Conservation of mass in the reaction of marble with acid

Aims of the experiment

- To observe the chemical decomposition of marble in hydrochloric acid and the consequent generation of carbon dioxide.
- To observe the conservation of mass.

Principles

Gases are formed in many chemical reactions. These gases are the product of two or more substances that react together. Despite the conversion of materials during the chemical reaction, the overall mass remains the same. This means that the mass of the products is the same as the mass of the reactants introduced at the beginning.

In this experiment, marble, which is a mixture of calcium carbonate $CaCO_3$ and magnesium carbonate $MgCO_3$, is dissolved in hydrochloric acid.

$$CaCO_3 + 2\ HCl \rightarrow CaCl_2 + H_2O + CO_2\uparrow$$

In the process, carbon dioxide CO_2 is generated, which can be observed by the formation of bubbles. The carbon dioxide is collected using a balloon and used for mass determination.

Risk assessment

When working with acids, always wear a laboratory coat, goggles and gloves.

Hydrochloric acid 1 mol/l

Signal word: Caution

Hazard warnings

H290 May be corrosive to metals.

Safety information

P234 Keep only in original container.

P390 Absorb spillage to prevent material damage.

Equipment and chemicals

1	Portable scales, 300 g : 0.01 g	OHTA302
1	Tweezers, blunt, 145 mm	667 0344
1	Erlenmeyer flask, DURAN, 250 ml	664 238
1	Test tubes, Fiolax, 16 x 160 mm, set of 10	664 043
1	Rubber balloons, set of 10	667 234
1	Graduated pipette, 10 ml	665 997
1	Pipetting ball (Peleus ball)	666 003
1	Overflow vessel, 400 ml	362 04
1	Measuring cylinder, Boro 3.3, 100 ml, glass	602 953
1	Hydrochloric acid, 1 mol/l, 500 ml	674 6900
1	Marble, small pieces, 250 g	673 2500

Fig. 1: Experimental set-up.

Set-up and preparation of the experiment

Preparation

1. Using the scales, weigh out approx. 2 g of marble and set aside.

2. Place the Erlenmeyer flask on the scales and place a test tube into the flask.

3. Place a balloon over the test tube and turn on the scales. (The scales must read “zero”, otherwise set the scales to “zero” once.)

4. Fill the overflow vessel up to the overflow and place it such that the overflowing water is collected by the measuring cylinder.

Performing the experiment

1. Place a bit of marble into the balloon.

2. Pipette 10 ml of 1 mol/l hydrochloric acid into the test tube.

3. Place the weighed marble into the balloon.

4. Carefully pull the balloon over the edge of the test tube. In doing so, be careful that no marble enters the test tube.

Note: There should be as little air in the balloon as possible.

5. After noting the displayed value at the scales, fill the marble from the balloon into the test tube.

6. After a period of gas formation, note the value of the scales and carefully pull the balloon off the test tube.

Note: When pulling off the balloon, make sure that the gas remains in the balloon.

7. Introduce the balloon into the overflow vessel and collect the displaced water using the measuring cylinder and note the value.

Observation

After adding the marble to the hydrochloric acid, the reaction begins and gas bubbles rise and the balloon begins to fill up. During this time, the value on the scales will drop.

Evaluation

The gas released during the reaction causes the value displayed on the scales to drop since the gas is displacing the surrounding air in the balloon as it fills, which is why the gas does not get measured by the scales.

In order to determine the mass difference Δm, the measured value before adding the marble is subtracted from the value at the end of the experiment.

Tab. 1: Determined and calculated values of the mass of hydrochloric acid and marble.

Measurement	Mass
Initial value m_1	12.02 g
Final value m_2	11.89 g
Difference $\Delta m = m_2 - m_1$	−0.13 g

To now determine the mass of gas generated, the mass m is calculated from the displaced volume V and the air density ρ. The following formula

$$m = \rho \cdot V$$

is used for this purpose.

Tab. 2: Determined and calculated values of the mass of gas generated.

Measurement	Measured parameter
Density of air ρ	1.204 g/l
Volume V	0.105 l
Mass m_{Gas}	0.13 g

Results

If the two masses are compared with one another, i.e. the mass loss in the test tube of −0.13 g with the mass increase in the air balloon of 0.13 g, it becomes clear that the two values are exactly the same. Thus the law of conservation of mass is proven.

Cleaning and disposal

The remaining hydrochloric acid is carefully poured into the sink with plenty of water and rinsed well. The rest of the marble is disposed of with normal waste after rinsing it thoroughly.