slit mechanism of the regular spectroscope for narrowing the source of light to an exceedingly fine line is also omitted, the extreme tenuity of the spark enabling the latter to act as its own "slit."

There is a position of maximum efficiency for the prism relative to the axis of the tubes of the opera glasses which is found as follows: With the prism first adjusted so that its front or outward face is perpendicular with the base board, look through the instrument at a candle flame, or other luminous object until its colored spectrum is seen. Now, holding the instrument quite steady, begin slowly revolving the prism's upper edge forward. The spectrum of the flame will be seen first to rise slightly, then come to a standstill, and finally begin to descend. When the flame spectrum is at its highest point or position of temporary rest the proper adjustment has been attained, and it will now be found that the prism's front face makes an angle of about 76 deg. with the base board. The prism has now been set to the "position of minimum deviation," the condition sought by the spectroscopists for maximum efficiency.

The sparks to be viewed should be not less than four inches in length, and must be the bright detonating discharges from the Leyden jars of the machine. In using the instrument the prism is held parallel with the general direction of the spark's axis, and at a distance from it of about fifteen feet.

A long spark viewed through the instrument in a darkened room presents a beautiful and interesting appearance. The spark, with all its many eccentricities of form, divides itself laterally into numerous brilliant variously colored separate counterparts of itself, arranged in beautiful sinuous parallel strata, the light of different wave lengths each producing its own distinct characteristically colored spark image or "line."

While the accompanying illustration may give a fair impression of the general aspect of the spectrum as to detail of form, it can of course afford no conception of the brilliant diversities of color and exquisite contrast and gradations of tint and luminous intensity which the various spark groupings and lamina present. The spectrum is crossed in many places by dark lanes or vacant spaces telling their story of missing wave lengths; while among the brighter separate lines are two especially prominent ones, a gleaming yellow, and farther down a fine bright metallic green. Owing to the advantages of binocular vision here afforded the spectrum has a beautiful appearance of transparency and relief difficult to describe.

If the influence machine is of sufficient power to produce six or eight inch sparks in an apparently continuous stream the spectrum of such a discharge becomes a magnificent sight. The constant contortions of the discharge cause the spectrum to become a writhing, waving band of gleaming colors, striped and lined with quivering bars of many hues like a fiery flag threshing in violent winds.

Careful attention must be given to proper focusing of the opera glass, much of the clearness of lineation depending upon this consideration. A curious modification of the appearance described above may be effected as follows: Hold the instrument to the eyes and slowly rotate the prism forward until the spectrum descends to its lowest position, keeping the spectrum constantly in view by following up its downward movement with a corresponding lowering of the instrument, until the spectrum has reached its last possible position of visibility. When this condition is attained the spectrum has lost much of its brilliancy and many of its separate lines; but those that do remain, of which there are still several bright ones, have become perfectly straight, giving the spectrum the familiar straight line aspect of ordinary spectroscopy. This seems an interesting circumstance in view of the extremely crooked nature of the "slit" in the present instance.

SIMPLE EXPERIMENTS WITH CARBONIC ACID GAS.

BY A. J. JARMAN.

Many very interesting experiments may be performed with carbonic acid, that do not call for any elaborate apparatus. The following suggestions are particularly adapted for the novice.

A few articles will be required, such as lime water, bicarbonate of soda, and four ounces of sulphuric acid, and a couple of pieces of glass tubing 8 inches long with a bore of 3/16 inch in diameter. If the lime water is not readily procurable, it can be easily made in the following manner: Procure three or four pieces of quicklime about the size of one's fist. Place these in a stone pitcher. Pour about four pints of cold water upon them. The quicklime will soon disintegrate, or slake as it is termed. The mixture must be well stirred. It will also become very hot. Now allow it to stand in a cool place for twelve hours, and then pour off the clear liquor, after removing the slight film that forms on top (this thin film is carbonate of lime). The clear liquor is the lime water required, and must be kept in a well-corked bottle. About 1½ pints will be the result, and this must be quite free from deposit.

Pour a small quantity of this liquor, about 2 ounces by measure, into a clean glass tumbler; take one of the pieces of glass tubing, and place one end into the mouth, allowing the other end to dip far down into the lime water. Now blow the breath through the lime water, causing it to bubble actively, when it will be found in the course of about half a minute that the lime water has become turbid. Continue the blowing for another half minute, and then examine the liquid. There will be found a moderately dense white deposit. This deposit is carbonate of lime, produced by the carbonic acid gas contained in the breath, combining with the lime in the water. Several such tests should be made, and the whole placed in a small glass funnel fitted with a clean light filter paper. The paper should be weighed before filtering and again after the filtered matter has dried upon the paper. The excess of weight will represent the carbonate of lime, or chalk, the carbonic acid gas (CO_2) in the breath having been produced by the combustion of the carbon contained in the food by the oxygen in the air we breathe.

Place into a glass tumbler a teaspoonful of bicarbonate of soda; add 2 ounces of cold water. Prepare in another tumbler a mixture of 3 ounces of water and 2 drachms of sulphuric acid. Stir this with a glass rod. Pour 1 ounce of this liquid into the bicarbonate of soda solution; considerable effervescence will occur. Now dip a lighted match into the upper portion of the tumbler; it will become extinguished instantly. Dip a lighted wax taper into it; this light will also become extinguished. Add another ounce of the acid solution to the bicarbonate, and then during effervescence carefully tilt this tumbler so as to pour the invisible gas above the liquid into an empty tumbler. (Do not allow any of the liquid to pass.) Upon dipping a lighted taper or match into this apparently empty tumbler, it will become immediately extinguished. This experiment, which is shown in Fig. 2, proves that carbonic acid gas, although invisible, has weight, and may be poured just like a liquid.

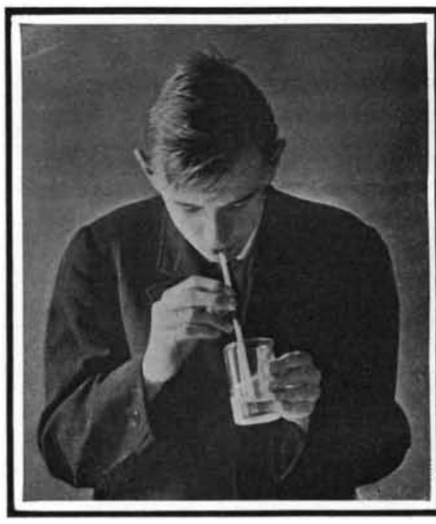
Now place a clean, dry, empty tumbler upon a scale pan, and adjust the scale so that the tumbler balances. Pour another ounce of the acid into the bicarbonate tumbler after adding another teaspoonful of bicarbonate of soda. While the mixture is effervescing pour the gas (not the liquid) carefully into the tumbler on the scale pan. Almost instantly the balance beam will turn, and the tumbler will go down suddenly, showing that the gas has not only weight, but is also a very heavy gas (Fig. 3). It is because of its great weight that this gas remains within the workings of a coal mine after an explosion; hence the name "after damp."

The following experiment, if carried out carefully, will prove the value of plant life in absorbing carbon and restoring oxygen: Procure a large glass fish globe; pluck some fresh leaves from a grapevine, fill the globe three parts full, generate some carbonic acid gas as above described, and fill the globe by testing with a lighted taper. Then place the globe, covered with a well-fitting dinner plate, into bright sunlight. Allow it to stand for about an hour, after which insert a lighted taper. Instead of instant extinction of the light, a surprising reverse effect will be produced. The light of the taper will burn more brilliantly than in common air, although not quite as brilliant as in pure oxygen. It will illustrate that the vital energy of the freshly plucked leaves possesses the wonderful property of retaining the carbon of the carbonic acid gas and liberating the oxygen.

Although carbonic acid gas is quite invisible in its ordinary state, and is also transparent, it may be shown to contain carbon by the following experiment: Obtain what is known as a small combustion tube, from any dealer in chemical glassware, shaped like the one shown in Fig. 4. Place in the bulb a pellet of the metal potassium, about the size of a pea, or perhaps two pieces will determine the question better. Now attach a piece of rubber tubing to the end of the combustion tube, and apply it to the outlet of the gas bottle as shown, having previously placed in the bottle one ounce of bicarbonate of soda and four ounces of water. Place the flame of a spirit lamp or Bunsen burner beneath the bulb, and pour into the thistle tube 1 ounce of diluted sulphuric acid. Immediately the carbonic acid gas (CO_2) is liberated, and on passing over the melted potassium the oxygen combines with the metal, and the carbon becomes deposited as a black powder. The generation of the gas must be repeated two or three times; the India rubber tube disengaged, and the combustion tube allowed to become cold. The bulb may now be broken, and the contents placed in a clean tumbler or glass beaker, and 2 ounces of distilled water added. If a trace of the metal potassium remains, it will instantly ignite the hydrogen contained in the water. This will prove of no consequence. Add 1 ounce more of water, then place the whole of the contents in a clean filter paper fitted into a glass funnel. When filtered, pour 4 ounces more of distilled water in the filter paper. When this has passed through, dry the paper. The black powder is the carbon (or charcoal) contained in the gas. In all these experiments, where bicarbonate of soda has been used in combination with diluted sulphuric acid, the latter has combined with the soda, forming sulphate of soda, while the carbonic acid contained in the bicarbonate has become liberated. Many substances can be used, such as granulated marble, common chalk, carbonate of lime. Bicarbonate of soda is best suited for all experimental purposes.

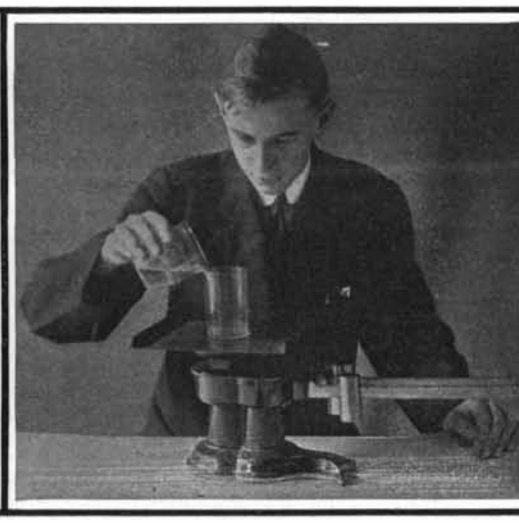
When we consider that an adult draws in at each respiration about forty cubic inches of air, and in the course of twenty-four hours respires four to five thousand gallons, it will be readily seen that a human being generates an enormous quantity of carbonic acid gas. This fact alone should prove the necessity of good ventilation in our dwelling rooms, and the sleeping apartments in particular.

The following simple experiment will prove the presence of carbonic acid in a close sleeping apartment: Pour a quantity of the lime water previously described into a large tea saucer. Allow it to stand upon a stool or box about one foot from the floor. In the morning it will be found that a slight crust has formed all over the surface. Upon tapping this crust with the handle of a teaspoon, the broken crust will fall to the bottom. Draining off the clear liquid, this crust will be found to be carbonate of lime, formed by the carbonic acid from the breath and partly from combustion.

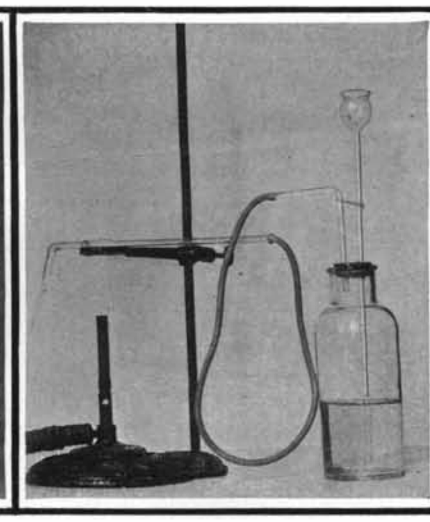


1.—Producing carbonate of lime.

2.—Extinguishing a lighted taper.



3.—Weighing carbonic acid gas.



4.—Depositing carbon from gas.