Decomposition of Copper Carbonate on Heating

Introduction

Copper can form two oxides, Cu_2O and CuO. I am to devise and perform an experiment to determine which of these two oxides is formed when Copper Carbonate is thermally decomposed. Because Copper c an form two possible oxides[1], there are two possible equations for the reaction:

$$2\,CuCO_3\,(s) \rightarrow Cu_2O\,(s) + 2CO_2\,(g) + \tfrac{1}{2}\,O_2\,(g)$$

Or

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

Calculations

I know that one mole of gas will occupy 24 dm^3 at room temperature and pressure (r.t.p.).[2] In the first equation, 1.25 moles (1 mole of CO_2 and ¼ of a mole of O_2) of gas are produced for every mole of $CuCO_3$ that reacts, however, in the second equation only 1 mole of gas (CO_2) is produced. Thus by measuring the volume of gas given off for a specific mass of Copper Carbonate, I can determine which reaction is taking place. If 1 mole of Copper Carbonate were reacted, then the reactions would produce 30 dm^3 and 24 dm^3 respectively. However, using these quantities would be impractical. One mole of Copper Carbonate would weigh 123 grams, and would most likely not fit inside the conical flasks we have available. The gas syringes available are also too small, with a maximum capacity of 100 cm^3 or 0.1 dm^3.

I will aim to collect a maximum of 80cm^3 of gas, to allow some error before the maximum capacity of the gas syringe is reached. Due to the fact that the first reaction will produce a greater volume of gas, and the figure being taken into consideration is the maximum volume produced, the first reaction is what shall be used to calculate sensible quantities for the reactant.

80 cm^3 = 0.08 dm^3

Volume / Volume Of One Mole = Number of Moles[1]

0.08/24 = 0.0033•

In the first reaction, there is a mole ratio of 1:1.25 for Copper Carbonate: Gas.

Moles Of Gas / Moles of Gas Produced per Mole of $CuCO_3$ = Moles of $CuCO_3$

- ⇨ 0.0033• / 1.25 = 0.0026

No. Of Moles * Relative Atomic Mass = Mass

- ⇨ 0.0026• * 123 = 0.328

Thus, to obtain 80 cm^3 of I would need to use roughly 0.328 grams of Copper Carbonate, assuming the first equation to be correct. Following is a calculation to estimate the volume of gas produced if the second equation is correct.

Ratio of $CuCO_3$: Gas is 1 : 1

- ⇨ No. Of Moles of $CuCO_3$ = No. Of Moles of Gas
- ⇨ No. Of Moles of $CuCO_3$ * Volume of One Mole = Volume
- ⇨ 0.0026• * 24 000 = 63.9•

Thus if the second equation was correct, I would expect to collect an amount of gas roughly equal to 64 cm^3.

Due to limitations on the equipment that is practically availa ble, there will be some scope for error in the readings taken from the experiment. Using weighing scales accurate to .001g means that there is a possible error of ±0.0005g. However, due to changes in pressure and other environmental factors, the last digit on a three d.p. scale tends to flicker between two values, meaning the actual error is more accurately calculated using ±0.002g, thus:

Possible Error / Reading Taken * 100 = Percentage Error

- ⇨ (0.002 / 0.328) * 100 = 0.61%

As well as error due to the electronic scales, I also have to take into account that the gas syringe is only accurate to ±0.5cm ^{3}, and because two readings are to be taken (an initial and final reading) this has to be doubled, so there is a potential error of ±1cm^3. This would have the greatest effect if the second equation were correct, and only 64cm^3 of gas produced. Thus I shall use the following calculation:

Percentage Error = (1/64)*100

= 1.56%

Combining the two, there is a maximum error of ≈ 2.17%

I think these quantities are a sensible amount to use. They are not so large that disposal becomes a problem, but they are large enough that the possible errors due to equipment limitations remain a very small percentage of the final results. The quantities are also large enough that there is a 16cm ^{3} difference between the two possible expected results, which is a large enough margin that it should be obvious which of the two is correct. Had I used a smaller value, the difference would have also decreased respectively, which could result in the two results being confused due to error in the final readings.

Equipment List

Following is a list of equipment I plan to use.

- 4 Boiling Tubes
- 4 Weighing Bottles
- Bung and Delivery Tube
- 100 cm^3 Gas Syringe w/ fitted rubber tubing.
- Bunsen Burner
- Safety Mat
- Stopwatch
- 2x Retort Stand
- 2x Cross Tee + Clamp
- Electronic Measuring Scales (accurate to 3 d.p.)
- Spatula
- Copper Carbonate Powder

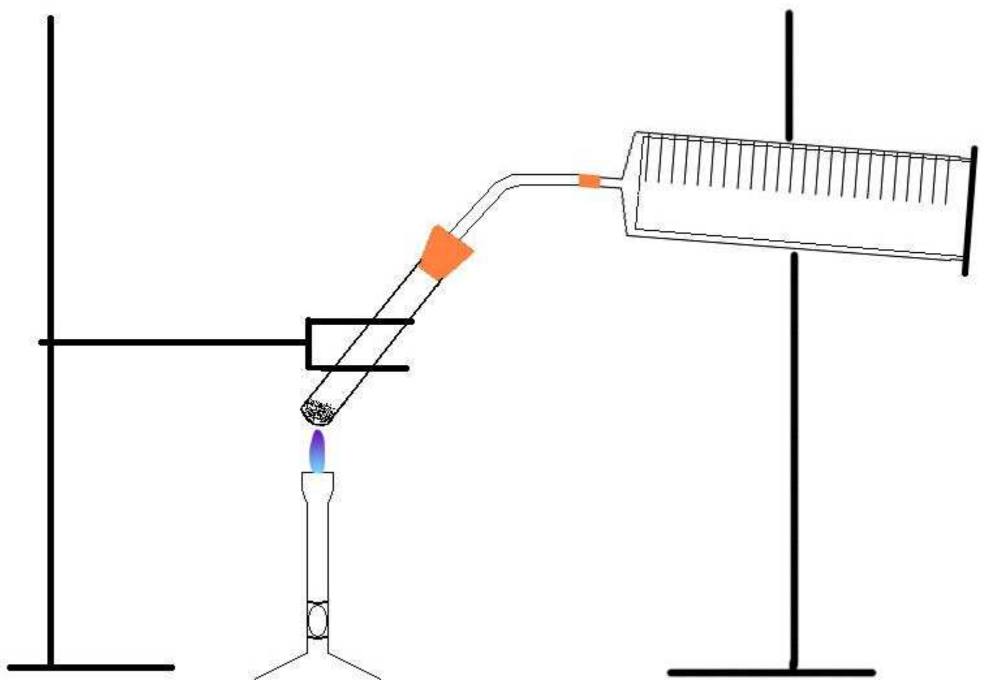
Safety

During my experiment, there is a chance of exposure to several chemicals, and some possibly dangerous procedures need to be carried out. Following is an outline of possibly dangerous chemicals or procedures, the hazards they present, and the precautions to be taken to minimise risk.

Chemical or Procedure	Hazard	Precautions
Heating with Bunsen Burner	Burns	Ensure Bunsen is on safety flame if unattended. Avoid handling
Utilising Glassware	Sharp if broken	Take care when handling, ensure it is clamped securely into position, but do not over tighten clamps.
Copper Carbonate[3]	Irritation to eyes, harmful if swallowed.	Wear safety goggles; avoid stirring up powder and any resulting ingestion.
$Cu_{(I)}O$	Irritant to the eyes and upper respiratory tract. Metal fume fever.	Wear safety goggles; avoid stirring up powder and any resulting inhalation.
$Cu_{(II)}O$	Irritant to the eyes and upper respiratory tract. Metal fume fever.	Wear safety goggles; avoid stirring up powder and any resulting inhalation.

Method

For the experiment the equipment should be set up as shown :



To perform the experiment correctly, the following procedure should be followed.

1) Collect all equipment listed in the equipment list
2) The weighing bottles should be placed on the scale, and the tare used to set that as the zero value. The required amount of copper carbonate should then be put into the weighing bottle using a spatula.
3) Transfer the copper carbonate to a boiling tube
4) Place a bung with delivery tube into the top of the boiling tube.
5) Place the boiling tube into position using one of the reto rt clamps, as shown in the diagram.
6) Attach a gas syringe to the other retort clamp
7) Insert the delivery tube of the bung into the rubber tubing of the gas syringe.

8) The gas syringe should be tilted very slightly, with the plunger end being lower, to counteract any resistance to motion due to friction.
9) The first reading should now be taken from the gas syringe, and then a Bunsen burner applied to the bottom of the boiling tube on the hottest flame until there is no further reaction.
10) Allow three minutes of heating, to ensure all of the copper carbonate has reacted.
11) At this point, it may be advisable to perform the first and second and third repeats of the experiment, as you should allow at least half an hour after each reaction for the gas to cool back to room temperature before taking a final reading. The amount of gas produced can be calculated easily by subtracting the initial reading from the final reading, if this result is close to $80cm^3$, then it is the first reaction that is taking place, if the result is close to $64cm^3$ then it is the second.

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[1] "Science for Conservators: An Introduction to Materials", Page 95, Routledge, 1992
[2] Foundation Worksheet F29 (Hills Road Sixth Form College), Pages 1, 4
[3] http://ptcl.chem.ox.ac.uk/MSDS/CO/copper_II_carbonate.html - 24/11/05