Version 2.0

CHEM C2000

CHEMISTRY SET

WARNING — This set contains chemicals and parts that may be harmful if misused. Read cautions on individual containers and in the manual carefully. Not to be used by children except under adult supervision.

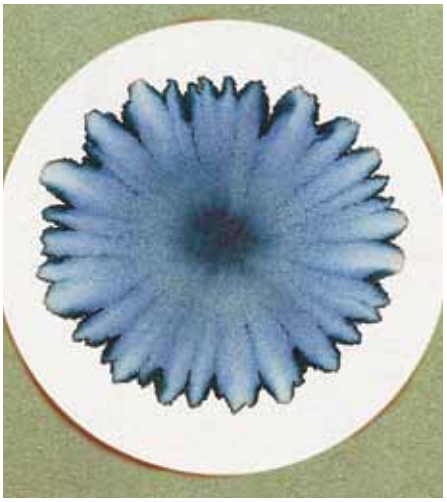
Experiment Manual

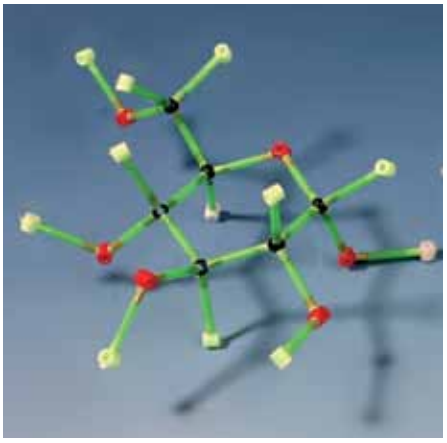
Thames & Kosmos

Contents

Safety and Precautions

The Experiments





Appendix

Divide the polystyrene tray here with a knife (see p. 11)

CHEM C2000 contains the following parts:

No.	Description	Item No.
1	Safety glasses	052347
2	Three conducting wires and copper wire (in bag)	773610
3	Two large graduated beakers	087077
4	Two lids for beakers	087087
5	Funnel	086228
	Alcohol burner consisting of	
6	Burner base	061117
7	Insulating piece	048067
8	Aluminum disk	021787
9	Wick holder	021777
10	Wick	051056
11	Burner cap	021797
12	Rubber stopper without hole	071078
13	Rubber stopper with hole	071028
14	Cork stopper with hole	071118
15	Safety cap with dropper insert for litmus vial	704092
16	Clip for 9-volt square battery	042106
17	Five test tubes	062118
18	Test tube stand	070187
19	Two dropper pipettes	232134
20	Carbon electrode	026217
21	Pointed glass tube	065308
22	Angled tube	065378
23	Immersion heater	065458
24	Test tube brush	000036
25	Test tube holder	000026
26	Double-headed measuring spoon	035017
27	Lid opener	070177
28	Vial for litmus solution	771501

No.	Description	Item No.
29	Sodium hydrogen sulfate	033402
30	Sodium carbonate	033412
31	Potassium hexacyanoferrate(II)	033422
32	Calcium hydroxide	033432
33	Ammonium chloride	033452
34	Potassium permanganate mixture (potassium permanganate-sodium sulfate mixture 1:2 m/m)	771530
35	Sulfur	033262
36	Copper(II) sulfate	033242
37	Litmus powder	771500
38	Magnesium strip	771761
39	Luminol mixture (luminol-sodium sulfate mixture 5% m/m)	033482
40	Potassium hexacyanoferrate(III)	033492

CAUTION! Some parts in this kit have pointed corners, sharp corners, or sharp edges required by their function. There is a risk of injury!

Save the packaging and instructions, since they contain important information.

We reserve the right to make technical changes.

Please check to make sure that all of the parts and chemicals listed in the parts list are contained in the kit.

How can individual parts be reordered?
Contact Thames & Kosmos at 800-587-2872 or visit our website at www.thamesandkosmos.com to inquire about an order.

Additional materials required
On page 14, we have made a list of the additional materials required for a number of experiments.

Water in solid and liquid form

> **!** For **copper sulfate**, note the "Hazardous materials and mixtures" information starting on p. 7.

EXPERIMENT 20 Of course, you can also use this method to rid water of other additives. Repeat the experiment with copper sulfate solution (dissolve 1 spoonful of copper sulfate in 5 cm water). The liquid dripping into the cooled test tube — the distillate — is completely colorless. A4

EXPERIMENT 21 Even more dramatic is a distillate from a downright filthy broth that you brew together from water, ink, and dirt. Even in this case, you will still get a colorless distillate: distilled water. A1

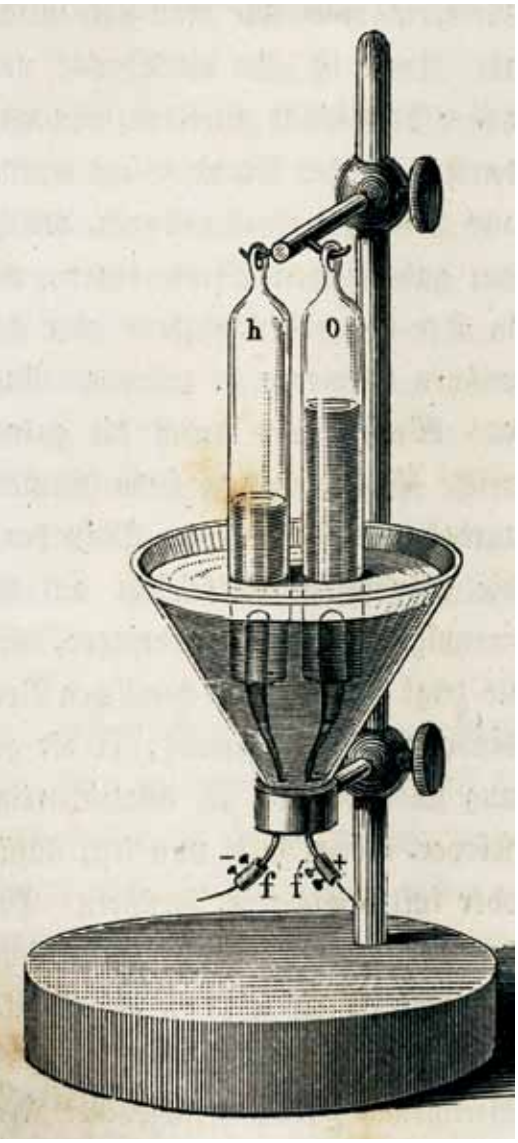
What is water actually made of?

"Funny question!" you might say. Water is water. Anyone can see that it's not made of other things. Let's let an experiment decide the matter.

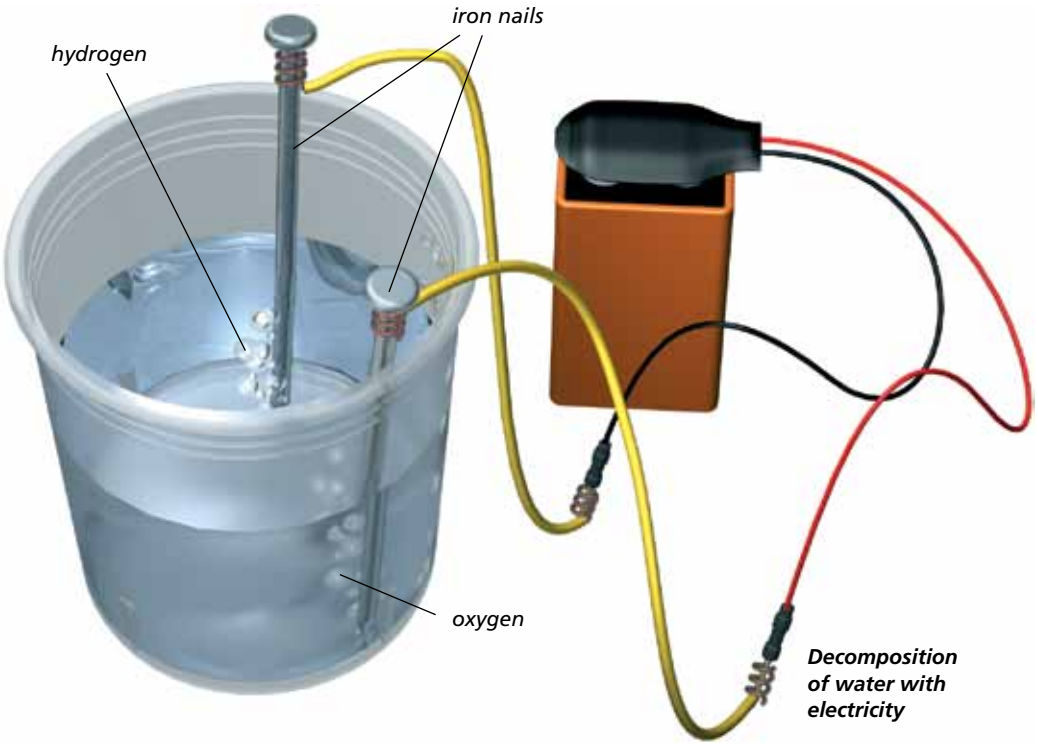
EXPERIMENT 22 ***Additional material:*** *Two uncoated iron nails, baking soda, 9-volt square battery*

Add two spoonfuls of baking soda (chemically: sodium hydrogen carbonate, or sodium bicarbonate) to a graduated beaker filled halfway with water, put on the lid, and shake. Now, using the yellow wire, connect the nails to the battery clip terminals. Immerse the ends of the nails in the solution in the graduated beaker — but don't let them touch each other.

If you watch closely, you can see that bubbles of gas are rising from both nails. A1



Historical device for electrolyzing water
From: Stöckhardt, The School of Chemistry (1863)



Decomposition of water with electricity

It would be tedious and boring to capture the bubbles of gas and study them. In later experiments, you will be producing larger quantities of the two gases.

Yes, there are *two* different gases: namely, **hydrogen** and **oxygen**. The two gases have combined to form a new substance with completely new properties: **water**. Hydrogen and oxygen are **basic materials** or **elements**, while water is a **compound.**

Basic Knowledge

Elements and compounds

For the Greek Empedocles, who lived in the 4th century BC, water was one of the four elements along with earth, fire, and air, and these elements were held to be the basis of all things. This doctrine of four elements persisted for over 2,000 years. In the 17th century — 1661, to be exact — the term **element** was defined by Robert Boyle (1627–1691) in the way we still understand it today: An element is a material that cannot be decomposed into simpler materials. At present, there are 118 chemical elements known. Composite materials, or **chemical compounds** — which number in the millions — are derived by combining the elements together.

It was not until the 18th century that scientists recognized that water was not an element, but rather a compound. Antoine Lavoisier (1743–1793) obtained hydrogen from water vapor that he conducted across glowing iron filings, and which he was thus able to identify as a component of water. Since hydrogen could be combusted into water in the presence of oxygen (produced for the first time in 1771), it was determined that water is a compound of the elements hydrogen and oxygen.

The table below lists the elements that you will be coming across in your experiments. Three of them — copper, magnesium, and sulfur — appear in elemental form in the kit (as wire, metal strips, or powder), while the others come in compounds. In addition to the English and Latin or Greek/Latin names, the table also contains the symbols for the elements, which you should pay attention to since you will often be needing them later on.

You already saw with the example of water that compounds often have quite different properties from the elements that compose them. This sort of quirk is something you will encounter often in chemistry.

Robert Boyle defined the term "element" in the way we still understand it today (photo: Deutsches Museum, Germany).

With the help of electric current, you can retrieve the elements back out of the compound again. The name for this process is electrolysis (decomposition by electric current; Greek *lysis* = decomposition or splitting). Hydrogen rises up from the nail connected to the negative terminal, while oxygen rises from the one connected to the positive terminal.

Are you wondering if the gases might actually come from the baking soda? Good question. But the two gases really do come from the water, and the baking soda is just there to ensure that the water is sufficiently conductive.

Water decomposition apparatus named after A.W. Hofmann (1818–1892), still in use today (photo: Deutsches Museum, Munich, Germany).

English Name	Latin or Greek-lat. Name	Symbol
Aluminium	Aluminium	Al
Carbon	Carboneum	C
Calcium	Calcium	Ca
Chlorine	Chlorum	Cl
Copper	Cuprum	Cu
Iron	Ferrum	Fe
Hydrogen	Hydrogenium	H
Iodine	Iodum	I
Potassium	Kalium	K
Magnesium	Magnesium	Mg
Manganese	Manganium	Mn
Nitrogen	Nitrogenium	N
Sodium	Natrium	Na
Oxygen	Oxygenium	O
Sulfur	Sulfur	S

The chemical elements that you will encounter in your experiments.

Industrial hydrogen production by the Lurgi pressure electrolysis process (Lurgi factory photo, Germany)

A miniature hydrogen factory

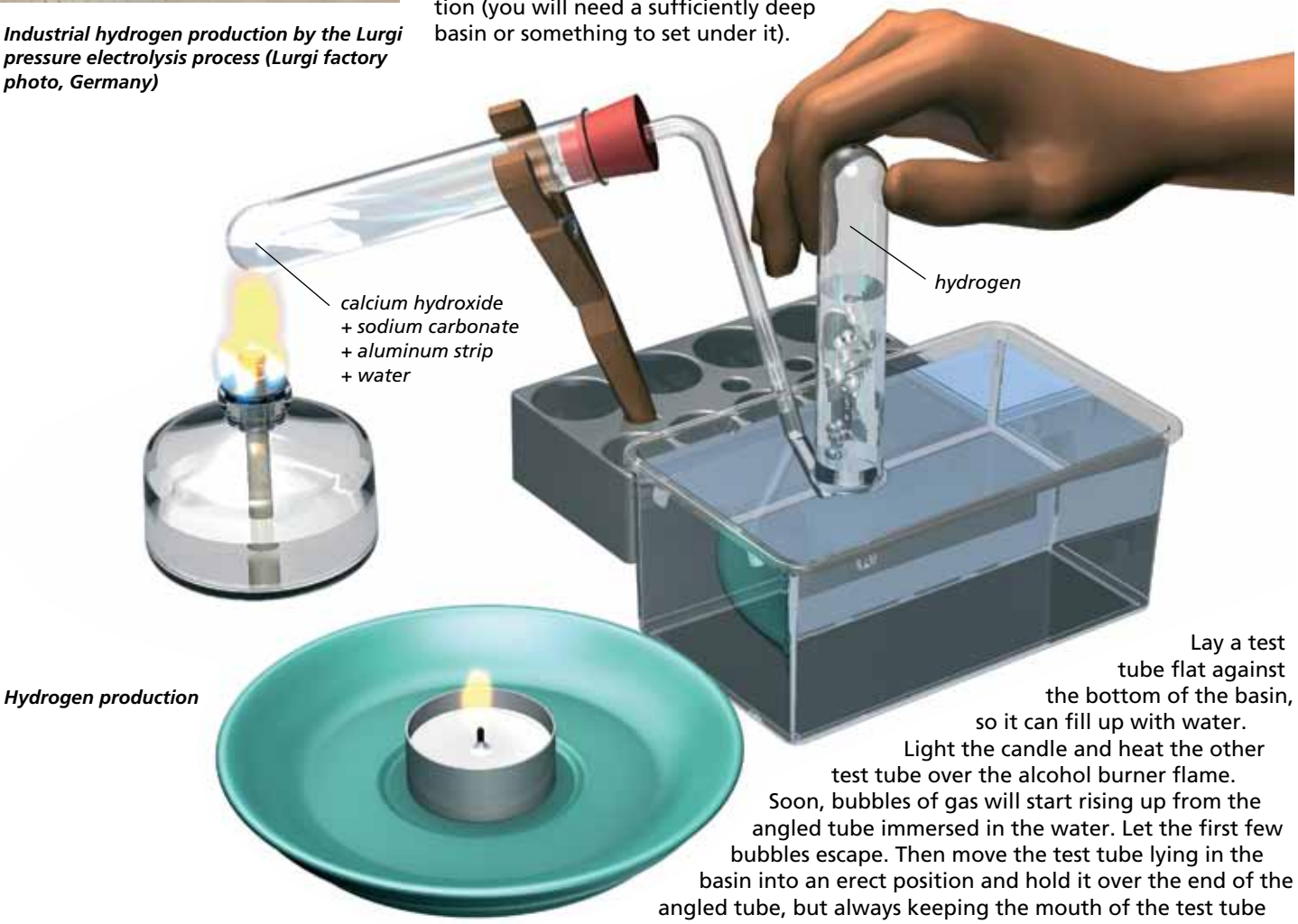
! For **calcium hydroxide** and **sodium carbonate**, note the "Hazardous materials and mixtures" information starting on p. 7. Be careful when twisting the angled tube into the stopper! Note the information on pages 13/14. In case of injury: **First Aid 5** (back cover).

Ask an adult to help you with this experiment.

EXPERIMENT 23

Additional material: *Aluminum foil, tealight candle*

Place 4 cm of water, two spoonfuls each of calcium hydroxide and sodium carbonate, and a little strip of aluminum foil in a test tube. Assemble the experimental apparatus shown in the illustration (you will need a sufficiently deep basin or something to set under it).



Hydrogen production

Lay a test tube flat against the bottom of the basin, so it can fill up with water. Light the candle and heat the other test tube over the alcohol burner flame. Soon, bubbles of gas will start rising up from the angled tube immersed in the water. Let the first few bubbles escape. Then move the test tube lying in the basin into an erect position and hold it over the end of the angled tube, but always keeping the mouth of the test tube under water (you will learn in the next chapter how it is that the water remains inside the test tube). Now the gas bubbles will rise up the test tube and push the water out of it, as you continue to keep its opening under water. With your free hand, move aside the test tube stand with the test tube clamped in it, so the angled tube no longer dips into the water. Disposal after Experiment 25: A2
Now ask your adult assistant to take apart the apparatus you moved aside and hand you the test tube holder.

A combustible gas

EXPERIMENT 24

Clamp the gas-filled test tube in the test tube holder, lift it out of the basin keeping the opening pointed downward, and move it toward the candle flame, as shown in the illustration. Don't be startled! You will hear a whistling noise and the flame will dart into the test tube.

What happened? The combustible hydrogen combined with the oxygen in the air — more about that in Chapter 4 — with a little explosion. The separated elements are back together again. The tealight candle flame served as the spark.

TECHNOLOGY AND ENVIRONMENT

Hydrogen — Element of the future?

Hydrogen is the lightest of all materials. It is 14 times lighter than air. That is why people used to use hydrogen to fill air balloons and air ships, even though it was not entirely safe due to the combustibility of the gas. There were some serious accidents in which air ships went up in flames. Today, the non-combustible gas helium is used for such purposes. The interplay of hydrogen and helium as energy sources is of much greater significance. In the sun, there is a constant conversion of hydrogen into helium taking place. In this process, a massive quantity of energy is released, which provides us with light and heat as it is radiated off by the sun.

Here on Earth, the sun's heat can be captured using solar collectors, or sunlight can be converted into electrical energy by means of solar cells. The electrical energy captured in this way can be used to perform electrolysis on water (Experiment 22). Even now, the hydrogen produced in the process can be used to power vehicles — directly as a fuel for internal combustion engines, or by conversion back into electrical energy with the help of fuel cells, i.e. for electrolysis.

Still, hydrogen produced by solar energy is not yet competitive due to its cost, which is why most hydrogen is obtained from natural gas for now.

From an environmental perspective, it is important to note that hydrogen is the cleanest fuel, since the only waste product created from its use is water.

Solar collector device on the roof of a single-family home

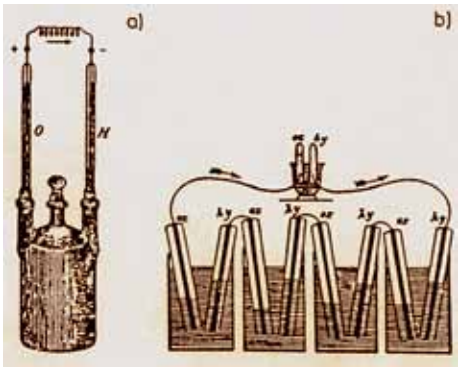
Solar cell array

EXPERIMENT 25

Repeat Experiment 23. Take the hydrogen-filled test tube out of the basin and hold it open-end-down for 3 or 4 seconds. Move the test tube toward the tealight candle flame, as in the last experiment. You will probably get another little explosion. A2

Hydrogen — as already mentioned — is lighter than air. It rises upward unless something prevents it from doing so. So you can hold the gas-filled test tube for several seconds with its opening pointing down, and not much of the hydrogen will escape.

Fuel cell car from the Thames & Kosmos experiment kit



Fuel cells are older than you think. a) fuel cell (1839) and b) gas battery (1842) of William Grove (1811–1896)