

# EXPERIMENTAL SCIENCE.

## CHAPTER I.

### PROPERTIES OF BODIES.

Extension, impenetrability, divisibility, porosity, compressibility, elasticity, inertia, and gravity are general properties common to all bodies, whether solid, liquid, or gaseous, while some bodies possess specific properties, such as solidity, fluidity, tenacity, malleability, color, hardness.

### EXTENSION AND IMPENETRABILITY.

To all matter must be attributed two essential qualities: first, that in virtue of which it occupies space, and which is

FIG. 1.



A Hatful of Cotton in a Tumblerful of Alcohol.

known as extension, and, second, that which allows only one particle or atom of matter to occupy a given space—the



property known as impenetrability. That matter occupies space is appreciated by our senses, and needs no particular proof, but that two portions of matter cannot occupy the same space at the same time sometimes seems anomalous, as is shown by some of the following experiments.

Into a tumbler filled with alcohol may be crowded a hatful of loose cotton without causing the alcohol to overflow.\* The success of the experiment depends upon the slow intro-

FIG. 2.



Solution of Sugar in Water.

duction of the cotton, allowing the alcohol to invest the fibers, before they are fairly plunged beneath the surface of the alcohol.

In this experiment the penetration of the alcohol is only apparent; the fibers displace some of the alcohol, but the quantity is so small as not to be observable. If the cotton were compressed to the smallest possible volume, it would be found to occupy but very little space. So small a body

\* See also chapter on projection.

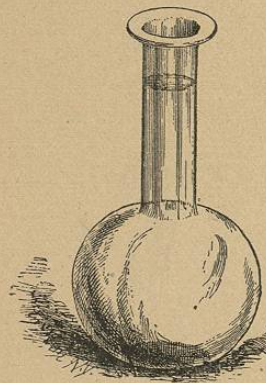
would be incapable of raising the level of the alcohol enough to be appreciable by an ordinary observer.

A more puzzling experiment consists in slowly introducing some fine sugar into a tumblerful of warm water. A considerable quantity of sugar may be dissolved in the water without increasing its bulk appreciably.

Here the physicist is forced to acknowledge that either the water is penetrated or its atoms are so disposed as to receive the sugar between them, possibly in the same way as a scuttle filled with coal might contain also a bucketful of sand. This latter view is adhered to. The atom or ultimate particle is held to be impenetrable.

In the case of the mixture of water and alcohol, or water

FIG. 3.



Representing Volume of Unmixed Alcohol and Water.

FIG. 4.



Reduction of Volume of Alcohol and Water Mixture.

and sulphuric acid, a curious phenomenon is presented. Take alcohol and water for example. Equal volumes of alcohol and water, when mixed, occupy less space than when separate. If the sum of the volumes of the two separate liquids is 100, the volume of the mixture will be only 94. In the case of the mixture of sulphuric acid and water, the difference is greater.

An easy way to perform this experiment is to fill a narrow-necked flask up to a line which may conveniently be marked by a rubber band around the neck, then removing one-half



of the water, measuring it exactly, and replacing it with a volume of alcohol exactly equal to that of the water removed. It will be found that when the liquids are mixed, the mixture will not fill the flask up to the original mark.\*

The only reasonable explanation of this phenomenon is that the molecules of the two liquids accommodate themselves to each other in such a manner as to reduce the pores, and thus diminish the volume of the mixture.

#### DIVISIBILITY.

The property of a body which admits of separating it into distinct parts, and which is known as divisibility, is possessed by all matter. An example of extreme divisibility is found in the coloring of a pail of water with a minute particle of aniline.

#### POROSITY.

There are two kinds of pores, viz., physical or intermolecular pores and sensible pores. In the case of the former, the interspaces are so small that the molecules are within each other's influence and may attract or repel each other. Expansion by heat, contraction by reduction of temperature, and reduction of volume by compression are among examples of phenomena rendered possible by the existence of physical pores.

Sensible pores are small cavities or spaces, across which molecular forces are unable to act.

The experiment illustrated by Fig. 5 shows the existence of sensible pores. In the neck of an Argand chimney is inserted a plug of Malacca wood, which is sealed around the periphery with wax or paraffine. In the top of the chimney is inserted a stopper, through which projects a short glass tube, having its upper end bent over or capped with a small test tube. To the outer end of the glass tube is applied a rubber tube. When the chimney is in an inverted position, as shown in the engraving, a quantity of mercury is placed in the larger part of the chimney, and the air is partly exhausted from the chimney, by applying the mouth to the

\* See also chapter on projection.

rubber tube and sucking. The mercury readily passes through the porous wood and falls in a shower. By employing an air pump for producing the partial vacuum, the mercury may be drawn through a plug of pine. These experiments show in a striking manner the porosity in a longitudinal direction of these pieces of wood.

Wood, vegetable, and animal tissues, sponge, pumice stone, and many other substances have sensible pores that

FIG. 5.



Mercurial Shower.

may readily be seen. Physical pores cannot be seen, even by the aid of the most powerful microscope; but their existence is proved by the fact that all bodies may be compressed or diminished in volume.

Sensible pores play an important part in the operations of nature, especially in the vegetable and animal kingdoms.

The property of porosity is utilized in the arts, in the



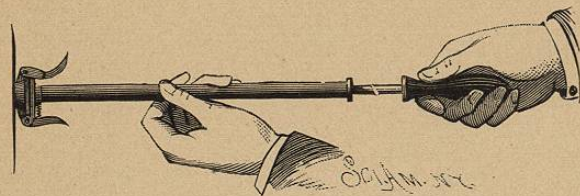
filtration of liquids, in the absorption of liquids and gases, in electrolytic processes, in assaying, etc.

#### COMPRESSIBILITY.

The property by virtue of which a body may be diminished in volume, by pressure, without losing weight, is known as compressibility. This property is possessed in the greatest degree by gases, which may be reduced by compression to from one-tenth to one-hundredth their original volume.

The simplest piece of apparatus for showing the compression of a gas is a well-made toy popgun, such for example as that shown in Fig. 6. By closing the mouth of this gun by means of a piece of sheet metal or mica, and oiling

FIG. 6



The Popgun used as a Pneumatic Syringe.

the piston well with a heavy oil, to prevent the escape of air from the barrel, it may readily be shown that the air contained by the barrel may be greatly reduced in volume by simply pushing in the piston.

#### ELASTICITY.\*

When a body resumes its original form or volume after distortion or compression, it possesses the property of elasticity, and is therefore known as an elastic body. Elasticity may be shown by pressure, by bending, by torsion or twisting, or by tension or stretching. Gases and liquids are perfectly elastic. When compressed and afterward allowed to

\* See also chapter on projection.

return to their original pressure, they are found to possess exactly their original volume.

Among solids, glass is apparently perfectly elastic. A plate of glass bent under pressure and allowed to remain under stress for twenty-five years, when released and carefully tested for any permanent set, was found to have returned to exactly its original shape. Elasticity by flexure or bending is seen in various springs, such as carriage springs, gun-lock springs, etc.

The elasticity of torsion is exhibited by door springs of certain forms, spiral springs, and by twisted threads of cotton, linen, and other material. The elasticity of tension is shown in the strings of all stringed musical instruments, and notably in soft rubber in its various forms.