LIFEPAC®

SCIENCE

STUDENT BOOK

11th Grade | Unit 3

Alpha Omega
PUBLICATIONS

SCIENCE 1103

GASES AND MOLES

LIFEPAC Test is located in the center of the booklet. Please remove before starting the unit.

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Gases and Moles

Introduction

This LIFEPAC® explores aspects of matter that we have looked at, but not really seen. Remember that the origin and source of all matter is God (Genesis): “In the beginning God created the heaven and the earth.” This same God provides energy for all things to exist. He continues to uphold this creation by the word of his power (Hebrews 1:3). We intend to discover and develop together the ways matter behaves and the order that this matter displays as it exists all around us. Natural laws and their regularity clearly show the masterpiece of the Designer.

Objectives

Read these objectives. The objectives tell you what you will be able to do when you have successfully completed this LIFEPAC. When you have finished this LIFEPAC, you should be able to:

1. Explain how diffusion takes place in matter.
2. Explain and use the Kinetic Molecular Theory of Matter.
3. Explain Boyle’s Law.
4. Use Boyle’s Law to solve numerical problems.
5. Explain Charles’s Law.
6. Use Charles’s Law to solve numerical problems.
7. Use the Combined Gas Law to solve problems.
8. Explain and use Avogadro’s Hypothesis.
9. Explain and use the mole concept.
10. Define and apply the Law of Conservation of Mass.

Survey the LIFEPAC. Ask yourself some questions about this study and write your questions here.

1. KINETIC MOLECULAR THEORY

Let's briefly review some ideas before we develop new concepts in this LIFEPAC. Read this section carefully.

Section Objectives

Review these objectives. When you have completed this section, you should be able to:

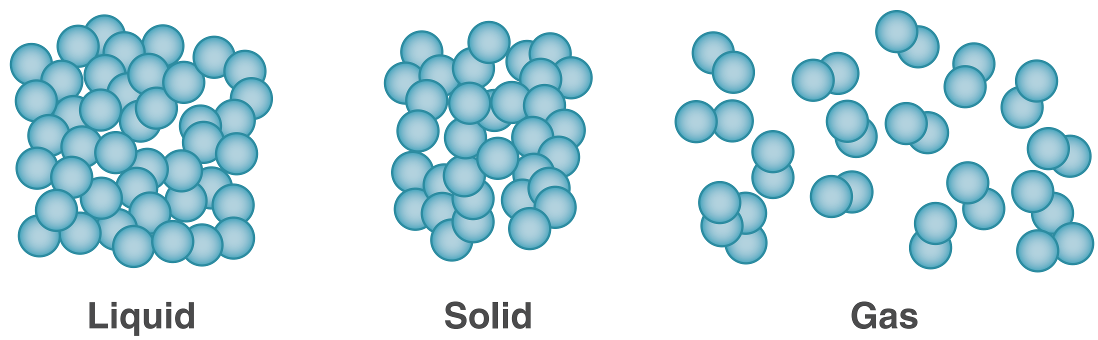
1. Explain how diffusion takes place in matter.
2. Explain and use the Kinetic Molecular Theory of Matter.

Vocabulary

Study these words to enhance your learning success in this section.

diffusion **kinetic energy** **Kinetic Molecular Theory**

Note: *All vocabulary words in this LIFEPAC appear in* **boldface** *print the first time they are used. If you are not sure of the meaning when you are reading, study the definitions given.*



| Figure 1: Phases of Matter

EVIDENCE

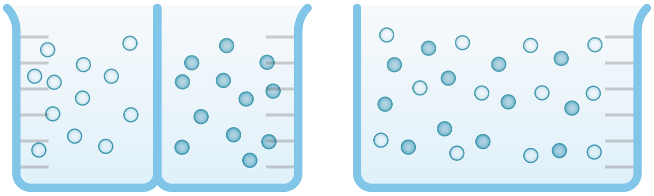
A flask may be only half full of water, but a flask is never only half full of gas. Figure 1 shows the molecular characteristics of the phases of matter. One characteristic that distinguishes solids, liquids, and gases is their shape. Solids have definite shape. They do not need a container to give them shape. Liquids assume the shape of their container, and gases expand to fill whatever volume is available.

Diffusion. A characteristic that the phases of matter have in common is **diffusion**. If pieces of gold and lead are clamped together, after a long period of time, traces of gold are found in the lead; and traces of lead are in the gold. Apparently solids are composed of moving particles.

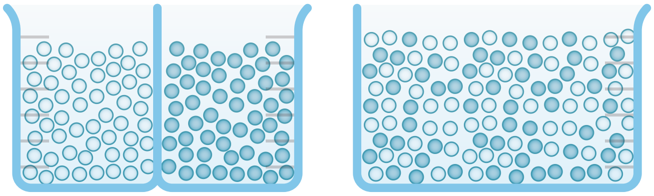
Solids diffuse in liquids, too. An example is sugar diffusing through a cup of coffee. Stirring is not necessary to get the sweet taste throughout the coffee. Diffusion results from moving particles of both solids and liquids.

Liquids also diffuse in liquids. Each liquid consists of molecules with spaces between them. When mixed, the molecules "fit together" or slip into spaces between each other.

A gas can also diffuse. You can notice someone with perfume across the room. Diffusion occurs in solids, in solids and liquids, in liquids, in liquids and gases, and in gases. How can diffusion be explained? Gases are good examples to use when studying diffusion. They diffuse very quickly, even in a closed room.



| Figure 2: Gas is mostly space



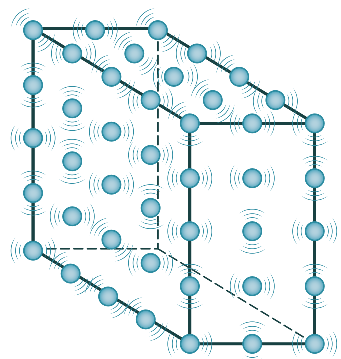
| Figure 3: Liquid particles vibrate and rotate

Figure 2 illustrates that gases consist of small moving particles with considerable space between them. These molecules are continually bumping each other. The collisions are elastic; that is, no energy is lost whatever the number of times a particle is hit. With no loss of energy, the molecules are moving all the time. The motion of the particle and the great distance between particles explains how gas molecules are able to work their way among the bouncing molecules of other gases until they are uniformly mixed.

Diffusion in liquids and solids occurs in much the same way except that the distance between liquid molecules, as seen in Figure 3, is much less than the distance between gaseous particles. The motion of molecules in solids is different. In Figure 4 it is pictured as vibratory or back and forth motion.

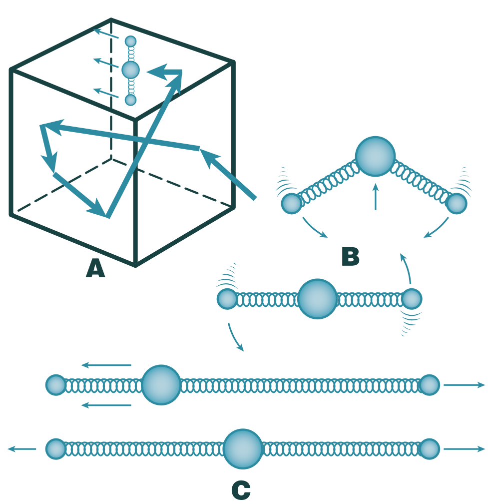
Liquids vibrate and also rotate. Gases vibrate, rotate, and have translational motion, or motion along a line. (See Figure 5.)

Pressure. A balloon, a basketball, or a bicycle tire each contain air which exerts pressure and keeps the object inflated. What causes air pressure?

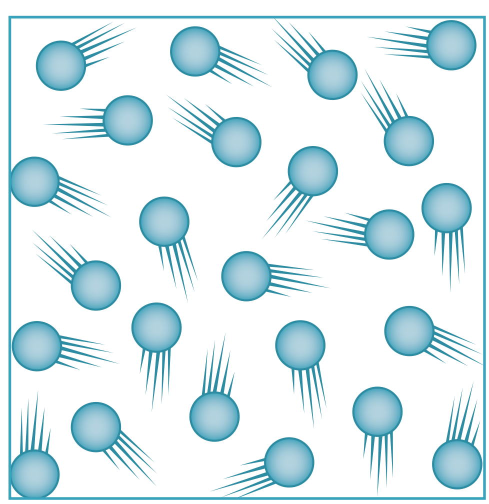


| Figure 4: Solid particles only vibrate

Air pressure is explained in terms of continually moving particles. Elastic collisions not only occur between molecules, but also between molecules and the walls of the container. A molecule strikes the wall, pushes on it, and then rebounds without losing energy. A gas contains many particles; therefore many collisions occur with the container walls. The total force of all these molecules striking and pushing against the walls is responsible for air pressure. (See Figure 6.)



| Figure 5: Gas particles move from place to place (A), rotate (B), and vibrate (C).



| Figure 6: Gases put pressure on the walls through collisions.

Complete these activities.

1.1 Explain this statement: "A flask may be only half full of a liquid, but it can never be only half full of a gas."

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1.2 A characteristic that all phases of matter have in common is ______________________ .

1.3 Apparently solids are composed of ____________________________ particles.

1.4 Diffusion occurs in solids, in solids and a. _________________________________ , in b. ______________________ , in liquids and c. __________________ , and in gases.

1.5 The collisions of molecules in gases may be described as a. ____________________ ; that is, no b. ____________________ is lost.

1.6 When the motion of molecules in gases is described, we say that molecules a. ________________ , b. ____________________ , and move along a(n) c. __________________ .

1.7 The total force of all the molecules of air striking and pushing against the walls of a container is responsible for air ___________________ .

CHARACTERISTICS

From evidence indicating that matter consists of small moving particles, scientists have developed a theory of moving molecules called the *Kinetic Molecular Theory*. Assumptions of the Kinetic Molecular Theory include the following statements:

1. Matter, in all phases, consists of very small particles.
2. Relative to their size, molecules of a gas are very far apart. In liquids and solids the molecules are much closer together.
3. The molecules of a gas are in rapid, continual, and random motion. In liquids, the motion is less extensive; the molecules move or roll over each other, but generally tend to cling together. Limited motion occurs in solids; the particles vibrate around fixed points.
4. The molecules of a gas collide with each other and the walls of their container and rebound without losing energy; all molecular collisions are perfectly elastic.
5. The attractive forces between molecules, which depend on the distance between them, are very weak in gases. In liquids and solids, where the molecules are much closer together, these forces are much stronger.
6. Temperature is a measure of the average **kinetic energy** of the molecules of a substance. The absolute temperature (Kelvin scale) of a gas is directly proportional to the average kinetic energy of the gas molecules.

Attractive forces. The Kinetic Molecular Theory can be compared to familiar situations. Molecules in a gas are spaced far apart. A gas is like a few fast moving basketball players on a large open floor. Moving molecules of a liquid are much closer together.

A liquid resembles the crowds coming into a gymnasium. The molecules of a crystalline solid are even closer together and are held in place by strong attractive forces. They vibrate in rows and layers around fixed points. A crystalline solid resembles the people seated in orderly rows in the bleachers.

Motion. As the space between molecules decreases, movement also decreases because of attractive forces between the molecules. As the space between molecules decreases, the effect of the attractive forces increases. An increase in attractive forces results in a decrease in motion. The greater forces hinder the movement of the molecules.

Whether a substance is a gas, liquid, or solid depends on the combined effect of two factors: (1) the attractive forces between molecules and (2) the extent of molecular motion as determined by the average kinetic energy or temperature.

For example, when steam cools sufficiently, it condenses to liquid water. This phase change can be explained by two factors. Cooling water vapor gives up heat to the surroundings, which decreases its molecular kinetic energy. The molecules move more slowly and come closer together. The decreased distance between molecules increases the attractive forces, and the molecules cling together to form a liquid.

When water cools sufficiently, it becomes a solid. Withdrawing heat energy from a liquid has the effect of decreasing the kinetic energy of the molecules of a liquid. At its freezing point, the molecules of a liquid take on only the vibratory motion of the molecules in the solid.

The Kinetic Molecular Theory specifically includes the term average kinetic energy. Some molecules will have more kinetic energy than the average kinetic energy and some will have less. Occasionally some of the molecules with higher-than-average kinetic energy break through the liquid surface and escape as gas. Some of these gas molecules collide with the liquid and are recaptured. Evaporation occurs when the number of molecules leaving the liquid is greater than the number returning. An evaporating liquid cools itself. As the more energetic molecules leave the liquid, the average kinetic energy decreases and the temperature is lowered. Temperature is a measure of average kinetic energy. (See Figure 7.)

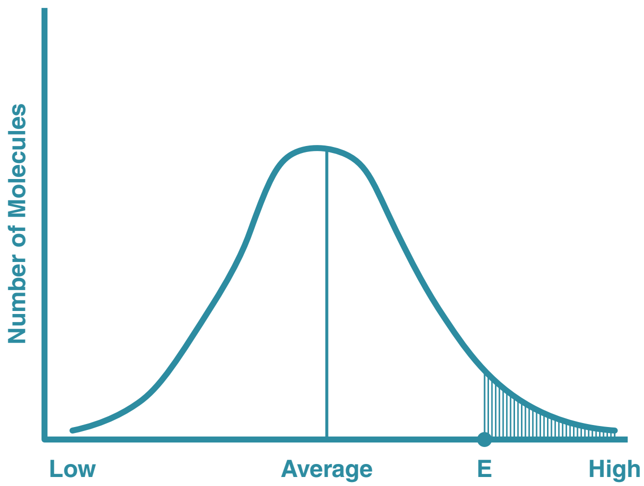
Molecules escaping from the liquid phase into the gaseous phase constitute the *vapor pressure* of the liquid. Vapor pressure is related to the molecular kinetic energy of the liquid. A rise in temperature is accompanied by an increased kinetic energy. Thus, the vapor pressure is higher at higher temperatures. A liquid reaches its boiling point when the vapor pressure becomes equal to the (air) pressure above the liquid.

The boiling point can be changed by altering the pressure above the liquid. This pressure behaves like a lid to the evaporation of the liquid. At high altitudes the atmospheric pressure is less than at sea level (standard pressure). Water at higher altitudes, therefore, boils at much lower temperature than it does at sea level.

Speed is associated with moving particles. The speeds of the molecules in the three phrases of matter are different. Gaseous particles move faster than the particles of a liquid or a solid. The speed of the particle is also influenced by the way the particle moves. Solids vibrate; liquids vibrate and rotate; and gases vibrate, rotate, and have translational motion.

If it were possible to adjust pressure and temperature so the three phases of matter could exist simultaneously, then the three phases would have the same average kinetic energy. The condition of temperature and pressure at which all three phases exist simultaneously is called the *triple point*.

Another relationship between the phases of matter that is sometimes difficult to understand is the relationship between mass and velocity. Two substances at the same temperature have the same average kinetic energy; why is one a solid and the other a



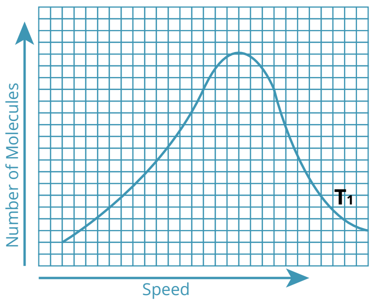
| Figure 7: Temperature measures average kinetic energy

gas? Particles of small mass and great velocity can have the same kinetic energy as a particle of large mass and low velocity. Conversely, particles of large mass need lower velocity to have the same kinetic energy as a less massive particle. A golf ball dropped on your toe from waist high does not hurt nearly as much as a bowling ball dropped from the same height, even though both have the same velocity. The inverse relationship between mass and velocity is stated mathematically as $K.E. = 1/2(mv^2)$ where m is the mass and v is the velocity of the particle.

You have learned that the main distinction between solids, liquids, and gases is the differences in their molecular motion. In crystalline solids, molecules are vibrating around fixed points. In liquids, the molecules are energetic enough to move over one another. In gases, the molecules are too excited even to keep company with one another.

Apply what you have learned.

This graph represents a population of molecules in a sample of matter versus the distribution of velocities in the population. Assume all molecules to be of the same mass.



1.8 On the graph, indicate the average kinetic energy of the population.

1.9 Explain your answer to 1.8. ______________________________

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1.10 What part of the graph indicates the temperature of the sample? ______________________________

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1.11 Explain your answer to 1.10.

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1.12 On the graph in 1.8, sketch a curve that represents the distribution of molecules at a temperature below the one shown. Label it as T_2.

1.13 Describe both T_1 and T_2 in terms of their average kinetic energy. Be specific and detailed.

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CHECK ______________ ______________
Teacher Date

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