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## Effect of Concentration on Reaction Speed

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### Abstract

This study aimed to investigate the effect of concentration on reaction speed, so that we can find out more about the relationship between reaction rates and factors that influence reaction rates, namely temperature and the concentration of reagents. 10 test tubes are provided on the tube rack, 5 tubes filled with 5 mL H<sub>2</sub>SO<sub>4</sub> (fixed concentration), 5 tubes filled with 5 mL, 4 mL, 3 mL, 2 mL, 1 mL Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> 0.1 M diluted to volume 5 mL with distilled water. Mix the contents of the tube from the first 5 preparations into the second preparation. The results show that the higher the concentration, the faster the reaction rate. Conversely, the lower the concentration, the slower the reaction rate.

**Keywords:** Reaction, Concentration, Temperature

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### Introduction

Chemical kinetics as science began in the mid-19th century, when Wilhelmy first introduced that the speed of chemical reactions follows a definite law, but although his work paved the way for Waage and Guldberg's laws of mass action, it attracted attention until it was picked up by Ostwald towards the end. Wilhelmy realized that the speed of the reaction depends on the concentration of the reactants, but before considering some examples, it is necessary to examine the chemical reaction processes that are classified (Cornish-Bowden, 2013).

Kinetic studies have been used as a tool to determine the reaction mechanism of chemical kinetics in a very broad and important part of the chemistry as a whole. This is also called chemical dynamics. The speed of chemical reactions varies with the conditions studied over the years. The correlation of the rate of reaction with the energy associated with the reaction molecule was first given by Arrhenius (Smith, 2008). The inversion of cane sugar in solution in the presence of hydrogen ions was studied by Wilhelmy, and he was the first scientist to investigate quantitative measurements of the speed of chemical reactions. There are various types of chemical reactions as well as experimental techniques used in the investigation of chemical kinetics (Patil, Katre, & Singh, 2007).

Based on the description above, a reaction speed experiment was carried out, so that we can find out more about the relationship between the reaction rate and the factors that affect the reaction rate, namely temperature (temperature) and the concentration of reagents.

The principle of this experiment is to determine the effect of temperature on reaction speed using Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> and H<sub>2</sub>SO<sub>4</sub> solutions which are treated in the form of heating the solution in a test tube with rubbing alcohol. Then, reacting Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> and H<sub>2</sub>SO<sub>4</sub> with varying volumes then adding distilled water until the volume becomes the same to determine the effect of concentration on reaction speed.

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### Reaction Speed

The study of reaction kinetics includes determining the parameters that can be used for the reaction results at any time under certain conditions. These parameters include reaction rate constants, equilibrium constants and activation energy (Sharma, Kodgire & Kachhwaha, 2019).

According to Chan, Dodani & Chang, (2012), the reaction speed of a reaction depends on the number of collisions between reacting molecules that occur per unit of time. The greater the number of collisions, the greater the reaction speed. One way to increase the number of collisions is to increase the number of molecules per volume, so that the likelihood of collisions between molecules will increase as well. The mathematical expression which gives the relationship between reaction speed and concentration at a fixed temperature is called the Law of Reaction Velocity (Hixson & Crowell, 1931). For elementary reactions, the reaction rate at any time is directly proportional to the concentration of the reactants at that time. For this type of reaction, the law of reaction velocity can be directly derived from the stoichiometric equation. Example for the reaction:



Is an elementary reaction, then the law of reaction speed is:

$$V = [A] [B] \text{ or } v = k [A] [B] \quad (2.2)$$

where k is a constant called the reaction rate constant. The value of k depends on the type of reaction, the time unit used and the specific temperature. Whereas for reactions that are not elementary reactions, such as reactions that run more and one stage or reactions that are endless, the law of reaction speed and reaction order can only be determined from experimental data (Chan, Dodani & Chang, 2012).

Increasing the reaction rate apart from increasing the concentration of the reacting substances, it can also increase the reaction temperature. This is because with an increase in temperature, the kinetic energy of the reacting molecules will increase. Thus the molecules will move at a higher speed, so that it will increase the number of collisions per unit time which results in the reaction going faster. Temperature will affect the volume of the mixture of substances that reacts with the reaction rate constant (k). The effect on the relative reaction rate constant is quite large. Mathematically, the effect of temperature on the reaction speed constant is given by an empirical expression known as the Arrhenius equation (Chan, Dodani & Chang, 2012).

So much so that even then, the dangers to the environment cannot be ignored. Various process improvements were made using Gay-Lussac and Glover furnaces. The latter is widely used because nitrogen oxides are reusable and their nitrate yield is greater. The idea of using a catalyst in the production of sulfuric acid, or specifically in the oxidation of sulfur dioxide, has been around since about 1830. Platinum catalysts proved to be effective but so expensive that they were not widely used. After half a century later, when the demand for sulfuric acid increased substantially, the idea of using a catalyst resurfaced. After the problem of catalyst poisoning is resolved, the process of using platinum catalysts, namely the contact process, becomes the main process in the production of sulfuric acid. The contact process is still used today even though the catalyst is not platinum, but a mixture including  $V_2O_5$  (Chan, Dodani & Chang, 2012).

### Reaction Order

According to Chan, Dodani & Chang (2012), the value of the reaction order can be 0, 1, 2, 3, even a simple fraction. The steps for determining the reaction order are based on experimental data, as follows:

- Experimental data must be at a constant temperature to get a fixed value for k.
- The order of the reaction is found by comparing the rate equation for the reaction:

$$\frac{[V_1]}{[V_2]} = \frac{[k_1]}{[k_2]} = \frac{[A_1]^n [B_1]^m}{[A_2]^n [B_2]^m} \quad (2.6)$$

The value of  $k_1 = k_2$  and the same concentration can be crossed out. Thus the reaction order of the changing concentration can be determined.

## **Factors Affecting Reaction Speed**

According to Chan, Dodani & Chang (2012), the factors that influence reaction speed are:

### ***Nature and State of Substance***

In a chemical reaction there is a breaking and the formation of bonds, where the type of bond possessed by the band can affect the rate of the reaction. In addition, the surface area of the substances that reacts greatly affects the rate of the reaction, so that a substance in the form of a powder and a chunk / chip will have a different reaction rate.

### ***Concentration***

The greater the concentration of the reactants, the more likely an effective collision will occur, so that the reaction rate will be faster. Effective collisions are collisions between molecules that produce a reaction, and can only occur when the molecules, which collide, have sufficient activation energy. Activation energy is the minimum energy that only molecules have for their collision to produce a reaction.

### ***Temperature***

Increasing the temperature means adding energy, so that the kinetic energy of the molecules will increase. As a result, the reacting molecules become more active in turn. In other words, the increase in temperature causes the motion of the molecules to accelerate so that the possibility of an effective collision increases.

### ***Catalyst***

A catalyst is a substance that speeds up a reaction, but doesn't react with it. The presence of a catalyst will reduce the activation energy ( $E_a$ ) of a reaction, so that it is easier for the reactant molecules to pass, as a result the reaction becomes faster.

## **Sulfuric Acid ( $H_2SO_4$ ) and Sodium Thiosulfate ( $Na_2S_2O_3$ )**

Pure sulfuric acid is colorless, a viscous liquid that freezes at  $10.4^\circ C$  and boils at  $279.6^\circ C$ . This material reacts violently with water and with organic compounds. Sulfuric acid can be mixed with water in any proportion, releasing a large amount of heat. Besides being corrosive, sulfuric acid is easy to handle and transport in steel drums. This fact, together with its acid strength and low price, has led to this sulfuric acid being used widely in various fields. In metal processing, sulfuric acid is used to leach copper, uranium and vanadium from ores and to "pickle," or descale, steel. In acidification, the oxide layer on the metal surface is dissolved by reaction with an acid. Much sulfuric acid is used as a dehydrating agent in the synthesis of organic chemicals. The use that is less but quite important is its use in the manufacture of hydrochloric acid and hydrofluoric acid and  $TiO_2$  pigments for paint (Oxtoby, Gillis & Butler, 2015).

Sodium Thiosulfate is a colorless crystal. This results in various reactions with free chlorine, depending on the pH of the solution. The pH of the sodium thiosulfate solution is close to neutral. Despite producing HCl during dechlorination, field studies have shown that the reaction does not change the pH of the solution. Thiosulfate is an oxygen collector and reducing agent. However, these substances collect less oxygen than sodium sulfite, bisulfite or metabisulfite. Sodium thiosulfate is a skin, eye, nose and throat irritant. It is quite toxic by the intravenous route. A Usepa toxicity study shows that sodium thiosulfate is less toxic to aquatic species.

There are no published data available regarding the stability of sodium thiosulfate. However, utilities using thiosulfates for dechlorination have reported that the strength of thiosulfate solutions does not decrease significantly after 2 or 3 days of storage (American Water Works Association, 2006).

## Methods

The tools used in this experiment were test tubes, stopwatches, tripods, gauze, tube racks, cup glasses, measuring pipettes and bulbs. The materials used in this experiment were 0.1 M H<sub>2</sub>SO<sub>4</sub>, 0.1 M Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>, distilled water, ice water, rolled tissue, and soap.

## Work Procedures

10 test tubes are provided on the tube rack, 5 tubes filled with 5 mL H<sub>2</sub>SO<sub>4</sub> (fixed concentration), 5 tubes filled with 5 mL, 4 mL, 3 mL, 2 mL, 1 mL Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> 0.1 M diluted to volume 5 mL with distilled water. Mix the contents of the tube from the first 5 preparations into the second preparation. Turn on the stopwatch when mixing, and stop after the reaction (cloudiness). The stopwatch is turned off before the solution gets too cloudy. Note the time used and determine the values for m, k, and make the equation for the reaction speed.

### Effect of Concentration H<sub>2</sub>SO<sub>4</sub>

10 test tubes are provided on the tube rack, 5 tubes are filled with 5 mL Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> (fixed concentration), each tube is filled with 5 mL, 4 mL, 3 mL, 2 mL, 1 mL of 0.1 M H<sub>2</sub>SO<sub>4</sub> diluted to a volume of 5 mL with aquades. Mix the contents of the tube from the first 5 preparations into the second preparation. Turn on the stopwatch when mixing and stop after the reaction (cloudiness). The stopwatch is turned off before the solution gets too cloudy. Note the time used and determine the values for m, k, and make the equation for the speed of the reaction.

### Effect of Temperature

6 test tubes were prepared on the tube rack. The concentration of H<sub>2</sub>SO<sub>4</sub> and Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> was chosen. From 3 test tubes filled with H<sub>2</sub>SO<sub>4</sub> and 3 pieces filled with Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>. Put cold water (15°C) into the beaker. Inserted a pair of tubes containing H<sub>2</sub>SO<sub>4</sub> and Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> into the beaker so that the temperature is evenly distributed along with the solution. A tube containing H<sub>2</sub>SO<sub>4</sub> and 1 tube containing Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> is taken in a beaker. The solution is mixed and the stopwatch is switched on. the tube containing H<sub>2</sub>SO<sub>4</sub> and Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>, remains in the beaker. The stopwatch is turned off in case of a reaction (cloudy). Record the time used and the reaction temperature. The series of procedures were reworked at a temperature of 31°C and a temperature of 85°C.

## Results

### The Effect of Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>

#### Initial Concentration

For 5 mL Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>		$V_1 \times M_1$	$= V_2 \times M_2$
		3 mL x 0,1 M	$= 5 \text{ mL} \times M_2$
$V_1 \times M_1$	$= V_2 \times M_2$	$M_2$	$= 0,06 \text{ M}$
5 mL x 0,1 M	$= 5 \text{ mL} \times M_2$	For 2 mL Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	
$M_2$	$= 0,1 \text{ M}$	$V_1 \times M_1$	$= V_2 \times M_2$
		2 mL x 0,1 M	$= 5 \text{ mL} \times M_2$
For 4 mL Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>		$M_2$	$= 0,04 \text{ M}$
$V_1 \times M_1$	$= V_2 \times M_2$	For 1 mL Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	
4 mL x 0,1 M	$= 5 \text{ mL} \times M_2$	$V_1 \times M_1$	$= V_2 \times M_2$
$M_2$	$= 0,08 \text{ M}$		
For 3 mL Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>			

$$1 \text{ mL} \times 0,1 \text{ M} = 5 \text{ mL} \times M_2 \quad M_2 = 0,02 \text{ M}$$

**Final Concentration**

For  $\text{Na}_2\text{S}_2\text{O}_3$  0,1 M

$$[\text{Na}_2\text{S}_2\text{O}_3]_{\text{final}} = 0,06 \text{ M} \times \frac{5 \text{ mL}}{10 \text{ mL}} = 0,03 \text{ M}$$

$$= [\text{Na}_2\text{S}_2\text{O}_3] \times \frac{V_{\text{initial}}}{V_{\text{final}}}$$

$$= 0,1 \text{ M} \times \frac{5 \text{ mL}}{10 \text{ mL}} = 0,05 \text{ M}$$

For  $\text{Na}_2\text{S}_2\text{O}_3$  0,04 M

$$[\text{Na}_2\text{S}_2\text{O}_3]_{\text{final}} = [\text{Na}_2\text{S}_2\text{O}_3] \times \frac{V_{\text{initial}}}{V_{\text{final}}}$$

For  $\text{Na}_2\text{S}_2\text{O}_3$  0,08 M

$$[\text{Na}_2\text{S}_2\text{O}_3]_{\text{final}} = 0,04 \text{ M} \times \frac{5 \text{ mL}}{10 \text{ mL}} = 0,02 \text{ M}$$

$$= [\text{Na}_2\text{S}_2\text{O}_3] \times \frac{V_{\text{initial}}}{V_{\text{final}}}$$

$$= 0,08 \text{ M} \times \frac{5 \text{ mL}}{10 \text{ mL}} = 0,04 \text{ M}$$

For  $\text{Na}_2\text{S}_2\text{O}_3$  0,02 M

$$[\text{Na}_2\text{S}_2\text{O}_3]_{\text{final}} = [\text{Na}_2\text{S}_2\text{O}_3] \times \frac{V_{\text{initial}}}{V_{\text{final}}}$$

For  $\text{Na}_2\text{S}_2\text{O}_3$  0,06 M

$$[\text{Na}_2\text{S}_2\text{O}_3]_{\text{final}} = 0,02 \text{ M} \times \frac{5 \text{ mL}}{10 \text{ mL}} = 0,01 \text{ M}$$

$$= [\text{Na}_2\text{S}_2\text{O}_3] \times \frac{V_{\text{initial}}}{V_{\text{final}}}$$

**Concentration Change  $\text{Na}_2\text{S}_2\text{O}_3$**

$$\frac{\Delta[\text{Na}_2\text{S}_2\text{O}_3]}{[\text{Na}_2\text{S}_2\text{O}_3]_{\text{initial}}} = \frac{[\text{Na}_2\text{S}_2\text{O}_3]_{\text{final}}}{[\text{Na}_2\text{S}_2\text{O}_3]_{\text{initial}}} = 0,03 \text{ M} - 0,06 \text{ M} = -0,03 \text{ M}$$

$$\frac{\Delta[\text{Na}_2\text{S}_2\text{O}_3]}{[\text{Na}_2\text{S}_2\text{O}_3]_{\text{initial}}} = \frac{[\text{Na}_2\text{S}_2\text{O}_3]_{\text{final}}}{[\text{Na}_2\text{S}_2\text{O}_3]_{\text{initial}}} = 0,02 \text{ M} - 0,04 \text{ M} = -0,02 \text{ M}$$

$$\frac{\Delta[\text{Na}_2\text{S}_2\text{O}_3]}{[\text{Na}_2\text{S}_2\text{O}_3]_{\text{initial}}} = \frac{[\text{Na}_2\text{S}_2\text{O}_3]_{\text{final}}}{[\text{Na}_2\text{S}_2\text{O}_3]_{\text{initial}}} = 0,01 \text{ M} - 0,02 \text{ M} = -0,01 \text{ M}$$

$$\frac{\Delta[\text{Na}_2\text{S}_2\text{O}_3]}{[\text{Na}_2\text{S}_2\text{O}_3]_{\text{initial}}} = \frac{[\text{Na}_2\text{S}_2\text{O}_3]_{\text{final}}}{[\text{Na}_2\text{S}_2\text{O}_3]_{\text{initial}}} = 0,01 \text{ M} - 0,02 \text{ M} = -0,01 \text{ M}$$

**Reaction Speed**

$$V_1 = \frac{-\Delta[\text{Na}_2\text{S}_2\text{O}_3]}{t} = \frac{-(-0,05 \text{ M})}{22 \text{ second}}$$

$$= 0,0022 \text{ M/second}$$

$$V_2 = \frac{-\Delta[\text{Na}_2\text{S}_2\text{O}_3]}{t}$$

$$= \frac{-(-0,04 \text{ M})}{27 \text{ second}}$$

$$= 0,0014 \text{ M/second}$$

$$V_3 = \frac{-\Delta[\text{Na}_2\text{S}_2\text{O}_3]}{t}$$

$$= \frac{-(-0,03 \text{ M})}{39 \text{ second}}$$

$$= 0,00076 \text{ M/second}$$

$$V_4 = \frac{-\Delta[\text{Na}_2\text{S}_2\text{O}_3]}{t}$$

$$= \frac{-(-0,02 \text{ M})}{62 \text{ seconds}}$$

$$= 0,00032 \text{ M/second}$$

$$V_5 = \frac{-\Delta[\text{Na}_2\text{S}_2\text{O}_3]}{t}$$

$$= \frac{-(-0,01 \text{ M})}{119 \text{ seconds}}$$

$$= 0,000084 \text{ M/second}$$

### The Effect of H<sub>2</sub>SO<sub>4</sub>

#### Initial Concentration

For 5 mL H<sub>2</sub>SO<sub>4</sub>

$$V_1 \times M_1 = V_2 \times M_2$$

$$5 \text{ mL} \times 0,1 \text{ M} = 5 \text{ mL} \times M_2$$

$$M_2 = 0,1 \text{ M}$$

For 4 mL H<sub>2</sub>SO<sub>4</sub>

$$V_1 \times M_1 = V_2 \times M_2$$

$$4 \text{ mL} \times 0,1 \text{ M} = 5 \text{ mL} \times M_2$$

$$M_2 = 0,08 \text{ M}$$

For 3 mL H<sub>2</sub>SO<sub>4</sub>

$$V_1 \times M_1 = V_2 \times M_2$$

$$3 \text{ mL} \times 0,1 \text{ M} = 5 \text{ mL} \times M_2$$

$$M_2 = 0,06 \text{ M}$$

For 2 mL H<sub>2</sub>SO<sub>4</sub>

$$V_1 \times M_1 = V_2 \times M_2$$

$$2 \text{ mL} \times 0,1 \text{ M} = 5 \text{ mL} \times M_2$$

$$M_2 = 0,04 \text{ M}$$

For 1 mL H<sub>2</sub>SO<sub>4</sub>

$$V_1 \times M_1 = V_2 \times M_2$$

$$1 \text{ mL} \times 0,1 \text{ M} = 5 \text{ mL} \times M_2$$

$$M_2 = 0,02 \text{ M}$$

#### Final Concentration

For H<sub>2</sub>SO<sub>4</sub> 0,1 M

$$[\text{H}_2\text{SO}_4]_{\text{final}} = [\text{H}_2\text{SO}_4] \times \frac{V_{\text{Initial}}}{V_{\text{final}}}$$

$$= 0,1 \text{ M} \times \frac{5 \text{ mL}}{10 \text{ mL}}$$

$$= 0,05 \text{ M}$$

For H<sub>2</sub>SO<sub>4</sub> 0,08 M

$$[\text{H}_2\text{SO}_4]_{\text{final}} = [\text{H}_2\text{SO}_4] \times \frac{V_{\text{Initial}}}{V_{\text{final}}}$$

For H<sub>2</sub>SO<sub>4</sub> 0,06 M

$$[\text{H}_2\text{SO}_4]_{\text{final}} = [\text{H}_2\text{SO}_4] \times \frac{V_{\text{Initial}}}{V_{\text{final}}}$$

$$= 0,06 \text{ M} \times \frac{5 \text{ mL}}{10 \text{ mL}}$$

$$= 0,03 \text{ M}$$

For H<sub>2</sub>SO<sub>4</sub> 0,04 M

$$[\text{H}_2\text{SO}_4]_{\text{final}}$$

$$= [\text{H}_2\text{SO}_4] \times \frac{V_{\text{Initial}}}{V_{\text{final}}}$$

$$= 0,04 \text{ M} \times \frac{5 \text{ mL}}{10 \text{ mL}}$$

$$= 0,02 \text{ M}$$

For H<sub>2</sub>SO<sub>4</sub> 0,02 M

$$[\text{H}_2\text{SO}_4]_{\text{final}}$$

$$= [\text{H}_2\text{SO}_4] \times \frac{V_{\text{Initial}}}{V_{\text{final}}}$$

$$= 0,02 \text{ M} \times \frac{5 \text{ mL}}{10 \text{ mL}}$$

$$= 0,01 \text{ M}$$

### Change in Concentration of H<sub>2</sub>SO<sub>4</sub>

$$\frac{\Delta[\text{H}_2\text{SO}_4]}{[\text{H}_2\text{SO}_4]_{\text{initial}}}$$

$$= \frac{[\text{H}_2\text{SO}_4]_{\text{final}} - [\text{H}_2\text{SO}_4]_{\text{initial}}}{[\text{H}_2\text{SO}_4]_{\text{initial}}}$$

$$= \frac{0,05 \text{ M} - 0,1 \text{ M}}{0,1 \text{ M}}$$

$$\frac{\Delta[\text{H}_2\text{SO}_4]}{[\text{H}_2\text{SO}_4]_{\text{initial}}}$$

$$= \frac{[\text{H}_2\text{SO}_4]_{\text{final}} - [\text{H}_2\text{SO}_4]_{\text{initial}}}{[\text{H}_2\text{SO}_4]_{\text{initial}}}$$

$$= \frac{0,04 \text{ M} - 0,08 \text{ M}}{0,08 \text{ M}}$$

$$\frac{\Delta[\text{H}_2\text{SO}_4]}{[\text{H}_2\text{SO}_4]_{\text{initial}}}$$

$$= \frac{[\text{H}_2\text{SO}_4]_{\text{final}} - [\text{H}_2\text{SO}_4]_{\text{initial}}}{[\text{H}_2\text{SO}_4]_{\text{initial}}}$$

$$= \frac{0,03 \text{ M} - 0,06 \text{ M}}{0,06 \text{ M}}$$

$$\frac{\Delta[\text{H}_2\text{SO}_4]}{[\text{H}_2\text{SO}_4]_{\text{initial}}}$$

$$= \frac{[\text{H}_2\text{SO}_4]_{\text{final}} - [\text{H}_2\text{SO}_4]_{\text{initial}}}{[\text{H}_2\text{SO}_4]_{\text{initial}}}$$

$$= \frac{0,02 \text{ M} - 0,04 \text{ M}}{0,04 \text{ M}}$$

$$\frac{\Delta[\text{H}_2\text{SO}_4]}{[\text{H}_2\text{SO}_4]_{\text{initial}}}$$

$$= \frac{[\text{H}_2\text{SO}_4]_{\text{final}} - [\text{H}_2\text{SO}_4]_{\text{initial}}}{[\text{H}_2\text{SO}_4]_{\text{initial}}}$$

$$= \frac{0,01 \text{ M} - 0,02 \text{ M}}{0,02 \text{ M}}$$

$$= -0,01 \text{ M}$$

### Reaction Speed

$$V_1 = \frac{-\Delta[\text{H}_2\text{SO}_4]}{t}$$

$$= \frac{-(-0,05 \text{ M})}{31 \text{ seconds}}$$

$$= 0,0016 \text{ M/second}$$

$$V_2 = \frac{-\Delta[\text{H}_2\text{SO}_4]}{t}$$

$$= \frac{-(-0,04 \text{ M})}{45 \text{ seconds}}$$

$$= 0,00088 \text{ M/second}$$

$$V_3 = \frac{-\Delta[\text{H}_2\text{SO}_4]}{t}$$

$$= \frac{-(-0,03 \text{ M})}{52 \text{ seconds}}$$

$$= 0,00057 \text{ M/second}$$

$$V_4 = \frac{-\Delta[\text{H}_2\text{SO}_4]}{t}$$

$$= \frac{-(-0,02 \text{ M})}{69 \text{ seconds}}$$

$$= 0,00028 \text{ M/second}$$

$$= \frac{-(-0,01 \text{ M})}{76 \text{ seconds}}$$

$$= 0.00013 \text{ M/second}$$

$$V_5 = \frac{-\Delta[\text{H}_2\text{SO}_4]}{t}$$

### Effect of Temperature

$$[\text{H}_2\text{SO}_4]_{\text{initial}} = 0,1 \text{ M}$$

$$[\text{H}_2\text{SO}_4]_{\text{final}}$$

$$= [\text{H}_2\text{SO}_4] \times \frac{V_{\text{initial}}}{V_{\text{final}}}$$

$$= 0,1 \text{ M} \times \frac{5 \text{ mL}}{10 \text{ mL}}$$

$$= 0,05 \text{ M}$$

$$d[\text{H}_2\text{SO}_4]_{\text{final}} = [\text{H}_2\text{SO}_4]_{\text{final}} -$$

$$[\text{H}_2\text{SO}_4]_{\text{initial}}$$

$$= 0,05 \text{ M} - 0,1$$

$$\text{M}$$

$$= -0,05 \text{ M}$$

$$V_1 = -\frac{d[\text{H}_2\text{SO}_4]}{dt}$$

$$= \frac{-(0,05)}{4}$$

$$= 0,0125 \text{ M/second}$$

$$V_2 = -\frac{d[\text{H}_2\text{SO}_4]}{dt}$$

$$= \frac{-(0,05)}{36}$$

$$= 0,0013 \text{ M/second}$$

$$V_3 = -\frac{d[\text{H}_2\text{SO}_4]}{dt}$$

$$= \frac{-(0,05)}{72}$$

$$= 0,00069 \text{ M/second}$$

### Conclusion

From the results of the experiments that have been carried out, it can be concluded that the concentration affects the speed of the reaction, the higher the concentration, the faster the reaction rate. Conversely, the lower the concentration, the slower the reaction rate. Temperature affects the speed of the reaction, the higher the temperature, the faster the reaction rate. Conversely, the lower the temperature, the slower the reaction rate.

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