Reduction of copper(II) oxide with methane

45

Copper metal of high purity is an essential of our way of life. It is used in all electrical apparatus from cell phones to aircraft and in many plumbing applications, such as pipes and tanks.

Lesson organisation

This experiment works well as a class practical for students working in pairs and involves heating a small quantity of copper(II) oxide in an atmosphere of methane. The reaction is rapid. Educational benefit can be obtained from allowing air to come into contact with the copper metal when it is still hot. This can be used to introduce reversible reactions and allows a discussion on rates of reaction. This practical is suitable for observing the reaction qualitatively, or for the determination of the formula of copper(II) oxide.

Apparatus and chemicals

Eye protection

Reaction tube (see technical note 2)
1-hole bung to fit reaction tube
Rubber tubing and adaptors
Bunsen burner
Clamp stand
Boss head
Clamp
Wire test tube holders

Copper(II) Oxide (**Harmful**, Refer to CLEAPSS® Hazcard 26) (See technical note 1)

Technical notes

1 Wire form copper(II) oxide gives the best results. Copper(II) oxide powder can be used as an alternative, as can copper(II) carbonate. If wire form copper(II) oxide is available use a pea-size amount. If the powder form only is available, use about 10 pin-heads equivalent, spread out. The wire form yields the best results for gravimetric experiments. 1g is a suitable amount. Methane gas can flow around and react with the wire form copper(II) oxide which it cannot do with a pile of copper(II) oxide powder.

2 Make the reaction tube as in experiment 14

Procedure

HEALTH & SAFETY: Wear eye protection.
Teachers **must supervise** lighting the burning of excess methane see **f** below. There is the potential for a very large flame.

a Clamp the reaction tube as close to the open end as possible, so it is supported by the stand, as in the diagram.

b Place the copper(II) oxide ¾ of the way down the tube and spread it out.

c Fit the bung and use the tubing and adaptors to connect to a methane gas supply.

d Open the gas supply to the tube for 10 seconds to flush out any air. (There is potential for an explosion if the air inside the apparatus is not flushed out with methane before the methane is lit). Then close off the gas supply.

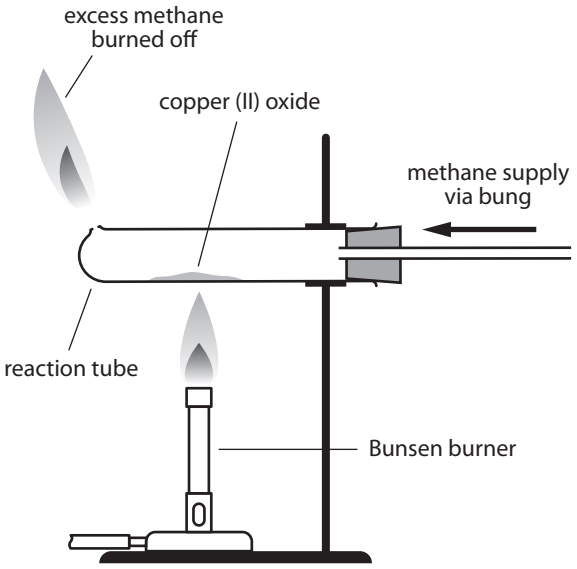
e Light a Bunsen burner and close the air hole.

f Holding the Bunsen flame near the hole in the reaction tube, open the gas tap very cautiously. Adjust the flame coming out of the reaction tube to about 5 cm.

g Adjust the Bunsen flame by opening the air hole fully.

h Adjust the height of the reaction tube so it corresponds to the hottest part of a blue Bunsen flame

i Heat the copper(II) oxide until it is reduced (copper coloured). It may be necessary to move the heating Bunsen burner in order to reduce all the copper(II) oxide.



j Turn off the gas supply to the Bunsen burner.

k Allow the apparatus to cool while the methane flame from the tube is still burning.

l When the apparatus is cool, close the gas tap.

m Examine the copper formed.

Teaching notes

At high temperatures methane reduces copper(II) oxide, $4CuO(s) + CH_4(g) \rightarrow 4Cu(s) + 2H_2O(g) + CO_2(g)$. The gaseous product is carried off with the excess methane.

If the experiment is not to be done with the intention of subsequent qualitative work, it is worth considering turning off both gas supplies when the copper formed is still hot and removing the bung. Oxygen from the air instantly oxidises the copper metal back to copper(II) oxide. Students are more likely to remember the reduction process if they have to do it for a second time and it also introduces the concepts of reversible reactions and the effect of heat on rates of reactions.

The cooling of the reaction tube after the experiment can be encouraged by using wire type sprung test tube holders. These should be alternately clipped to the tube until they get hot and the clamp stand until they get cold. This makes the cooling process quicker and occupies students, getting them thinking about heat transfer and temperature. They can estimate the temperature of the tube (and hence when it is cool enough to touch) by touching the test tube holder which has just been removed from the reaction tube.

Copper(II) carbonate can be used for this experiment. Copper(II) carbonate (green) decomposes to form copper(II)oxide (black) on heating.

$CuCO_3(s) \rightarrow CuO(s) + CO_2(g)$.

The copper metal that is formed in this experiment is similar to the 'blistered' copper metal that is formed by the first stage of the industrial extraction of copper. It is not sufficiently pure for the uses in electronics and plumbing for which copper is used. A second electrolytic purification process is necessary.

Reference

This experiment was written by Mike Thompson on behalf of the RSC