The Cartesian Diver
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Introduction

The Cartesian Diver, named for the French philosopher, scientist, and mathematician, Rene' Descartes (1596-1650), is a popular science toy. It is commonly found in science classrooms, or perhaps you have seen the Diving Tony toy distributed in boxes of Frosted Flakes™. The Cartesian diver offers an eloquent demonstration of the most unique property of a gas, its compressibility.

Materials

One 2-liter plastic bottle with cap
One glass eyedropper and one beaker or drinking cup

Procedure

1) Fill the drinking cup or beaker about 3/4 full of water.
2) Draw water into the dropper until it is 1/3 full.
3) Place the dropper in the beaker of water. Adjust the amount of water in the dropper until it will float but is almost completely submerged.
4) Fill the bottle with water.
5) Place the dropper into the 2-liter bottle and screw the cap tightly in place.

Activity

Squeeze the bottle. What do you observe? Release the pressure and observe again.

Questions

Why does the dropper sink when you apply pressure to the bottle?

As you squeeze the bottle the pressure inside increases. Liquids are not easily compressed but gases are. Therefore, the air in the dropper compresses and allows more water to flow into the dropper. This increases the weight of the dropper. As the weight increases, the density increases until it becomes greater than the density of water. Objects that have a density greater than water will sink.

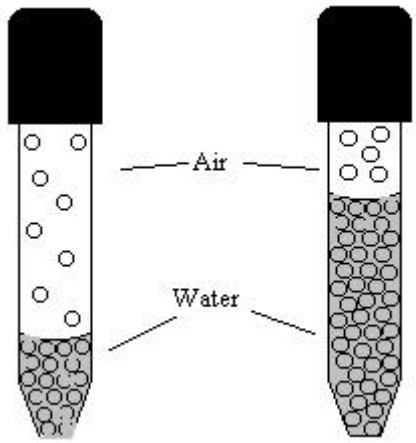
Why does the dropper float when you release the bottle?

When the bottle is released, the pressure decreases. The air in the dropper expands pushing water out of the dropper. The density of the dropper decreases until it is less dense than water. Objects with a density less than that of water will float.

Why are gases easily compressed and liquids are not?

In gases the particles are very far apart. In other words, gases are mostly empty space. When put under increased pressure, the gas molecules can move closer together and the gas will occupy a smaller volume.

In liquids the molecules are already crowded very close together. Since there is very little empty space between the molecules, an increase in pressure cannot cause much of a decrease in volume. In the drawing below circles represent molecules.



Low Pressure High Pressure

Drawing of a dropper before and after squeezing the bottle.

Note: It is incorrect to state, "The molecules of a gas are compressible." Molecules never decrease in size. The more correct statement is, "Gases are compressible." or "When gases are compressed, the molecules move closer together."