Decomposition of h2o2 effects

Enzymes are proteins that enter a biochemical reaction and speed up the reaction rate. Enzymes actually help the reaction by lowering its activation energy. Like other proteins, they work properly because of their active site and a conformational change. The molecule that attaches to the active site is called the substrate. Cells and systems prosper due to enzymes increasing reaction rates. The rate of reaction due to the enzyme will constantly increase a significant amount as long as there is a constant abundance of the substrate. Once this concentration starts to lower, the enzyme will interact with less as time continues, therefore the reaction rate will decrease. 1

Many factors can affect the enzyme’s ability to attach with the substrate and efficiently help the biochemical reaction. Competitive inhibitors attach to the active site to stop the bond of the substrate. Noncompetitive inhibitors attach at another section so that there is a conformational change and the active site changes shape. Besides molecules that actually attach to the enzyme, the environmental conditions affect its efficiency as well. There is a prime range of salt concentration, pH level, and temperature when the enzyme prospers, but too high or too low will lead to the denatured protein. When the enzyme denatures, it comes apart so that it can no longer function. 2

A spontaneous reaction is one that has negative free energy (G). These reactions can occur without outside energy entering the system. The energy produced in the process is reused for the reactions. Being a spontaneous reaction does not mean that it is a quick reaction, therefore the reaction can

actually occur very slowly. This is where enzymes help because they lower the activation energy and can greatly speed up the reaction. 3

The decomposition of H2O2 (hydrogen peroxide) into H2O and O2 is a spontaneous reaction that needs an enzyme to speed up the reaction to become efficient. The chemical equation is:

2 H2O2 ïƒ 2 H2O + O2

The enzyme that catalyzes the decomposition is Catalase. 2 With this enzyme, the decomposition rate will increase.

Sulfuric acid, H2SO4, is an acid. When acids are added to a solution, the pH level decreases (becomes more acidic). As explained above, enzymes have a specific pH level they efficiently work at, and if it varies from this level, then the protein will denature. When the sulfuric acid is added to the solution, it acts as an inhibitor as the catalase denatures and the decomposition of H2O2 slows down to its normal rate. 2

Potassium permanganate, KMnO4, reacts with hydrogen peroxide and sulfuric acid to make other products. After all H2O2 is used in the reaction, then the KMnO4 will not be consumed, therefore it will just stay in the solution. Since the KMnO4 has a purplish color, the solution will stay a purplish brown when this happens. The measurement of KMnO4 is proportional to the H2O2, therefore, if the amount of KMnO4 consumed before the solution changes colors is measured. This shows how much H2O2 is left in the solution, which can be compared with the initial amount to find how much was consumed. The actual chemical equation is:

5 H2O2 + 2 KMnO4 + 3 H2SO4 ïƒ K2SO4 + 2 MnSO4 + 8H2O + 5 O2

The potassium permanganate reacts with both the hydrogen peroxide and sulfuric acid, therefore all the reactants in the solution will be used when the KMnO4 is added. The products include water and oxygen, which are also the products when H2O2 decomposes. 2

The purpose of the experiment is to compare the rate of reaction of H2O2 decomposing with and without the presence of catalase to discover the importance of the enzyme for the reaction. The rate of reaction without the enzyme after days is also tested. The effect of the enzyme catalase on the rate of reaction over a few time intervals is tested to see if the rate decreases or increases.

It was hypothesized that the rate of reaction of the non-catalyzed reaction would be very slow; therefore, there would be a lot of H2O2 left compared to the reactions with the catalase. It was hypothesized that if the H2O2 was left in a closed off environment for a long period, as in a few days, the reaction rate would not increase and there would be hardly any H2O2 gone. As time progressed during a reaction with catalase, H2O2 would continue to react, but the reaction rate would slowly decrease, so less and less H2O2 would be used in the later time intervals.

Materials and Methods

Experiment One

- 1. 5% H2O2
- 2 Beakers/Containers

- H2O
- H2SO2 (1 M Solution)
- White Paper
- 2 Pipettes
- KMnO4

10 mL of 15% H2O2 was placed in a beaker, and 1 mL of H2O was added. Then 10 mL of H2SO4 was added and the solution was mixed well. 5mL of the new solution was taken and placed in another small beaker and placed on a sheet of white paper to be able to see the change of color of the solution. Next, a pipette was filled with KMnO4 and this was added to the beaker one drop at a time while the solution was being mixed. Drops were added until the mixture turned a light purple brownish color. The amount of KMnO4 used was noted. The solution was discarded in the sink and the containers were cleaned.

Experiment Two

15mL of the H2O2 solution was placed in a glass and sat uncovered at room temperature for about 72 hours. After that time, 1 mL of H2O was added, then 10mL of H2SO4 was added and the solution was mixed. 5 mL of the solution was taken and placed in another beaker. A pipette was filled with KMnO4 and was added to the solution one drop at a time as it was being stirred. Drops were added until the solution turned to a purplish brown. The amount of KMnO4 used in the pipette was noted.

Experiment Three

The Base Line was found from experiment one since both experiments were done at the same time and under the same conditions, therefore the H2O2 was the same solution concentration from that experiment to this one. Next, 10mL of H2O2 was added to a container and one mL of catalase was added to it. The mixture was stirred for the certain amount of time, 10 seconds, then 10 mL of H2SO4 was added. 5mL of the new solution was taken out and put in a new container. KMnO4 was put in a syringe and a drop at a time was added to the solution until it turned a purplish brown. As each drop was added, the mixture was stirred. Then another 10mL of H2O2 went through the same process, except that 30 seconds occurred until the H2SO4 was added to the mixture. This same process occurred for 60, 90, 120, 180, and 360 seconds as well. Each time, the base line, initial reading of the KMnO4 syringe, and the final reading of the syringe was written down. In the end, all the solutions were discarded in the sink and the containers and syringes were cleaned.

It was hypothesized that without catalase, the decomposition of H2O2 would go very slow. During experiment one, this was tested to see how different the rate of reaction with and without the catalase is. In this experiment, water was added to the solution in place of the catalase. As shown in Table 1, 5mL of KMnO4 was consumed before the solution turned a light brown. Since the KMnO4 reacts with H2O2, the color of the solution does not change until there is no more hydrogen peroxide to react with. Therefore, it was concluded that there was 5mL of H2O2 left in the solution after decomposition occurred. Since there was a lot of H2O2 left in the titration when tested, it was concluded that the reaction rate without the enzyme is

very slow. This is the base line to compare to reactions including catalase so that the difference that the enzyme makes on the reaction rate can be seen.

It was hypothesized that over a few days, in unchanged conditions, H2O2 would not decompose a significant amount. In experiment two, this was tested. In ideal conditions and if the H2O2 was covered, then the concentration would stay similar to the original 1. 5% solution. The results show that 5mL of KMnO4 was used in the reaction with H2O2, therefore 5mL of H2O2 was present in the solution. H2O2 was not noticeably consumed during the 72 hours because the base line from experiment one had the same amount of H2O2 left as the titration in this experiment, as shown in Table 1 and 2. Therefore, it was concluded that the decomposition rate of H2O2 without catalase is almost so slow for a significantly long time that the reaction hardly occurs. The reaction is still a spontaneous reaction, but the rate is very slow. This shows how important the enzyme is in the reaction for systems such as the human body. Without the enzyme, the decomposition of H2O2 would hardly happen and the concentration of the hydrogen peroxide would increase.

In experiment three, it was hypothesized that the H2O2 would continue to react at each time interval, but that the reaction rate would decrease after a certain point. As shown in Table 4, the KMnO4 consumed during each time interval decreased. Since it is a direct proportion of the H2O2 left in the solution, it was concluded that the H2O2 was continually consumed during the time intervals. Therefore, the hypothesis was correct. There was a significant increase of H2O2 consumed from the base line in the short time period when the catalase was added. This is significant because it shows how

important the catalase is for the reaction to occur at an increased rate. The rate of reaction eventually slowed overall at the 180-second interval. Starting here, the reaction rate slowed overall. As shown in Figure 1, the slope of the line increases between 10 and 60 seconds and 90 and 180 seconds at a steeper slant than 180 to 360 seconds. Therefore, it was concluded that the rate of reaction eventually slowed even with the enzyme. This is due to the concentration of substrate in the solution. In the beginning of the reaction, the rate was high, and by the end of the time, the reaction started to slow. It was concluded that as the longer the reaction occurred, the slower the reaction would take place.