Version 2.0

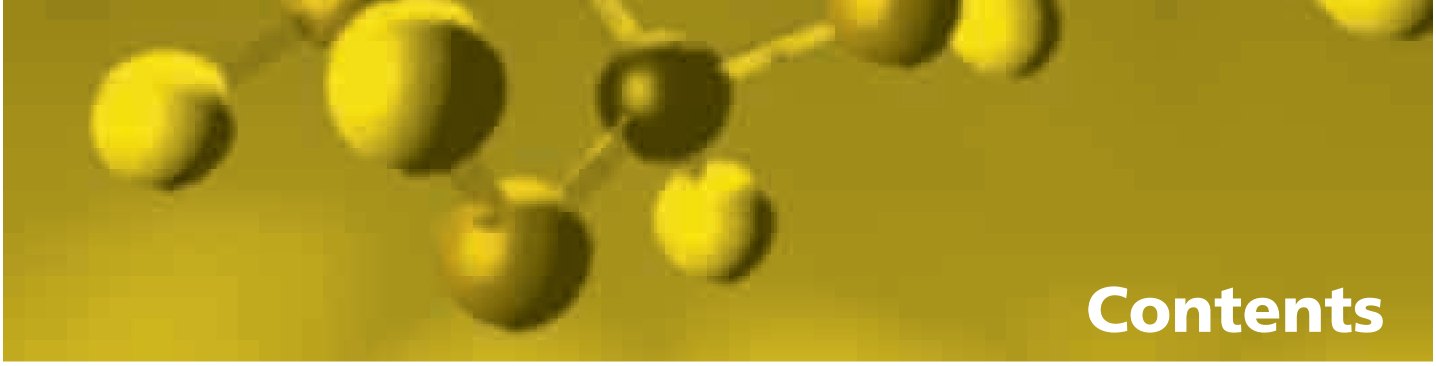
CHEM C1000

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

Introduction and Precautions

The Experiments

Appendix

CHEM C1000 contains the following parts:

No.	Description	Item no.
1	Protective goggles	052297
2	Two dropper pipettes	232134
3	Clip for 9-volt battery	042106
4	Safety cap with dropper insert for litmus bottle	704092
5	Copper wire	703059
6	Two large graduated beakers	087077
7	Two lids for large graduated beakers	087087
8	Four test tubes	062118
9	Test tube brush	000036
10	Rubber stopper with hole	071028
11	Rubber stopper without hole	071078
12	Funnel	086228
13	Sodium carbonate	033412
14	Potassium hexacyanoferrate(II)	033422
15	Calcium hydroxide	033432
16	Ammonium iron(III) sulfate	033442
17	Copper(II) sulfate	033242
18	Citric acid	032132
19	Litmus powder	771500
20	Small bottle for litmus solution	771501
21	Lid opener	070177
22	Double-headed measuring spoon	035017
23	Angled tube	065378
24	Experiment station (part of the polystyrene insert)	709812

The experiment station (for more info, see p. 10) can be divided here using a sharp knife. An adult must do this step.

Please note: The actual design of your experiment station and component storage tray may vary from what is pictured here.

CAUTION! Some parts of this kit have pointed or sharp corners or edges due to their function. There is a risk of injury! We reserve the right to make technical changes.

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

Please check whether 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 13, we have made a list of the additional materials required for a number of experiments.

3 Magic Blue and Secret Inks

Round filters and filter bags from which you can trim round filters.

For now, the magic blue is still hidden in the chemical vial labeled "Litmus powder." When you open the vial, you will discover a dark, fine-grained substance inside. To perform experiments with it, you will need to prepare a litmus solution, which lasts one day. You know: sugar and salt dissolve in water so easily that it seems as if it disappears. It's not quite so easy with the litmus powder. First you need to become acquainted with one of the most important laboratory techniques: **filtering**.

Supersieves in action

You will need white coffee filters for filtering: either the round ones or the larger filter bags out of which you can cut round filters (diameter approx. 9 cm).

In the following experiments, we will call these filters filter paper. Because you will need them often, they are not listed in the experiments as additionally required materials.

EXPERIMENT 01

Additional material: *Sand*
Fold a round filter paper as shown in the illustration. You will end up with a cone consisting of one layer of filter paper on one side and of three layers on the other. Place the filter cone into the funnel and moisten it with a little water. This will help it stick better to the wall of the funnel. In a sealed test tube, shake some sand with 6 cm of water (remember, keep your thumb on the stopper!) and pour the mixture into the filter cone. The sand remains in the filter and a nearly clear liquid, the filtrate, drips into the test tube below.

The solution prepared from litmus powder is filtered.

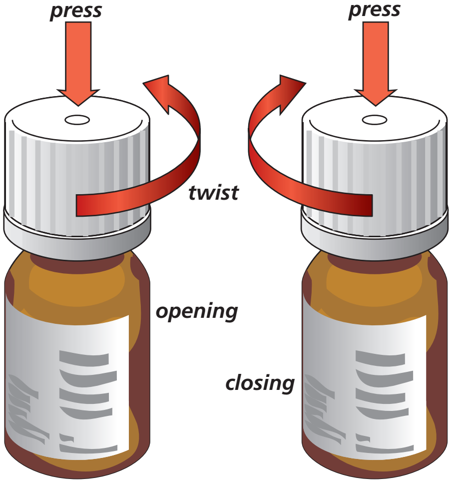
What's happening here?

Sand is made of small quartz crystals. The particles are difficult to dissolve or not soluble at all in water and too large to pass through the tiny pores of the filter paper. In contrast, the particles of water and the soluble substances are so small that they overcome the "filter blockade" with no trouble. By using super-fine sieves, you can separate the soluble from the insoluble components of a mixture.

EXPERIMENT 02

Preparing the litmus solution. Place 3 cm of water in a test tube and add 3 small spoonfuls of litmus powder to it (level scoop). Close the tube with the stopper, shake vigorously and allow the closed tube to stand for one day somewhere that is out of the reach of young children.

Now set up the funnel and filter for filtering like in the previous experiment. Place the funnel on the vial provided for the litmus solution and pour the deep-blue mixture into the filter. You can dispose of the insoluble leftovers in the trash. If denatured alcohol (careful, fire hazard!) is available, an adult should add a half pipette of it to the vial.



How the safety closure of the vial for the litmus solution works.

Litmus is a plant product with a limited shelf life. The denatured alcohol acts as a preservative.

DANGER

!

Denatured alcohol: Liquid and vapor readily flammable. – Keep away from open flame and hot surfaces. Do not smoke. – Keep container tightly closed.

Now place the safety closure with dropper insert onto the vial and close it (by turning the closure clockwise). The illustration on the previous page shows how to close and open the safety closure by turning and pressing it at the same time.

When refilling (recommended due to the limited shelf life), the dripper insert must first be removed. Have an adult help you with this if necessary. Okay, now the litmus solution is ready to use.

?

Question 1. The safety closures are designed to prevent small children from opening the vials. What features make this a safety closure, and why?*

Blue here, red there

EXPERIMENT 03

Additional material: *White vinegar (wine vinegar)*
To a test tube with 3 cm of water, add 3 drops of litmus solution. The solution is light blue. Pour a little vinegar into a test tube and drip it into the litmus solution using a pipette. The first drops already cause the color to turn bright red. You will need this solution for the next experiment.

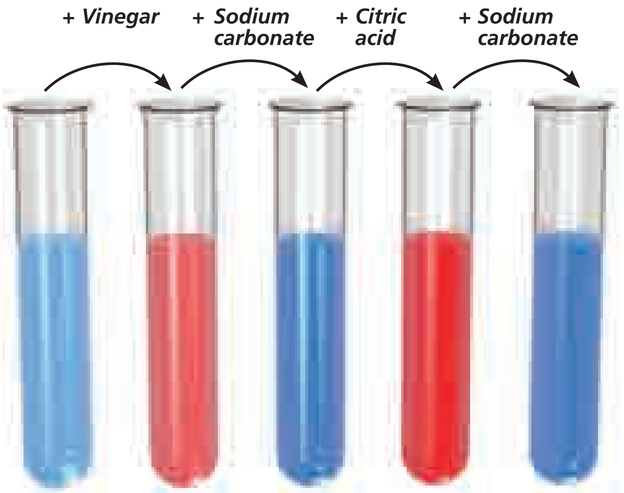
Regarding Experiments 4 – 8:

!

For **sodium carbonate** and **citric acid**, note the warnings in "Hazardous substances and mixtures" on pp. 7 – 8.

EXPERIMENT 04

Add a spoon tip of sodium carbonate to the red solution from the previous experiment. Rock the tube gently back and forth: The solution turns blue again, this time a bit darker than the aqueous (watery) solution in Experiment 3. Don't throw this solution away, either!



Blue here, red there

Side Notes

The optical brightener of the Netherlands

Litmus is a mixture of plant materials that is obtained above all from lichens such as Roccella montanei shown below. The Dutch once used the dye for "bluing" their laundry. The blue covers the yellow tint in textiles and thus produces the "whitest of whites." Today, the "optical brighteners" contained in detergents — products of chemical ingenuity — do the trick.

The name comes from the Netherlands, too: lakmoes, a Dutch word whose origin linguists are not completely in agreement about. There is pretty much a consensus about the second syllable, moes, meaning puree, pulp, mush. Whereas some think that lak means paint (hence "colored pulp"), others say that hidden in lak is the Old Dutch word lêken, meaning to drip. Both interpretations are consistent with the preparation process. The lichens were ground with water between millstones into a colored pulp that was allowed to ferment and drain. The dried deep-blue mass was then ground into powder.

The lichen Roccella montagnei, from which litmus powder is obtained (photo: Prof. Dr. v. Wirth, Karlsruhe).

Pressed litmus (© and photo: chemie-master.de)

TECHNOLOGY AND ENVIRONMENT

From limestone to lime

The detection of carbon dioxide using lime water plays an important role in chemical investigations, since the gas — as you will soon see — is involved in a wide variety of processes. But by far the largest quantity of calcium hydroxide is used for quite another purpose: building houses. In regions with abundant lime, limestone — calcium carbonate, chemically speaking — is broken down and often "burned" right then and there in tall shaft furnaces. The burning breaks the carbonate down into calcium oxide and carbon dioxide. The calcium oxide, "quicklime" or burnt lime, is "slaked" through the addition of water (as in the expression "to slake your thirst"). Slaking is the term used by those working in construction to refer to the conversion of the calcium oxide into calcium hydroxide, which they therefore call slaked lime.

In earlier times, the slaking was done exclusively at the construction site, but nowadays it takes place in lime plants for the most part. Using slaked lime, sand, and water, the bricklayers then prepared the mortar that holds the building stones together as a binder. In this step, exactly the opposite happens as during the burning of the lime. The calcium hydroxide component of the mortar absorbs carbon dioxide from the air and hardens again into calcium carbonate, into limestone. This process is referred to as the "carbonation" or "hardening" of the mortar. Chemically speaking, the same reaction takes place as when detecting carbon dioxide using lime water: the formation of calcium carbonate — in one case as the hardening of the mortar and in the other case as the formation of a precipitate.

Shaft furnaces in which slaked lime is manufactured from limestone (photo: Dyckerhoff AG, Lengerich plant)

Another blue — this time from Berlin

In the following experiments, you will be introduced to two new chemicals: ammonium iron(III) sulfate and potassium hexacyanoferrate(II). You must use the latter of the two substances sparingly. It is harmful to aquatic organisms but is indispensable to you. So prepare a potassium hexacyanoferrate(II) solution that you will need for a number of experiments.

TIP

Preparing Potassium hexacyanoferrate(II) solution:
Dissolve 2 spoonfuls of potassium hexanocyanoferrate(II) in a test tube in 6 cm of water and store the solution in a carefully cleaned, labeled vial. Remove only the amount needed in each case (usually only a few drops).
You can throw the reaction products (most notably Berlin blue) into the drain with a little detergent. Rinse well afterward.

! For **ammonium iron(III) sulfate** and **potassium hexacyanoferrate(II)**, note the warnings in "Hazardous substances and mixtures" on pp. 7 – 8.

First let's allow the solutions of the two substances react with each other in a test tube.

EXPERIMENT 13 Add 1 spoon tip of ammonium iron(III) sulfate to a test tube filled halfway up with water, seal the tube and shake. The light-violet crystals dissolve and you obtain a faintly yellowish-brown solution. If you now add a few drops of the potassium hexacyanoferrate(II) solution you just prepared, you get a splendid blue: **Berlin blue**, to be precise.

If the ammonium iron(III) sulfate has melted and solidified again, you can loosen the crystal plug from the storage vial, dry it with absorbent paper, and grind it between two layers of clean paper using a heavy object (for example, a hammer, but don't pound, just press). Then place the substance back into the dried storage jar.

EXPERIMENT 14 Add 1 drop of ammonium iron(III) sulfate to a small piece of filter paper. Rinse the pipette out well (or use the other pipette) and now put 1 drop of potassium hexacyanoferrate(II) solution in the same place. A deep Berlin blue forms on the paper.

What's happening here?

Calcium hydroxide (pronounced KAL-see-um hi-DROX-ide), potassium hexacyanoferrate(II) (pronounced po-TASS-ee-um hex-a-sigh-ann-o-FARE-ate 2), ammonium iron(III) sulfate (pronounced ah-MOAN-ee-um EYE-urn 3 SUL-fate)… why do chemical names have to be so complicated and such tongue-twisters? Because to those in the know — and that means you, too, sooner or later — they say something about the composition of substances.

Over time, scientists found out that there are certain substances that cannot be broken down into simpler ones. They are called **elements** or "basic materials," and there are less than 120 of them. They include the light metals calcium, sodium, and potassium. If two or more elements combine with each other, they form **chemical compounds**. Calcium hydroxide, sodium carbonate, and potassium hexacyanoferrate(II) are examples of chemical compounds. You can see immediately from the names that they contain the elements calcium, sodium, and potassium, respectively.

The other elements in the compounds above are a bit more concealed. If a compound contains "carbonate" in its name, then we know it contains carbon. If its name contains "hydroxide," we know that it contains hydrogen and oxygen. When components occur more than once in a compound, chemical names also include Greek numerals, for example *di* for two and *hexa* for six.

We will reveal some more about the Roman numerals (II and III) in chemical names at the end of Chapter 7. Take a look at the chemical elements table below. There you will find the elements that you'll encounter in your experiments, some as stand-alone elements (in copper wire, for example) and some as compounds (in copper sulfate, for example).

Chemical elements

Name	Latin or Greek name (chemistry symbol)	Type
Aluminium	Aluminium (Al)	Light metal
Calcium	Calcium (Ca)	Light metal
Carbon	Carboneum (C)	Non-metal
Chlorine	Chlorum (Cl)	Gas
Copper	Cuprum (Cu)	Heavy metal
Hydrogen	Hydrogenium (H)	Gas
Iodine	Iodum (I)	Non-metal
Iron	Ferrum (Fe)	Heavy metal
Nitrogen	Nitrogenium (N)	Gas
Oxygen	Oxygenium (O)	Gas
Potassium	Kalium (K)	Light metal
Sodium	Natrium (Na)	Light metal
Sulfur	Sulphurium (S)	Non-metal

In 1661, Robert Boyle (1627 – 1691) named substances that cannot be broken down into simpler ones "elements" (photo: Deutsches Museum, Munich).

? **Question 4.** Potassium hexacyanoferrate(II) is a compound that contains a total of six elements. One is of course potassium. Using the chemical elements table above and a little of your feel for language, can you identify another of them based on the name?

Chemical elements at play in your experiments: Copper (1), iron (2), carbon in the form of activated charcoal (3), iodine in crystalline form (4), sodium under petroleum (prevents oxygen from getting in) and cut on the glass plate (5), aluminum as foil and grit (coarse powder) (6), sulfur as powder and in pieces (roll sulfur) (7), calcium in grainy form and in larger chips

Blue secret ink

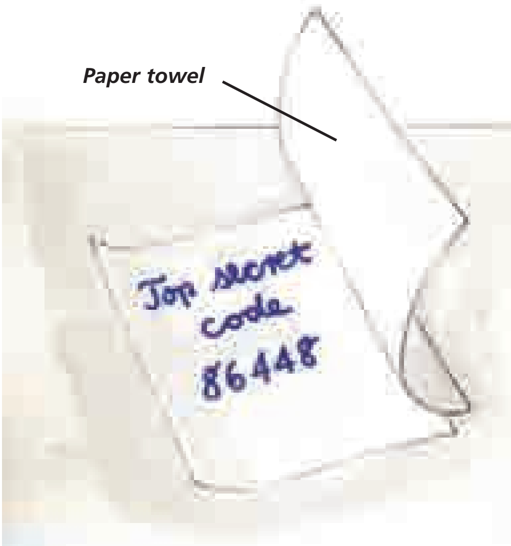
On some special occasion, you may want to send a secret message that only the addressee can decode. You can do it using the following secret ink.

> **!** For **ammonium iron(III) sulfate, sodium carbonate,** and **potassium hexacyanoferrate(II)**, note the warnings in "Hazardous substances and mixtures" on pp. 7 – 8.
> Filter paper or cotton balls that are soaked or moistened with chemical solutions should only be touched with protective gloves.

For the following experiments, you will need a **steel fountain pen** or a **fine hair paint brush** from a painting kit.

EXPERIMENT 15

Additional material: *Paper to write on, paper towels*
The ammonium iron(III) sulfate (1 small spoonful in 2 cm of water) is the ink with which you write your secret message onto paper (yellowish paper works best). After it's dry, your writing is invisible.



> **?** **Question 5.** How can the addressee render your message visible again? Keep the message for the next experiment.

EXPERIMENT 16

Additional material: *Cotton*
You can make the Berlin blue writing disappear again, too. Add 1 cm of water to each graduated beaker. In one beaker, dissolve 1 small spoonful of sodium carbonate, and dissolve 1 small spoonful of citric acid in the other. Stir each with the spoon, rinsing the spoon off thoroughly before stirring the second beaker.

Dab the writing using a cotton ball that you have previously dipped into the sodium carbonate solution. Wait until the paper is dry and now dab it with a cotton ball that you have moistened with the citric acid solution.

> **?** **Question 6.** What can you conclude from the dabbing experiments?

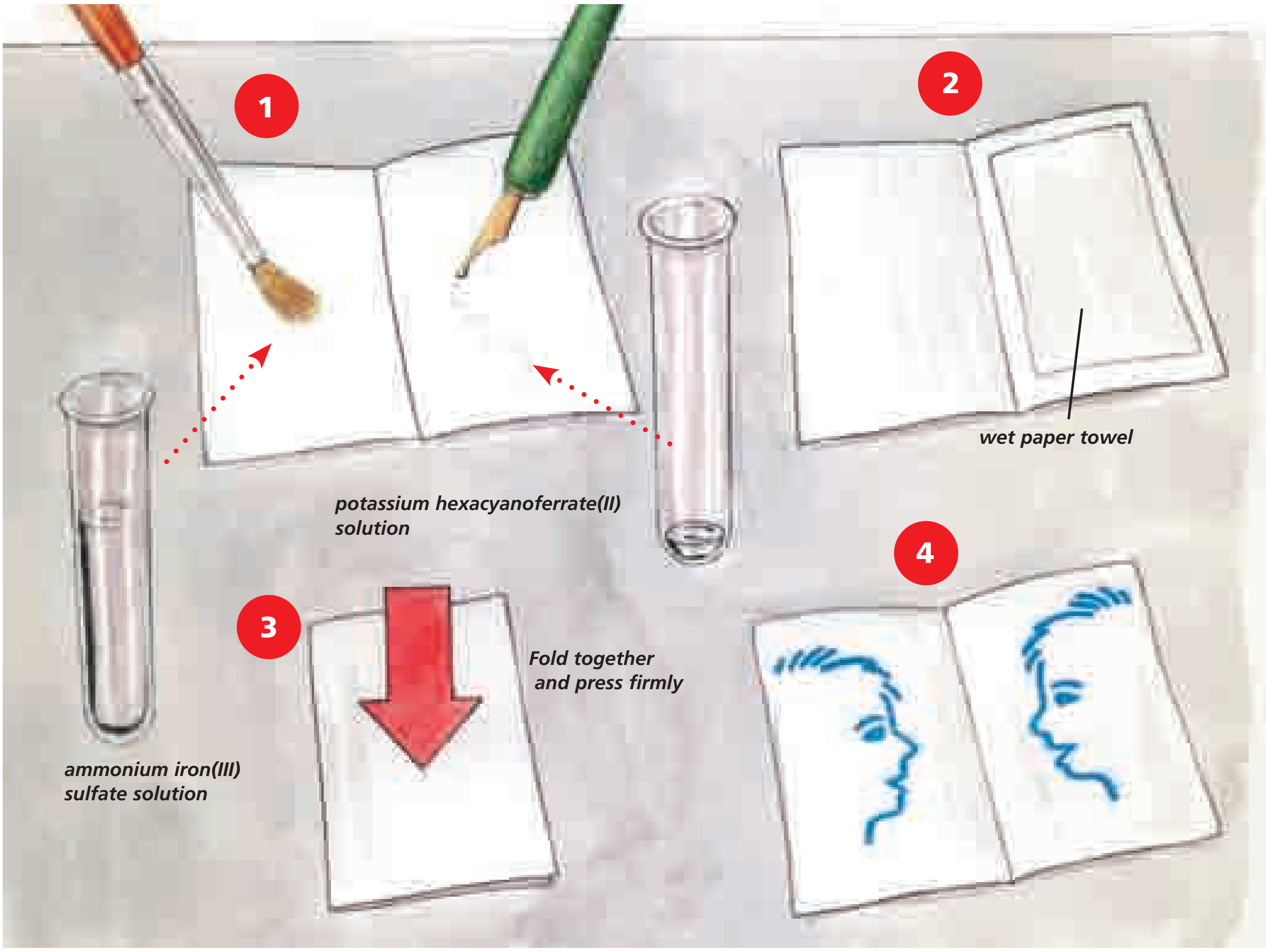


Image and mirror image

With ammonium iron(III) sulfate and potassium hexacyanoferrate(II), you can make other "printing products" too — a folded image, for example.

EXPERIMENT 17

Additional material: *White paper to write on, paper towels*

❶ Fold a white sheet of writing paper (half of a standard 8½ by 11 inch sheet) as shown in the illustration. Using the paint brush, moisten the inside completely with ammonium iron(III) sulfate solution (1 small spoonful in 2 cm of water). On the other side, draw or paint a picture (a profile, for example) using the potassium hexacyanoferrate(II) solution. Let the whole thing dry. ❷ Then moisten a paper towel with water and press it briefly onto your drawing. Remove the moist paper towel. ❸ Press the two sides of the folded sheet firmly together. ❹ When you open the folded sheet, the drawing and its mirror-inverted impression emerge.

You can also send secret messages this way. This way, the addressee doesn't need any special chemicals to "develop" it — just a paper towel and water.

Secret inks from the kitchen

But you don't even necessarily need special chemicals for the secret ink itself. It also works with lemon juice, **household vinegar,** and **onion juice**.

! In the following experiments, be careful not to burn yourself. Ask an adult to help you.

Secret inks that are available in any household