- Boyle's law
- Charles's law
- pressure

Introduction

The molecules of a gas in a closed container, such as a balloon, are not only constantly moving. They are also constantly bumping into each other and into the sides of their container. The sketch in **Figure** 1.1 shows how this happens. The force of the particles against whatever they bump into creates pressure.

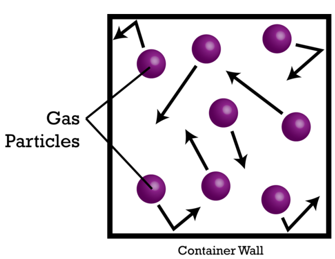

FIGURE 1.1
The particles of a gas keep bumping into the sides of its container.

What Is Pressure?

Pressure is defined as the amount of force pushing against a given area. How much pressure a gas exerts depends on the amount of gas. The more gas particles there are, the greater the pressure.

You usually cannot feel it, but air has pressure. The gases in Earth's atmosphere exert pressure against everything they contact. The atmosphere rises high above Earth's surface. It contains a huge number of individual gas particles. As a result, the pressure of the tower of air above a given spot on Earth's surface is substantial. If you were standing at sea level, the amount of force would be equal to 10.14 newtons per square centimeter (14.7 pounds per square inch). This is illustrated in **Figure** 1.2.

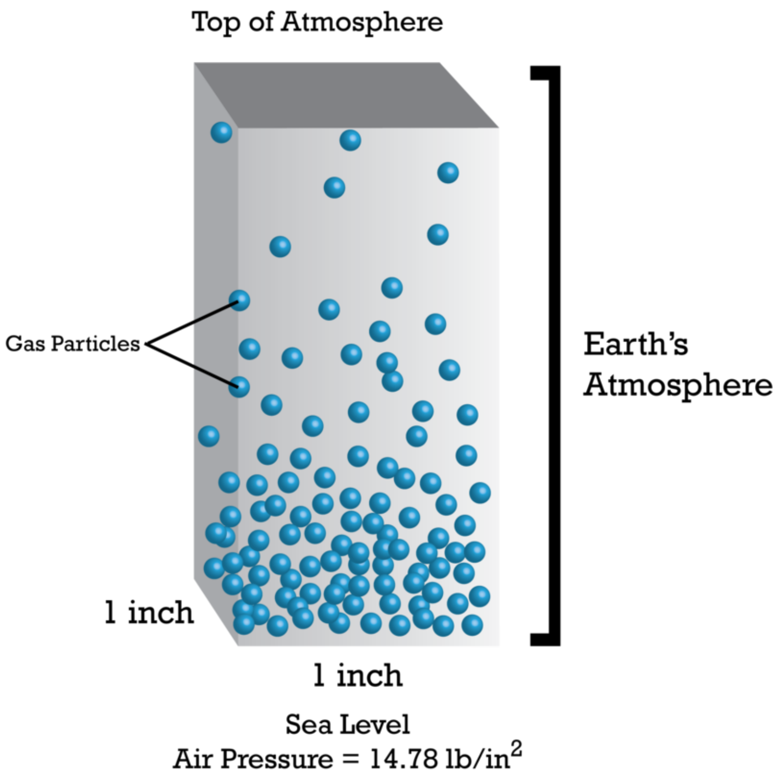

FIGURE 1.2
Earth's atmosphere exerts pressure. This pressure is greatest at sea level. Can you explain why?

The Gas Laws

For a given amount of gas, scientists have discovered that the pressure, volume, and temperature of a gas are related in certain ways. Because these relationships always hold in nature, they are called laws. The laws are named for the scientists that discovered them.

Boyle's Law

Boyle's law was discovered in the 1600s by an Irish chemist named Robert Boyle. According to **Boyle's law**, if the temperature of a gas is held constant, increasing the volume of the gas decreases its pressure. Why is this the case? As the volume of a gas increases, its particles have more room to spread out. This means that there are fewer particles bumping into any given area. This decreases the pressure of the gas. The graph in **Figure** 1.3 shows this relationship between volume and pressure. Because pressure and volume change in opposite directions, their relationship is called an inverse relationship. You can see an animation of the relationship at this URL: http://www.grc.nasa.gov/WWW/K-12/airplane/aboyle.html .

A scuba diver, like the one in **Figure** 1.4, releases air bubbles when he breathes under water. As he gets closer to the surface of the water, the air bubbles get bigger. Boyle's law explains why. The pressure of the water decreases as the diver gets closer to the surface. Because the bubbles are under less pressure, they increase in volume even though the amount of gas in the bubbles remains the same.

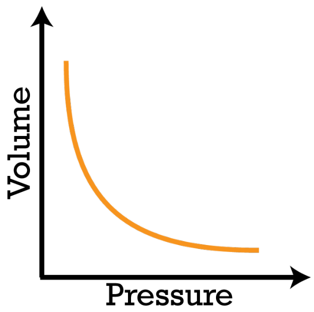

FIGURE 1.3
As the volume of a gas increases, its pressure decreases.

FIGURE 1.4
Gas bubbles get bigger when they are under less pressure.

Charles's Law

Charles's law was discovered in the 1700s by a French physicist named Jacques Charles. According to **Charles's law**, if the pressure of a gas is held constant, increasing the temperature of the gas increases its volume. What happens when a gas is heated? Its particles gain energy. With more energy, the particles have a greater speed. Therefore, they can move more and spread out farther. The volume of the gas increases as it expands and takes up more space. The graph in **Figure** 1.5 shows this relationship between the temperature and volume of a gas. You can see an animation of the relationship at this URL: http://www.grc.nasa.gov/WWW/K-12/airplane/aglussac.html .

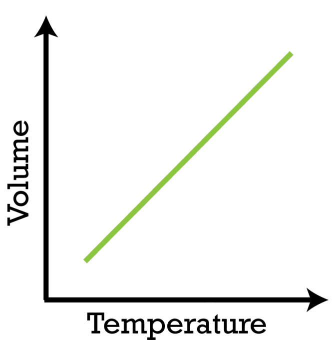

FIGURE 1.5
As the temperature of a gas increases, its volume also increases.

Roger had a latex balloon full of air inside his air-conditioned house. When he took the balloon outside in the hot sun, it got bigger and bigger until it popped. Charles's law explains why. As the gas in the balloon warmed in the sun, its volume increased. It stretched and expanded the latex of the balloon until the balloon burst.

Amonton's Law

Amonton's law was discovered in the late 1600s by a French physicist named Guillaume Amonton. According to **Amonton's law**, if the volume of a gas is held constant, increasing the temperature of the gas increases its pressure. Why is this the case? A heated gas has more energy. Its particles move more and have more collisions, so the pressure of the gas increases. The graph in **Figure** 1.6 shows this relationship.

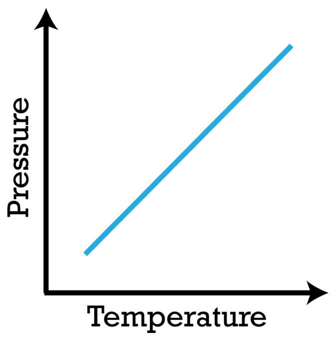

FIGURE 1.6
As the temperature of a gas increases, its pressure increases as well.

A woman checked the air pressure in her tires before driving her car on a cold day (see **Figure** 1.7). The tire pressure gauge registered 29 pounds of pressure per square inch. After driving the car several miles on the highway, the woman stopped and checked the tire pressure again. This time the gauge registered 32 pounds per square inch. Amonton's law explains what happened. As the tires rolled over the road, they got warmer. The air inside the tires also warmed. As it did, its pressure increased.

FIGURE 1.7
A tire pressure gauge measures the pressure of the air inside a car tire. Why is the pressure likely to increase as the car is driven?

Lesson Summary

- Particles of a gas are constantly moving and bumping into things. This gives gases pressure.
- The gas laws describe the relationship among pressure, volume, and temperature of a given amount of gas.

Lesson Review Questions

Recall

Apply Concepts

Think Critically

Points to Consider

In this lesson, you read that heating a gas gives its particles more kinetic energy. As a result, its volume or pressure also increases. The opposite happens when a gas is cooled.

- What might happen if you cool a gas to an even lower temperature? Might it change state and become a liquid?
- Can you predict the role of energy in changes of state?

References

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