Changing concentration of hydrochloric acid

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How will changing the concentration of hydrochloric (HCl) acid affect the rate of hydrogen gas (H2) production during the reaction with magnesium (Mg), using the pressure buildup by hydrogen gas?

Introduction

Factors that influence rates of reactions include change in concentration, temperature, surface area, or the addition of a catalyst. This experiment will specifically investigate the effect of concentration change of the reactants upon the rate of reaction, using hydrochloric acid and magnesium strip. The concentration of HCl acid solution is controlled through serial dilution.

2HCl(aq) + Mg(s) â†’ MgCl2(aq) + H2(g)

This experiment in particular will explore how the pressure changes as the above reaction proceeds. Because the reaction produces hydrogen gas as a product, building up more pressure within the confined space of a test tube, a pressure sensor will measure the rate of reaction. After the reaction begins, approximately 20 seconds of data will be collected with each trial, in order to formulate a common trend (a graph of pressure over time). With average slopes of different amount of concentrations, a linear regression line will then be created to sketch the trend, regarding the effect of concentration upon pressure-the rate of reaction.

Hypothesis

According to Collision Theory, the reactant particles must collide together, and thus creating a reaction. Because increasing the concentration of HCl acid solution also means an increase in the number of hydrogen and chloride ions, collision between the reactant particles increases as well, resulting in

more products-hydrogen gas. With more production of hydrogen gas in the confined test tube, pressure will build up.

Therefore, if-at a given period of time-the concentration of HCl acid solution increases, then the rate of reaction will increase accordingly, because more collisions will occur, producing hydrogen gas at a higher rate.

- Variables
- Variable description
- Method of measuring variable
- Dependent variable

Pressure buildup due to the reaction between hydrochloric acid solution and magnesium

During the reaction, H2gas is produced, thus increasing the volume within the confined space of a test tube and increasing the pressure. This change will be recorded by a pressure sensor. Collecting data for about 10 seconds before the injection of the magnesium strip, the measurement of pressure will continue for about 20 seconds after the reaction begins. Three trials are required for each concentration of HCl solution to minimize random error.

Rate of reaction

Using the more accurate initial rate of the reaction, about 10 seconds of the graph after the reaction begins will be used to create a slope of change in pressure over time.

Independent variable

Concentration of HCl solution

Using serial dilution along with apparatus such as micropipette and flask, the 1M hydrochloric acid solution will be diluted into 0. 5M, 0. 25M, 0. 125M, and 0. 0625M.

Controlled variables

Mg strip (length)

Using a ruler and scissor, the Mg strip will be cut into 15 pieces, each being 1cm.

Volume of hydrochloric acid solution

For each concentration, 3cm3of hydrochloric acid solution is used, accurately measured by a pipette.

Temperature of reactants

The temperature remains constant at room temperature (approx. 25 degrees Celsius) throughout the entire experiment.

Shaking of the test tube

To create the most accurate results possible, physical motion when slightly shaking the test tubes must be repetitive in the same way for each trial.

Size of the test tube

Because different sizes of test tubes would mean different volumes as well, constant size (volume) is essential, preferably small so that the reaction will be more conspicuous. To do this, 15 identical test tubes are used.

Table 1: List of Variables

Apparatus and Materials

- 1M hydrochloric acid solution
- Distilled water
- Magnesium strip
- Flask (50cm3)
- Pressure sensor
- Logger Pro
- Micropipette
- 15 identical test tubes
- Sandpaper
- Scissor

Procedure

Put 20cm3 of 1M HCL solution in the flask and dilute it to 0. 5M with 20cm3 of distilled water.

Using the serial dilution as in step 1, prepare 10cm3 solutions with concentrations of 1M, 0. 5M, 0. 25M, 0. 125M, and 0. 0625M.

Add 3 cm3 of each solution into labeled test tubes using the micropipette.

Repeat step 3 to prepare three test tubes of each solution (15 in total)

Cut out the magnesium strip into 15 pieces of 1cm and sand them with sandpaper.

Put the cut out magnesium strip into the test tube with 1M HCl solution.

Then quickly cover the test tube with the pressure sensor.

Start collecting data while shaking the test tube in a consistent manner for about 25 seconds after the reaction begins.

Repeat steps 6 to 8 for all other test tubes.

Data Collection and Processing

Qualitative Data

After the injection of the magnesium strip into the HCl solution, it effervesces and pressure inside the test tube begins to build up.

With test tubes of higher concentration, the pressure seems to be higher within the time limit and more bubbles form.

At the end of the reaction, the solution’s color changed to transparent yellow.

The reacted solution (product) gives off a foul smell.

Processed Data

Data Presentation

1 0. 5 0. 25 0. 125 0. 0625

Uncertainties

Standard Deviation

Standard deviation was calculated and represented in the rate of reaction vs. concentration graph as error bars.

Standard deviation for different concentration of HCl solution

Standard deviation was calculated by a graphing calculator.

Uncertainty due to the serial dilution of HCl solution

Uncertainty due to 1cm3

Uncertainty during dilution & measuring pressure (?)

Conclusion

In Figure 1, the trend of different concentrations of reactants influencing the rate of reaction is illustrated. The linear regression line demonstrates the clear change in rate of reaction, according to the change in concentration- the lower the concentration, the slower the rate of reaction. Hence, the initial hypothesis, stating the direct relationship between concentration and rate of reaction, is justified and validated.

Evaluation

Shown by Table 4, in which the standard deviations for each concentration of HCl solution are calculated, the results of this experiment are fairly precise, but not to a great extent. Moreover, uncertainties created during the preparation of the experiment, as with the management of apparatus and materials such as the gas pressure sensor, flask, and micropipette decreases the accuracy. Although Figure 1, the graph containing the general trend of concentration's effect upon the rate of reaction seems to validate the hypothesis, the rate of reaction of 0. 25M HCl solution stands out of the trend, decreasing the validity of this experiment's results.

More factors that may have hindered obtaining accurate results of this experiment include:

- Error
- Impact
- Improvements

Using hand to shake the test tubes for faster reaction rate

Any non-perceptible (by humans) changes influenced each reaction to proceed differently, ultimately creating different circumstances for each trial. This change in circumstances is crucial since it greatly hinders accurate results.

The use of a vibration plate instead may reduce error as it is more consistent. Reproducible circumstances can be better achieved.