Extraction of copper from copper oxide

Aims of the experiment

- To understand the industrial extraction of copper
- To observe the conversion of substances
- To learn about redox reactions

Principles

Where ores are concerned we are dealing with heterogeneous mixtures of stones quarried from the Earth's crust by mining and usually further processed, and containing metals combined with other substances. The ores that occur in nature are mainly sulfides and oxides.

In the case of copper, the most common ores are copper sulfides, such as chalcopyrite ($CuFeS_2$) and bornite (Cu_5FeS_4). The most common oxides of copper are black copper oxide (CuO) and red copper oxide (Cu_2O). Deposits of copper ores are found over North America, Russia, Chile, the Congo and Zimbabwe. It is also in these areas where mining is frequently carried out.

It is not only since antiquity that copper has been used by mankind. For example, copper was already being used as long ago as 5000 years BC. This use of copper gave the period its name: the Copper Age (Chalcolithic). An alloy, e.g. a mixture, of copper and tin called bronze has been used since about 3000 B.C. This gave the following geological period its name (Bronze Age).

Copper occurs in nature only rarely as the pure element, e.g. as a metal. In most copper deposits copper ores are found. Copper can be extracted from these ores by smelting.

In the case of copper oxides, this takes place by reduction at high temperatures in large furnaces. Sulfides are roasted beforehand in an atmosphere of oxygen to produce oxides.

In our society, copper, because of its excellent electrical conductivity, is used to manufacture electrical conductors (colloquially: cables). Along with its very good electrical conductivity, copper also has a good heat conductivity. For this reason it is also used for cooking and cooling utensils. It also plays an important role in everyday life, for example as a coinage metal, as well as for use in roofing.

In mixtures with other metals, many various alloys result that can be used in the widest variety of applications. The most common and well-known alloys are bronze and brass.

In this experiment, copper(II) oxide, which occurs in nature as black copper oxide, will be reduced to elemental copper with the help of carbon.

Risk assessment

Apart from the general risks associated with chemicals, particular care must be taken when handling calcium hydroxide solution, as this is corrosive. Do not dispose of copper(II) oxide into the waste water, as it is highly toxic for aquatic organisms. Do not touch glass wool with your fingers. Wear protective glasses. Protect long hair from the burner.

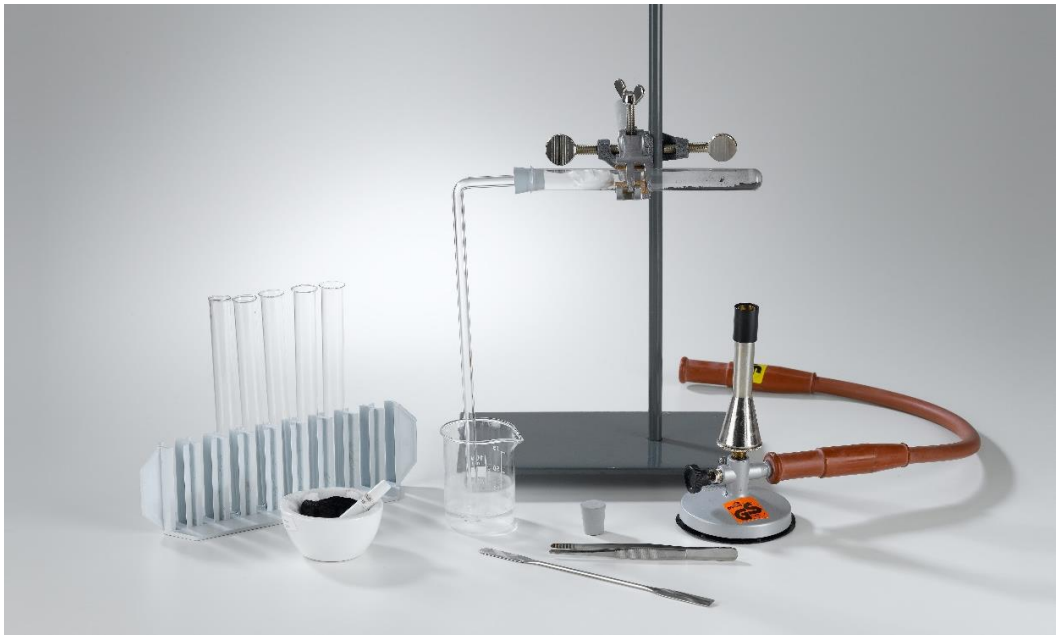

Fig. 1: Set-up of the experiment

Copper(II) oxide, powder	
 **Signal word: Caution**	**Hazard statements** H302 Harmful if swallowed. H410 Very toxic to aquatic life with long-lasting effects. **Precautionary statements** P260 Do not breathe dust. P273 Avoid release to the environment.
Calcium hydroxide	
 **Signal word: Hazard**	**Hazard statements** H318 Causes serious eye damage. **Precautionary statements** P280 Wear protective gloves/ protective clothing/eye protection/face protection.

Equipment and chemicals

1 Bunsen stand, 450 mm 666 502
1 Bosshead S.....301 09
1 Universal clamp 0...80 mm 666 555
2 Beaker, DURAN, 100 ml, squat 664 101
1 Tripod, 26 cm x 14 cm Ø 666 683
1 Wire gauze 160 mm x 160 mm 666 685
or
1 Magnetic stirrer with hotplate, round 666 8471
1 Mortar, porcelain, 70 mm Ø 667 092
1 Pestle 52 mm.....608 360
1 Funnel Boro glass 3.3, 80 mm Ø. 665 004
1 Folded filter paper type 595, 100 pcs.....609 082
1 Test tube rack for 9 tubes, 18 mm Ø.....667 050
1 Test tube, Supermax, 16 x 160 mm, 10pcs ...664 047
1 Double-ended spatula, stainless steel 666 962
1 Rubber stopper, one hole, 14-18 mm Ø.....667 254
1 Tweezers, blunt, 130 mm.....667 027
1 Angled tube 90°, 250/50 mm, 8 mm Ø.....665 231
1 Teclu burner, universal 656 017
1 Safety gas hose, 1 m 666 729
1 Compact balance, 600 g: 0.01 g.....ADAHCB602H
1 Wood charcoal, small pieces, 500 g 672 2490
1 Calcium hydroxide, 50 g 671 2900
1 Copper(II) oxide, powder, 50 g.....672 9500
1 Glass wool, 100 g 672 1010
1 Water, pure, 1 l 675 3400

Set-up and preparation of the experiment

Preparation

1. Fasten the universal clamp to the Bunsen stand using the S bosshead.
2. Place a 100 ml beaker onto the tripod with a wire gauze or onto the magnetic stirrer with hotplate.
3. First break up a small piece of wood charcoal using the mortar and pestle and grind it to a fine powder.
4. Then produce a saturated solution of calcium hydroxide. For this, dissolve 0.1 g of calcium hydroxide in 50 ml of H_2O by heating (on the tripod or on the magnetic stirrer with hotplate) and stirring.

Caution: Danger of burning, e.g. of long hair.

5. Filter the solution after cooling. For this, clamp the funnel in the universal clamp and place a folded filter paper into the funnel. Place a second glass beaker beneath the funnel to collect the filtrate. Filter a second time, if necessary, in order to obtain a clear liquid. The calcium hydroxide solution thus produced is also called lime water.

Performing the experiment

1. Place four spatula tips of copper(II) oxide and two spatula tips of ground wood charcoal powder into a test tube and mix by gentle shaking. Clamp the test tube horizontally in the stand using a universal clamp.
2. Using the tweezers, place a little glass wool into the middle of the test tube.
3. Push the short arm of the angled tube into the hole in the rubber stopper. Close the test tube with the rubber stopper so that the opening of the angled tube is facing downwards.

Note: To make is easier to insert the tube into the stopper, wet the stopper beforehand. The tube could otherwise break if too much pressure is used.

4. Fill the beaker about half full with calcium hydroxide solution and place it under the angled tube. The tube should be immersed by a few millimetres in the liquid.
5. Light the burner and open the air supply fully. To avoid heat stress in the reagent tube, first warm the whole tube and then only the area containing the copper(I) oxide and powdered charcoal.

Caution: Danger of burning, e.g. of long hair.

6. Remove the angled tube from the calcium hydroxide solution after several minutes and discontinue the heating. Turn off the burner flame.

Observation

After a short time, gas bubbles rise up in the beaker and a white precipitate is formed. Red copper forms in the test tube.

Evaluation

The copper(II) oxide is reduced by the carbon. This results in the formation of elemental (red) copper and carbon dioxide.

$$2\ CuO + C \rightarrow 2\ Cu + CO_2$$

The carbon dioxide formed is detected using the lime water. While bubbles are forming in the lime water, white calcium carbonate is precipitated.

$$Ca^{2+} + 2OH^- + CO_2 \rightarrow CaCO_3 + H_2O$$

Results

In the reduction of copper(II) oxide with charcoal, elemental copper is obtained. The carbon dioxide formed was detected with the help of the lime water.

Cleaning and disposal

Dispose of the charcoal/copper(II) oxide mixture from the test tube in the collecting container for heavy metals. Dispose of the calcium hydroxide solution in the drain and flush with a large amount of water.