The Thermal Decomposition of Copper Carbonate

Copper carbonate goes through thermal decomposition to form one of these oxides. The two possible equations are:

Equation 1: 2CuCO(s) CuO (s) + 2 CO (g) + ½ O (g)

Equation 2: CuCO (s) CuO (s) + CO (g)

Aim

To find out which of the above equations is correct. I will use the mole theory to work out the expected volume of gas released. This predicted will volume will prove which of the two equations is correct.

Apparatus

- 100 cm^3 gas syringe
- 2 retort stands
- Clamp
- Delivery tube through bung
- Test Tube
- Bungs
- Bunsen Burner
- Heat Proof Mat

- Top pan Balance
- Spatula

Chemicals

- Powered Copper Carbonate

Amounts and Errors

I will collect the amount of gas produced in a gas syringe, and aim to collect approximately 80cm^3 . This volume is far enough from the 100cm^3 to account for any errors that may cause the volume to increase beyond the scale, if too much gas is evolved. The gas syringes available have a maximum volume of

100cm^3, hence why the chosen volume is lower than 100cm^3.

There is also the possibility of the gas expanding in the heat, and resulting in the gas having a larger volume than the available volume in the gas syringe. To overcome this problem I will need to let the gas cool before measuring the volume, and may need to cool the gas as it enters the gas syringe.

At room temperature and pressure, the volume of one mole of gas is 24dm^3. From this I can find the number of moles of gas each equation will produce, and therefore how much copper carbonate to use. I will use the formula:

$$\text{Volume}(dm^3) = \text{Number of Moles} \times 24dm^3$$

$80cm^3 = 0.08dm^3$

$$\text{Number of moles} = \frac{0.08}{24}$$

$$= 0.00333 \text{ moles}$$

To get a idea of which equation will give off most gas, equation 2 can be changed to have the same amount of copper carbonate as in equation 1, to start with:

Equation 2: $2CuCO$ (s) $2CuO$ (s) + $2CO$ (g) (2 moles of gas)

Equation 1: $2CuCO$ (s) $\longrightarrow$ CuO (s) + 2 CO (g) + ½ O (g) (2½ moles of gas)

From this I can see that equation 1 will give off more gas, with a ratio of 5:4 to the gas given off in equation 2. Therefore I will base the mass of copper carbonate used, on equation 1 giving off 80cm^3, so that is the most gas possible.

The molecular mass of copper carbonate is 123.5, which means one mole will have a mass of 123.5g.

From the equation 1, we can see that 2 ½ moles of gas require 2 moles of copper carbonate.

$0.0033 \div 2\frac{1}{2} = 0.0013333$

So one mole of copper carbonate = 0.001333333, but we need 2.

2 x 0.0013333333 =0.002666666667 moles of CuCO .

This means that 0.0033 mole of gas will require 0.00267 mole of copper carbonate.

From equation 2, we can see that 2 moles of gas requires 2 moles of copper carbonate.

0.0033÷2 = 0.001666666667

So one mole of copper carbonate = 1.666666667, but we need 2.

2 x 0.001666666667 =0.00333333... Moles of CuCO

Using the formula:

$$\text{Number of Moles} = \frac{\text{Mass (g)}}{\text{Molecular Formula}} = \frac{M}{Mr}$$

So, to work out the mass of CuCO required:

Mass = Number of moles x Molecular Formula

Mass = 0.002666666667 x 123.5

= 0.3293333337g

= 0.330g (3 s.f)

Using the above mass we can work out the exact number of moles of gas produced from the two equations:

Equation 1:

The number of moles of CuCO used is: $\frac{0.330}{123.5}$ = 0.00267206478 moles

As there are 2 moles of CuCO , we need to divide by 2 to give 1 mole.

$= \frac{0.00267206478}{2} = 0.00133603239$

But there are 2½ moles of gas so we need to multiply the amount for 1 mole by 2½.

0.00133603239 x 2.5 = 0.003340080975 moles of gas

Equation 2:

As above, the number of moles of CuCO is 0.00267206478.

With a ratio of 1:1, the number of moles of gas produced is equal to the number of moles of CuCO , so is 0.00267206478 moles.

In order to find the volume of gas given off, the number of moles needs to be multiplied by 24 dm^3, (the volume of one mole of gas).

Volume (dm^3) = Number of Moles x 24 (dm^3)

We know that in equation 1, the number of moles of gas given off is 0.003340080975 , and that in equation 2, the number of moles of gas given off is 0.00267206478. We can put these two values into the above equation to find out the volume of gas produced.

Equation 1: 2CuCO (s) $\longrightarrow$ Cu2O (s) + 2 CO (g) + ½ O (g)

Equation 2: CuCO (s) $\longrightarrow$ CuO (s) + CO (g)

The ratio of copper Carbonate to the gas given off is:

EQUATION 1

Ratio: 4 : 5

Volume = 0.003340080975 x 24

= 0.0801619434dm^3 or 80.1619434 cm^3

= 80.2 cm^3

EQUATION 2

Ratio: 1 : 1

Volume = 0.00267206478 x 24

= 0.0641 dm^3 or 64.1cm^3

This means that if 80.2cm^3 of gas is given off, equation 1 is correct, while if 64.1 cm^3 of gas is given off, equation 2 is correct.

Risk Assessment

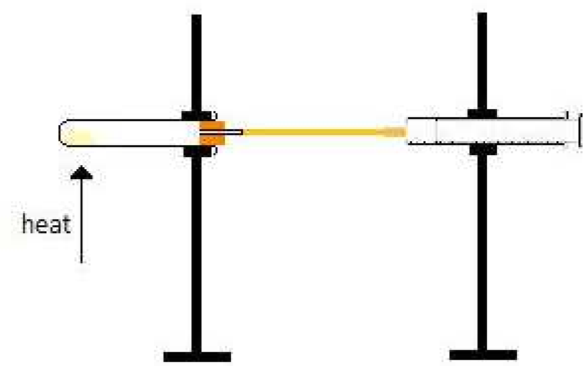
Copper Carbonate is harmful if swallowed, and is harmful to the lungs if it is inhaled. It is also an eye irritant . To minimise risk, wear goggles and a lab coat while carrying out the experiment. Always wipe up spillages as soon as they occur.

Using a Bunsen burner will mean there is a risk of burns. To minimise risk, always hold the Bunsen at the bottom, and leave all apparatus to cool before touching it. The seriousness of the burn depends on the appearance and texture of the burn. Burns should be run under very cold water for at least 5 minutes, to reduce redness.

Use of glassware carries the risk of breaking it and getting cut. When sliding into rubber tubing and inserting bungs, always hold the glass as close as possible to the end.

Method

Collect the chemicals and set up all the equipment, as shown in the diagram below:



Measure exactly 0.330g of Copper Carbonate ($CuCO_3$) in a Petri dish Record the Mass.

Transfer the Copper Carbonate into the boiling tube and place a bung into the top of the boiling tube.

Fix the test tube to the retort stand, using a clamp. Make sure the test tube and clamp is fixed correctly to the retort stand.

Attach the gas syringe to the delivery tube (from the test tube), making sure that the syringe is fully depressed.

Light the Bunsen Burner, and open the air hole to produce a blue flame. Make sure that the flame is under the powder in the test tube.

Apply heat to the test tube

Continue heating the test tube until the powder turns black and until the volume of gas remains constant.
Once the powder has turned black, turn the Bunsen burner off, and allow all the equipment to cool.
Once the plunger on the gas syringe has stopped moving, record the volume of gas given off, by looking at the scale along the side of the syringe.
The reaction will be complete when the volume in the gas syringe remains constant.
It is important that the gas is at room temperature for the results to be accurate.
Repeat the experiment another 2 times to eradicate any anomalies.