Chemistry Coursework Skill P: Decomposition of copper carbonate

This is an experiment to determine the thermal decomposition of copper carbonate. As seen in equation 1 and 2 Cu2O and CuO are possible outcomes.

Equation 1: 2 CuCO3 (s) ----------> Cu2O (s) + 2 CO2 (g) + ½ O2 (g)

Equation 2: CuCO3 (s) ----------> CuO (s) + CO2 (g)

By performing a quantitative analysis of the gas volume the two equations can be distinguished.

Background theory

Copper carbonate is found in nature as the mineral malachite and is a green powder. When heated it decomposes to give black copper oxide (CuO) and carbon dioxid. The melting point is
260 °C. Copper has two different oxides, CuO and Cu2O. CuO transfers at 900 °C into Cu2O with loss of oxygen (Hollemann - Wiberg). Thus for this experiment I expect equation 2 to be correct.

Calculating the correct mass of copper carbonate

To receive an adequate amount of gas volume(maximum volume of burette: 50 cm^3) I first have to calculate the necessary amount of CuCO3:

With a molar ratio of 1:1 I use Equation two to calculate the necessary mass of copper carbonate

Equation 2: CuCO3 (s) ----------> CuO (s) + CO2 (g)

'1 mole of copper carbonate will decompose to 1 mole of CuO and 1 mole of CO2'

'1 mole of gas occupies 24360 cm^3 at 20°C, 100kPa'.

I aim at 30 cm^3 volume of gas, so I can ensure all gas is measured.
Thus, if 1 mole of copper carbonate produces 24360 cm^3 of CO2, to produce 30 cm^3 we need:

- number of moles = volume cm^3/24360 cm^3
  = 30 cm^3 /24360 cm^3
  = 0.0012315271 moles of gas

- Mr of CuCO3 = 63.5+12+(3*16)= 123.5

- Mass= moles* Mr = 0.0012315271 moles* 123.5 =0.1520935969 g =0.15 g (2 d.p.) of CuCO3

With equation 2 0,15g of $CuCO_3$ will result in 30 cm^3 gas.

I now calculate the expected volume of gas given equation one is correct:

Equation 1: $2\ CuCO_3\ (s)$ ----------> $Cu_2O\ (s) + 2\ CO_2\ (g) + \frac{1}{2}\ O_2\ (g)$

- The molar ratio in equation one is 2:2.5
- number of moles = mass/Mr
  = 0.1520935969 g /123.5 = 0.0012315271 moles of copper carbonate
- 0.0012315271 moles * 1.25= 0.0015394089 moles of gas

---> to find moles of gas I multiply moles of $CuCO_3$ by 1.25, as 2.5/2 = 1.25.

- 0.0015394089 moles * 24360 cm^3 = 37.5 cm^3

At 20°C, 100kPa the two possible results are 30 and 37.5 cm^3 respectively.

<u>Fair test/ Sources of Error</u>

- copper carbonate has to be weighed out exactly to two decimal places
- bung has to be inserted tightly into test tube before the reaction occurs
- ensure that delivery tube is underneath burette and that burette is vertical
- do not stop reaction as long as bubbles are created
- wait circa 10 min (gas to reach room temperature) after ending of reaction to measure gas evolved
- ensure that there are no air bubbles in the burette
- perform experiment accordingly without $CuCO_3$ and measure collected gas. This volume is to be deducted from the actual results (temperature effect)
- ensure that all copper carbonate has been fully decomposed (colour change)
- precise reading for temperature and air pressure

<u>Variables</u>

controlled variables:

- the pressure of the room, to measure with a barometer for the final calculation.
- the temperature. An increase in temperature may cause an increase in the volume of gas given out by the expansion of the air.
- degree of decomposition of copper carbonate. The green copper carbonate has to turn black completely and has to be heated evenly(heating time).
-

Dependent variable:

- amount of gas.
-

Independent variable

- copper carbonate - fixed

<u>Risk assessment</u>

- copper carbonate is toxic and it can irritate lungs and eyes
- copper(1)oxide is harmful if swallowed and can irritate lungs and eyes
- carbon dioxide has a low hazard symbol. It is asphyxiate and lowers the oxygen content of the air.

    - use the Bunsen burner careful and turn on safety flame when not in use
    - wear goggles and lab coat all the time.
    - when something is spoiled it should be rinsed up immediately
- wear your hair looped up
- apparatus may be hot

Apparatus list

- 1 Bunsen burner for heating
- 1 test tube, good for small weighted sample and, only little air enclosed
- 1 delivery tube to deliver gas to burette
- 1 pair of goggles for safety
- 1 lab coat for safety
- 2 clamp stands for holding test tube and burette
- 1 50 cm^3 burette, accurate to 0.05 cm^3, used to collect the evolved gas
- 1 heat mat underneath Bunsen burner
- 1 bung to close test tube, leak proofed
- 1 spatula to deliver $CuCO3$
- 1 top pan balance, accurate to 0.005g , is use d to weigh copper carbonate
- 0.15g copper carbonate
- 150 cm^3 distilled water
- 1 100 cm^3 beaker, container to keep end of burette under water
- 1 sheet of paper
- 1 Thermometer for correct measurement of temperature
- barometer (not available)
-

Sketch

Method

1. wear goggles and lab coat. Pin hair up
2. collect all apparatus in front of you
3. set up apparatus as shown in the sketch above
4. put a piece of paper on the top ban balance and reset the scale
5. put copper carbonate with a spatula onto the piece of pap er and weigh exactly 0.15g

6. transfer $CuCO_3$ into middle of test tube and insert the bung tightly (no air gaps)
7. measure temperature
8. begin heating powder gently with Bunsen burner
9. gas is led into vertical burette
10. when no more gas bubbles are formed, lift end of delivery tube out of water and stop heating
11. after 10 minutes read and note exactly volume of gas (reading minus 50 cm^3) (2 d.p.)
12. repeat experiment three times
13. work out average volume of gas evolved

The volume of gas is temperature and pressure depende nt. Therefore you have to use a barometer (not available at school) and a thermometer to calculate the correct volume. I reduce the temperature effect of the heated gas by waiting 10 minutes before measuring it.

General gas equation

P*V= n*R*T

P= Pressure
V= Volume
n=moles of gas
R= gas constant =8.314 J k?' mol?'
T= temperature

Example calculation:
P*V=n*R*T
V= (n*R*T)/P
= (1 mol*8.314J k?' mol?' *293 kelvin)/100kPa
= 24.36 dm^3 at 20 °C and 100kPa pressure

After calculating an average volume o f gas produced you can compare this with the theoretical results of 30 cm^3 for equation two and 37.5 cm^3 for equation one. As mentioned above I predict equation 2 to be correct, thus 30 cm^3, or closest to this, of gas should be measured. Due to the small amount of reactants already small deviations in measurement of weight, temperature and pressure could, when added up, show a certain margin of error. Thus more accurate tools (e.g. analytical balance), increased mass of reactants and standardized heating w ill improve accuracy of results.
Alternatively use gravimetric measurement of $CuCO_3$ and CuO respectively.

Bibliography

- Hazcard references from the school laboratory
- Personal class notes
- OCR chemistry, page 1-20
- www.wikipedia.org/wiki/copper%28
- Advanced Chemistry by Michael Clugston and Rosalind Flemming, page 114-122
- Holleman- Wiberg, Lehrbuch der Anorganischen Chemie, page 784 -796

- Hans Rudolf Christen, Chemie, page 147 -150