

are called *anions*. Now the hydrogen ( $H$ ) atoms are always charged positively, and these ions of the water ( $H_2O$ ), or other electrolyte, collect at the *negative* electrode, which is the carbon connected with the zinc pole of the battery, while the oxygen ( $O$ ) atoms are always charged negatively, and these ions collect at the *positive* electrode, which is the carbon connected with the carbon pole of the battery, as shown in Fig. 73.

**How to Make Synthetic Water with an Electric Spark.** Since oxygen ( $O$ ) and hydrogen ( $H$ ) are obtained when water ( $H_2O$ ) is decomposed, these two gases should form water ( $H_2O$ ) when they are chemically combined, and this they do. The apparatus for this experiment is rather costly and is not altogether easy to make, but as it proves that oxygen ( $O$ ) and hydrogen ( $H$ ) when they combine form water ( $H_2O$ ), I will tell you how to do it.

First, you need a piece of apparatus called a eudiometer, and this consists of a long glass test tube; a pair of platinum wires are sealed in the wall of the tube near the closed end and form a spark gap, as shown in Fig. 74. The outside ends of the wires are connected with a small induction coil, or *spark coil*, as it is usually called, and this is energized by a battery, as shown in Fig. 75.

Now fill the eudiometer full of mercury ( $Hg$ ), so that

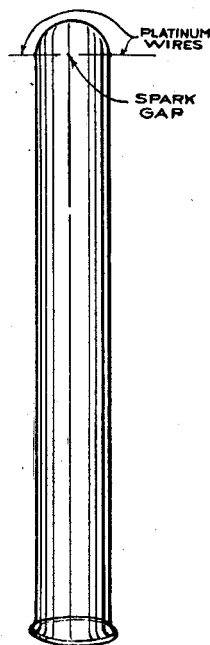


FIG. 74.—The Eudiometer.

there will be no air in it, then invert it in a bowl of mercury ( $Hg$ ) and keep it in an upright position with the aid of the ring-stand, as in Fig. 76. The next step is to place the free end of the delivery tube of your oxygen generator, which is shown in Fig. 42, under the mercury ( $Hg$ ) and in the mouth of the eudiometer, and pass enough oxygen ( $O$ ) into it to displace about 1 inch of the mercury ( $Hg$ ). This done,

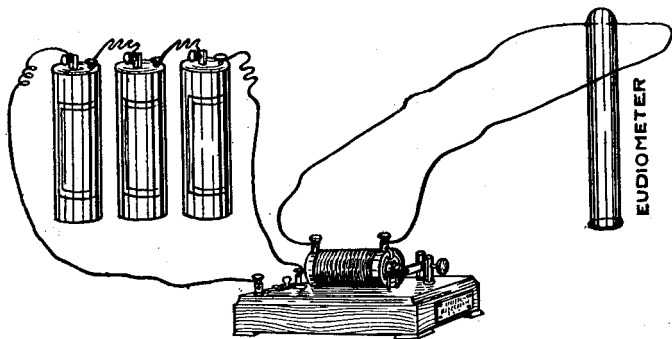


FIG. 75.—The Eudiometer Connected with the Spark Coil.

withdraw the tube and insert one that is connected with your hydrogen generator, which is shown in Fig. 72, and pass enough hydrogen ( $H$ ) into it to displace 2 inches more of mercury.

Now as long as these two gases in the tube are merely *mixed* they will remain in this condition for a long time, but the moment a spark is made to pass between the points of the platinum wires in the eudiometer, it will ignite them, a little explosion will take place, and they will combine chemically and form a minute quantity of water ( $H_2O$ ).

**How to Make Synthetic Water with an Alcohol Flame.**

You do not need the elaborate apparatus just described to produce water ( $H_2O$ ) synthetically; instead here is a very simple way in which you can generate hydrogen ( $H$ ) and make it combine with the oxygen ( $O$ ) of the air, and form water ( $H_2O$ ).

Put a little methyl alcohol ( $CH_3OH$ ), or wood alcohol,

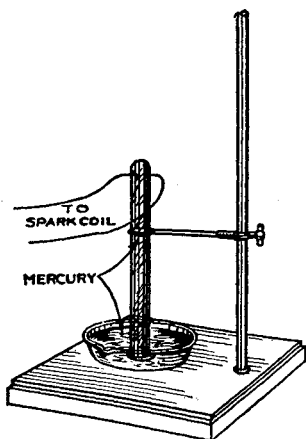


FIG. 76.—The Eudiometer Ready for the Experiment.

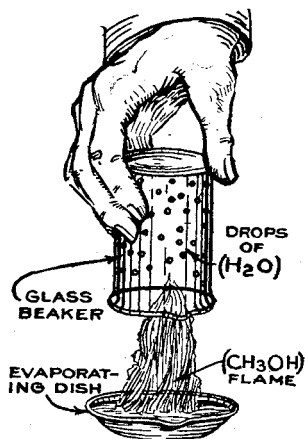


FIG. 77.—Producing Water with an Alcohol Flame.

as it is called, into your evaporating-dish and light it. Now hold a perfectly dry cold beaker over the flame, and very soon minute drops of water ( $H_2O$ ) will form on the inside surface of it, as shown in Fig. 77.

**How the Experiment Works.** The alcohol ( $CH_3OH$ ) contains, as the formula just given shows, 4 atoms of hydrogen ( $H$ ) and the heat of the flame makes the oxygen ( $O$ ) of the air combine with it, so that water ( $H_2O$ ) is formed.

**How to Make Hydrogen.** This is the usual way that hydrogen ( $H$ ) is made for experimental purposes. First, cut up a piece of sheet zinc ( $Zn$ ) into bits, or better, get some granulated zinc ( $Zn$ ) and put the zinc into an Erlenmeyer flask; now seal a glass delivery tube and a funnel tube, commonly known as a "thistle tube" from its shape, in a cork with sealing wax and put this into the mouth of the flask. Make it tight, or the hydrogen ( $H$ ) will leak out.

This done, pour a little sulphuric acid ( $H_2SO_4$ ), or *oil of vitriol*, as it is sometimes called, into the flask and add 5 or 6 times its volume of water ( $H_2O$ ), and the zinc ( $Zn$ ) will instantly act on it; the solution will boil and a great deal of heat will be evolved and a large amount of hydrogen ( $H$ ) will be set free. As hydrogen ( $H$ ) is so much lighter than the air, it can be collected in an inverted bottle, as shown in Fig. 78, where it will displace the air and remain for some time.

**How the Experiment Works.** When the zinc ( $Zn$ ) acts on the sulphuric acid ( $H_2SO_4$ ) the hydrogen ( $H$ ) of the latter is set free and the zinc ( $Zn$ ) takes its place, forming zinc sulphate ( $ZnSO_4$ ) which, as its formula shows, contains zinc ( $Zn$ ), sulphur ( $S$ ), and oxygen ( $O$ ). The zinc sulphate ( $ZnSO_4$ ) thus formed is dissolved in the water ( $H_2O$ ) of the acid, but you can easily recover it by evaporating the solution, upon which it will remain in the dish as a white solid.

NOTE.—Whenever you make hydrogen ( $H$ ), you should never light it until it has passed off from the generating apparatus for at least 5 minutes. This is because there is always air mixed with the first of the gas that passes off,

and this forms a very explosive mixture, due to the oxygen ( $O$ ) of the former.

It is also a good plan to wrap a cloth around the flask, so that if there should be an explosion the flask will not fly to pieces. Further, always make a test of the gas first, and this you can do by filling a test tube with it and light-

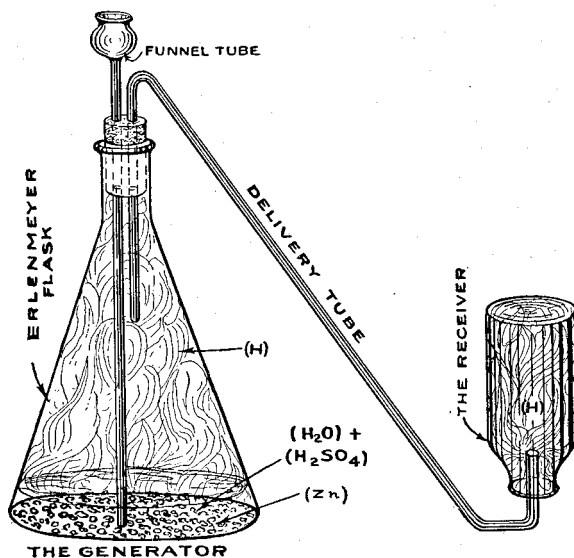


FIG. 78.—How to Make Hydrogen.

ing it; if it burns quietly, you can then safely light it as it issues from the delivery tube.

**How to Make Hydrogen without an Acid.** Put 1 ounce of potassium hydroxide ( $KOH$ ), which is commonly called caustic potash, in an Erlenmeyer flask, or one of the ordinary kind, add  $\frac{1}{2}$  ounce each of fine granulated zinc ( $Zn$ ) and some iron turnings ( $Fe$ ) and then cover these over with

water ( $H_2O$ ). This done, fit a cork with a delivery tube in it into the neck of the flask; a reaction is now set up in which the hydrogen ( $H$ ) is liberated, and this you can collect in another tube, or you can light it at the tip of the delivery tube.

**How the Experiment Works.** The zinc ( $Zn$ ) acts on the potassium hydroxide ( $KOH$ ) and forms potassium ( $K$ ),

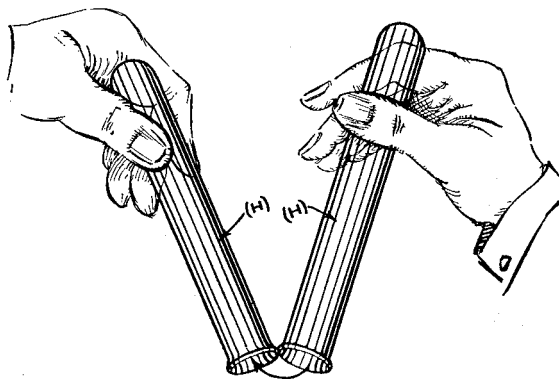
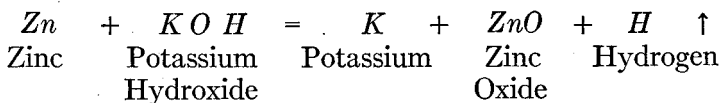


FIG. 79.—How to Pour Out Hydrogen.

zinc oxide ( $ZnO$ ), and hydrogen ( $H$ ), which is set free. By writing this reaction in the form of an equation<sup>1</sup> it is made clearer because of its brevity, thus:



Note:—Wherever you see an arrow pointing up in an equation you will know that the preceding substance is a gas.

<sup>1</sup> The nature of an equation is explained in Chapter X.

**How to Pour out Hydrogen.** Since hydrogen ( $H$ ) is about  $14\frac{1}{2}$  times lighter than air, if you want to transfer it from one vessel to another you must pour it upward, as shown in Fig. 79. To do this, take a test tube and fill it with hydrogen ( $H$ ), then hold another test tube vertically with its mouth down; hold the full tube vertically at first with its mouth down, with the edge of it touching the edge of the other one; now lower the closed end of the full tube and the gas will ascend and you will have performed the feat of pouring it up.

**The Diffusion of Hydrogen.** Take two test tubes and fill one with hydrogen ( $H$ ) and, of course, hold it with its mouth down to keep the hydrogen ( $H$ ) in. Hold

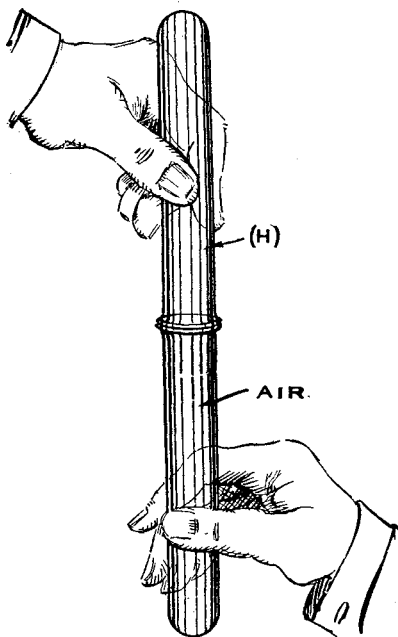


FIG. 80.—The Diffusion of Hydrogen.

another test tube with air in it with its mouth up and place the tubes together, as shown in Fig. 80. Since air is so much heavier than hydrogen ( $H$ ), it would seem that they would remain separated in their respective tubes, but such, however, is not at all the case; after a little while the hydrogen ( $H$ ) sinks into the air just as though gravity were pulling

it down, and this curious effect is called *diffusion*. The same action takes place when you open a bottle of perfume and its scent penetrates the air everywhere in the room.

**How to Make a Hydrogen Flame.** To make a hydrogen (*H*) flame, all you need to do is to take the rubber bulb

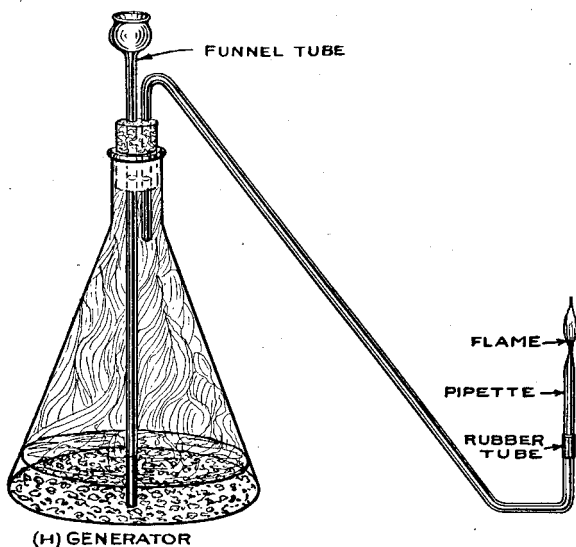


FIG. 81.—How to Make a Hydrogen Flame.

from a pipette and couple the large end of it with the free end of the delivery tube of your generating apparatus by means of a bit of rubber tubing, as shown in Fig. 81. Before lighting the gas at the tip of the pipette, be sure to let the generator run at least 5 minutes to get rid of all of the air or else you are liable to have an explosion, as explained under the caption of "How to Make Hydrogen."



**How Hydrogen Acts on Flame.** Take a large test tube full of hydrogen ( $H$ ) and keep it inverted, as shown in Fig. 82. Now light a match and hold it to the mouth of the tube and the gas will catch fire and burn with an almost invisible flame, which will work its way into the tube and

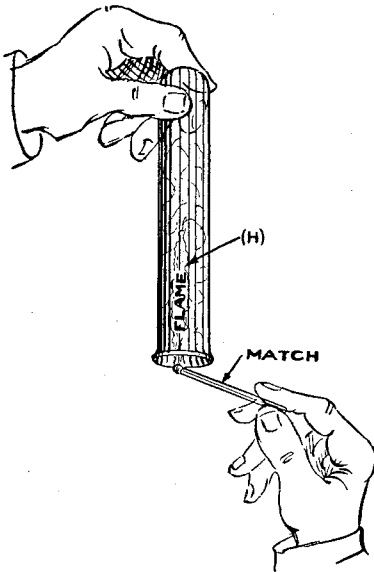


FIG. 82.—The Hydrogen Burns Gently.

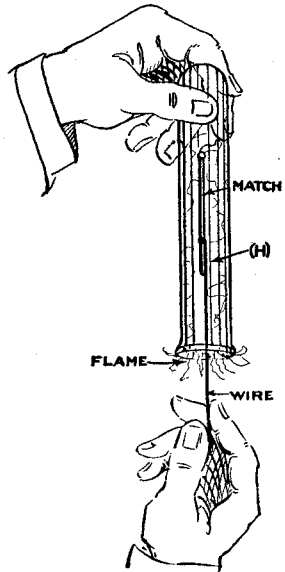


FIG. 83.—The Match is Extinguished.

finally go out. This experiment shows that hydrogen ( $H$ ) is a combustible gas.

Twist a wire around a match and light it. Now take another test tube of hydrogen ( $H$ ), hold it mouth downward as before, quickly push the lighted match up to the top of the tube, as in Fig. 83, and it will go out, though

the gas will burn at the mouth. This experiment shows that hydrogen ( $H$ ) will not support combustion.

Finally, take another test tube full of hydrogen ( $H$ ), hold it mouth upward, as in Fig. 84, and touch a lighted match to the mouth of it, and there will be an explosion. This experiment shows that when hydrogen ( $H$ ) and oxygen

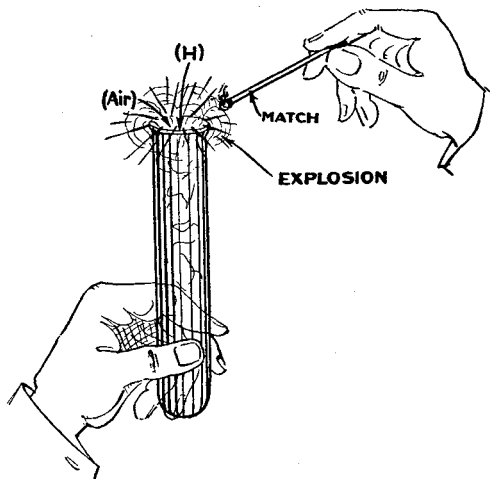


FIG. 84.—The Hydrogen Mixed with Air Explodes.

( $O$ ) come in contact with each other they form an explosive mixture.

**How to Blow Hydrogen Soap Bubbles.** Connect a bladder<sup>1</sup> or, better, a small rubber gas bag, to the delivery tube of your hydrogen-generating apparatus, fill it with gas, and

<sup>1</sup> To prepare a bladder for use as a gas bag, rub it well with a mixture of 1 part of glycerine and 2 parts of water. A rubber gas bag is cheap, clean, and convenient and can be bought of dealers in chemical apparatus.