DISCOVERY OF INFLAMMABLE AIR

TOPIC:

Gases

SCIENTIST:

Henry Cavendish 1731–1810

INTRODUCTION:

The end of the eighteenth century was a time of great expansion in chemistry in general, and in the study of gases in particular. Air, once thought to be a single element, was now recognized to be a mixture of gases. Henry Cavendish made one of many contributions to the study of gases in 1766. In that year Cavendish published his experiments on "factitious airs," describing gases released by the action of acids on various substances. He showed that by treating zinc or iron with dilute acid, a gas was produced that burned with a popping sound when lit in air. He called this new gas "inflammable air"; now we call it hydrogen. Later, in 1781, he found that "when inflammable air and common air were exploded in a proper proportion, almost all the inflammable air, and near one-fifth of the common air, lose their elasticity [*i.e.*, disappear as gases] and are condensed into dew. And by this experiment it appears that this dew is plain water, and consequently that almost all the inflammable air, about one-fifth of the common air, is turned into pure water." Cavendish had shown that hydrogen burned in air to produce water, and that about one-fifth of the air—the oxygen—was used up in the process.

TIME NEEDED:

1 hour

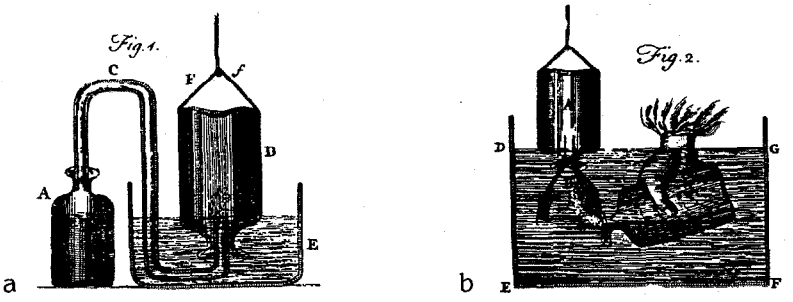
MATERIALS:

250-ml Erlenmeyer flask with side arm
glass delivery tube
10–15 cm of rubber tubing to link side arm to delivery tube
small buret
rubber stopper to fit Erlenmeyer flask with central hole through which end of buret fits
filter funnel
dishpan
wooden splints
ring stand with clamp
1M sulfuric acid
zinc granules
copper sulfate solution
eyedropper
teaspoon
2 test tubes with stoppers
test tube rack
safety goggles
bunsen burner or spirit lamp

Original Materials:

Cavendish's materials were not so different from the materials you are using. In an interpretation of a print made in Cavendish's time, figure 1a shows hydrogen being produced and collected, while figure 1b shows hydrogen being transferred to a storage vessel.

Figure 1



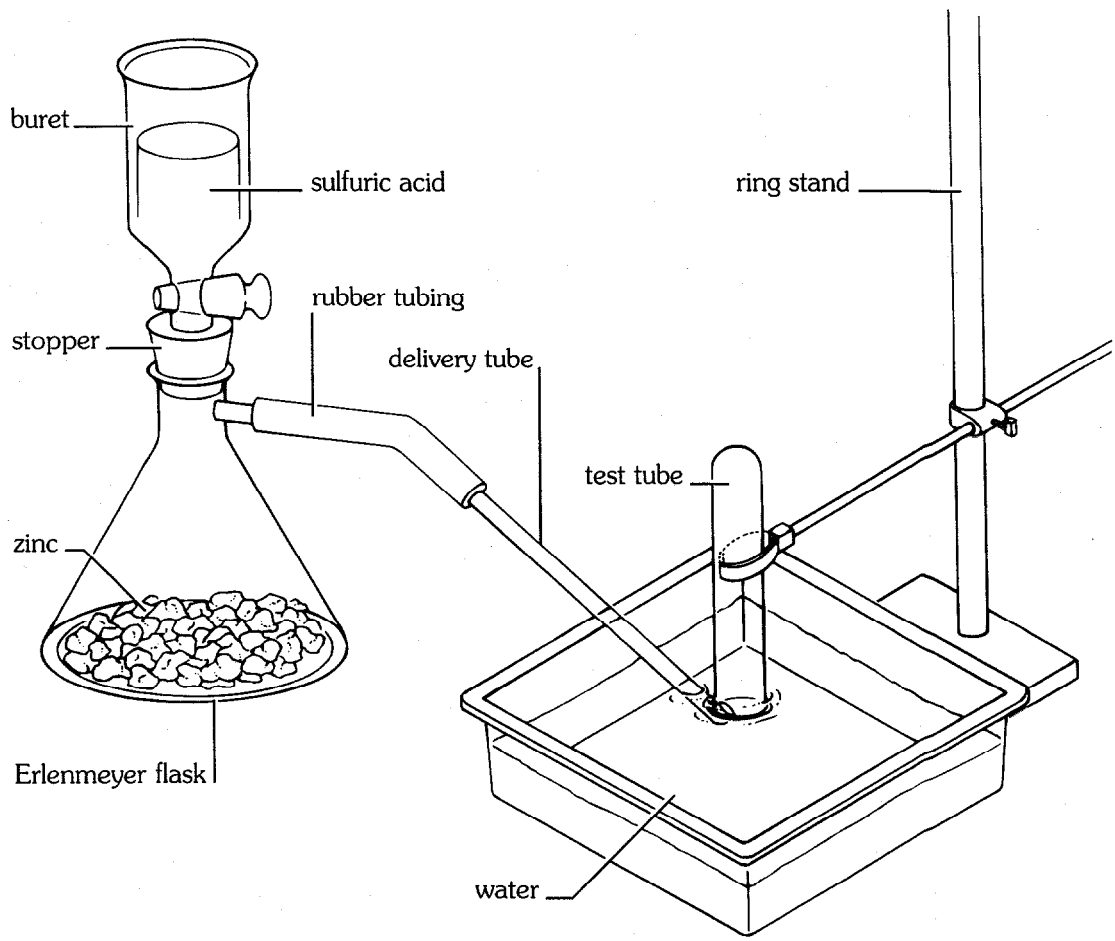
Safety Precautions

Adult supervision required. Please read and copy the safety precautions at the beginning of this book. Safety goggles must be worn while carrying out this experiment.

PROCEDURE:

1. Ask the adult to push the bottom of the buret through the hole in the rubber stopper.
2. Put 6 spoonfuls of zinc granules into the Erlenmeyer flask. Add a few drops of copper sulfate solution to the zinc (to act as a catalyst).
3. Put the stopper with the buret into the Erlenmeyer flask.
4. Attach the delivery tube to the side arm of the Erlenmeyer flask using the length of rubber tubing.
5. Half fill the dishpan with water.
6. Adjust the position of the Erlenmeyer flask so that the delivery tube is pointing into the dishpan, with the end of the delivery tube under water (see figure 2).

Figure 2



7. Place a test tube in the dishpan and fill it with water. Without removing it from the water, turn the test tube upside down and clamp it, using the ring stand, with its opening over the end of the delivery tube (see figure 2).
8. Put the safety goggles on. Make sure the buret stopcock is closed. Put the funnel into the top of the buret. Half fill the buret with sulfuric acid.
9. Open the stopcock of the buret slightly to allow the sulfuric acid to drip onto the zinc granules. Observe what happens.

10. Place the bunsen burner or spirit lamp away from the Erlenmeyer flask. Light the bunsen burner or spirit lamp. Adjust the flame so that it is small.

11. When the test tube has filled with gas, put your finger securely over its open end under the water, loosen the clamp, and remove the test tube from the dishpan. Remove your finger and immediately replace it with a stopper. Put the test tube in the test tube rack.

12. As in step 7, immediately fill another test tube with water in the dishpan and replace it over the end of the delivery tube.

13. Take the first test tube from the test tube rack. Take a wooden splint and light it. Remove the stopper from the test tube and immediately put the lighted end of the splint into it. Record your observations.

14. When the second test tube has filled with gas, close the buret stopcock. Remove the test tube from the clamp and ring stand, holding your finger over the open end and then replacing it with a stopper, as in step 11. Test the gas inside the test tube as in step 13. Turn off the bunsen burner or spirit lamp. Remove the delivery tube from the dishpan.

ANALYSIS:

1. What happened when you added sulfuric acid to the zinc granules?
2. What happened when you pushed the lighted splint into the first test tube of gas?
3. What happened when you pushed the lighted splint into the second test tube? Did this observation differ from your observation in 2?
4. How can you explain your observations in this experiment?

OUR FINDINGS:

Click on above link to see what we found.

SPECIAL SAFETY NOTE TO EXPERIMENTERS

Each experiment includes any special safety precautions that are relevant to that particular project. These do not include all of the basic safety precautions that are necessary whenever you are working on a scientific experiment. For this reason, it is absolutely necessary that you read, copy, and remain mindful of the General Safety Precautions that follow this note.

Experimental science can be dangerous, and good laboratory procedure always includes carefully following basic safety rules. Things can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following basic safety guidelines the *entire* time you are performing the experiment, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual experiments. We made this choice for one reason: We want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical to your safety.

One further note: The book assumes that you will read the safety precautions that follow, as well as those in the box within each experiment you are preparing to perform, and that you will *remember* them. Except in rare instances, these precautions will not be repeated in the procedure itself. It is up to you to use your good judgment and pay attention when performing potentially dangerous parts of the procedure. Just because the book does not say BE CAREFUL WITH HOT LIQUIDS or DON'T CUT YOURSELF WITH THE KNIFE does not mean that you should be careless when simmering water or stripping an electrical wire. It does mean that when you see a special note to be careful, it is extremely important that you pay attention to it.

If you ever have a question about whether a procedure or material is dangerous, wait to perform it until you find out for sure that it is safe.

GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking unnecessary risks can be avoided by practicing safety procedures and being alert while conducting experiments. Be sure to check the experiments in this book for additional safety regulations and adult supervision requirements. If you will be working in a lab, do not work alone.

PREPARING:
—Clear all surfaces before beginning experiments
—Read the instructions before you start
—Know the hazards of the experiments and anticipate dangers

PROTECTING YOURSELF:
—Follow the directions step-by-step; do only one experiment at a time
—Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eye wash, and first-aid kit
—Make sure there is adequate ventilation
—Do not horseplay
—Wear an apron and goggles
—Do not wear contact lenses, open shoes, loose clothing, or loose hair
—Keep floor and work space neat, clean, and dry
—Clean up spills immediately
—Never eat, drink, or smoke in laboratory or work space
—Do not eat or drink any substances tested unless expressly permitted to do so by a knowledgeable adult

USING EQUIPMENT WITH CARE:
—Set up apparatus far from the edge of the desk
—Use knives and other sharp or pointed instruments with caution
—Pull plugs, not cords, when removing electrical plugs
—Don't use your mouth to pipette; use a suction bulb
—Clean glassware before and after use
—Check glassware for scratches, cracks, and sharp edges
—Clean up broken glassware immediately
—Do not use reflected sunlight to illuminate your microscope
—Do not touch metal conductors
—Use only low voltage and current materials such as lantern batteries
—Be careful when using stepstools, chairs, and ladders

USING CHEMICALS:
—Never taste or inhale chemicals
—Label all bottles and apparatus containing chemicals
—Read labels carefully
—Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves)
—Do not touch chemical solutions
—Wash hands before and after using solutions
—Wipe up spills thoroughly

HEATING SUBSTANCES:
—Use goggles, apron, and gloves when boiling water
—Keep your face away from test tubes and beakers
—Never leave apparatus unattended
—Use safety tongs and heat-resistant mittens
—Turn off hot plates, bunsen burners, and gas when you are done
—Keep flammable substances away from heat
—Have fire extinguisher on hand

FINISHING UP:
—Thoroughly clean your work area and glassware
—Be careful not to return chemicals or contaminated reagents to the wrong containers
—Don't dispose of materials in the sink unless instructed to do so
—Wash your hands
—Clean up all residue and put in proper containers for disposal
—Dispose of all chemicals according to all local, state, and federal laws

BE SAFETY CONSCIOUS AT ALL TIMES