Enzyme Lab

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Data

Procedure A

Time (s)	0	15	30	45	60	75	90	105	120
H_2O_2/H_2O	24.2	21.6	20.5	20.4	20.3	20.3	20.1	20.1	20.1
H_2O_2/lj	23.5	29.1	29.9	29.3	29	29	28.8	28.2	28.2

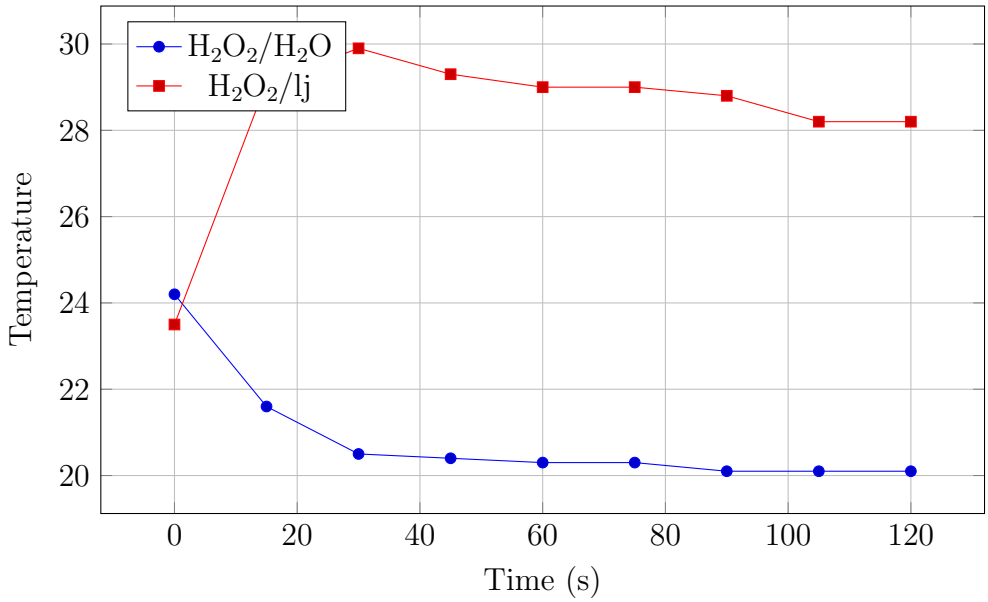


Figure 1: Temperature Changes Over Time for H_2O_2 with Water and Liver Juice

Procedure B

Time (s)	0	15	30	45	60	75	90	105	120
H_2O_2/boiled lj	22	20.5	20.1	20.1	20	20.2	20.2	20.1	20.2
H_2O_2/acid lj	22	21.5	21.5	21	21	21	21.1	21	20.9
H_2O_2/base lj	22	21.2	21.2	21.3	21.2	21.5	21.6	21.8	21.9
H_2O_2/salt lj	23	23.2	24.5	26.9	28.9	31	31.5	31.9	31.7
Boiled H_2O_2/lj	23	31	38	41	41	41	39	38	37.5

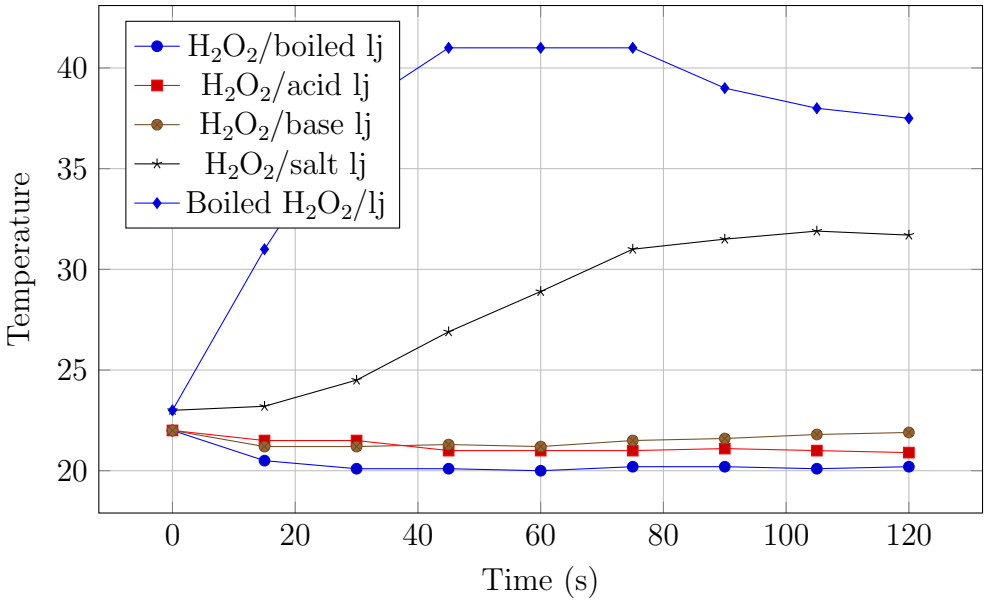


Figure 2: Temperature Changes Over Time for Different Treatments of H_2O_2 with Liver Juice

Procedure C

Time (s)	0	15	30	45	60	75	90	105	120
1.5% H_2O_2	22	26.1	26.9	28.9	26.5	26.2	26.2	26.1	26
3% H_2O_2	23	29.1	30	29.9	29.1	29	28.9	28.5	28.2
6% H_2O_2	23	34	37	36.5	36	35.1	34.9	34.1	33.9
10% H_2O_2	23	38	43	42	41	40	39	38	37.5

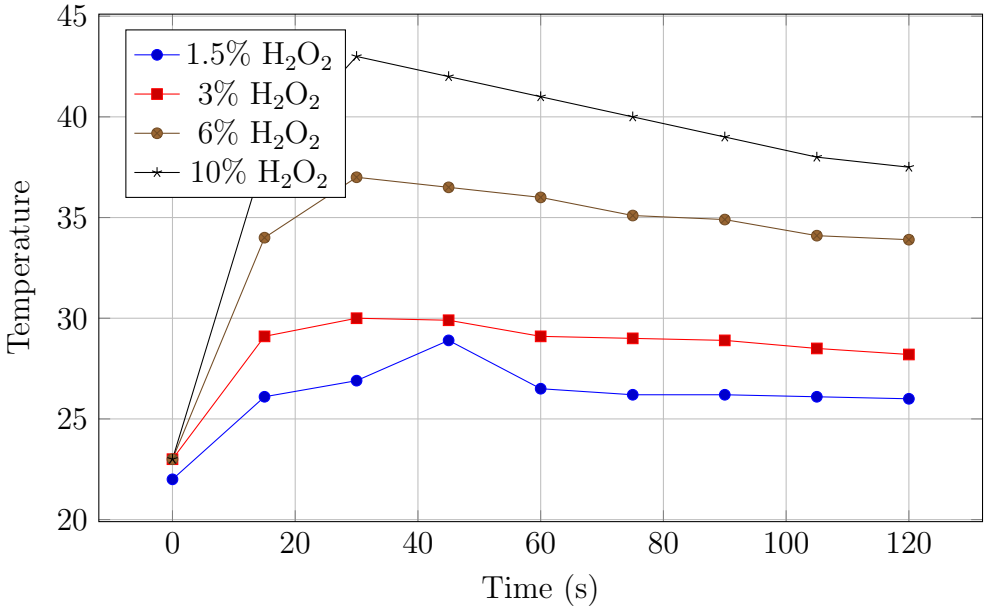


Figure 3: Temperature Changes Over Time for Different Concentrations of H_2O_2

Data Analysis

Question 2

(a) The test tube with water and H_2O_2 saw a slight decrease in temperature because the water was stored colder than room temperature. This test tube serves as a control. It is to show the speed of reaction and temperature increases without enzymes, confirming that the temperature increase we saw was due to the liver juice catalyzing the decomposition of H_2O_2.

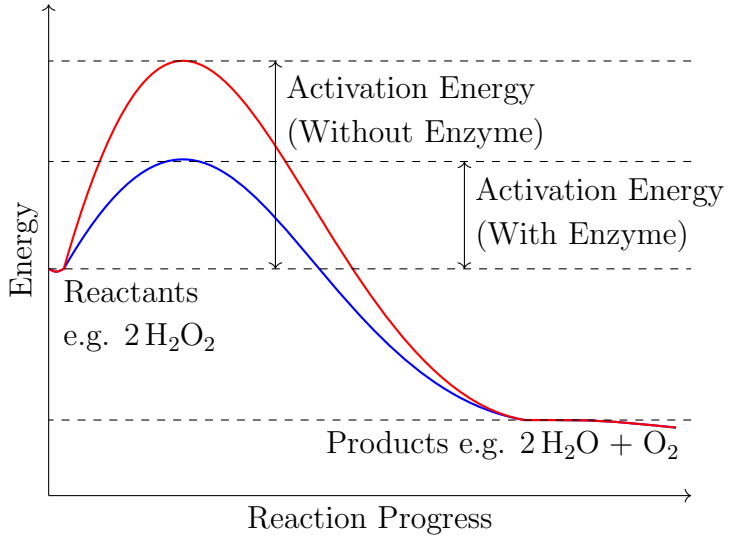
(b) We could tell a reaction was occuring in test tube B because the temperature increased, as shown by the thermometer. Additionally, bubbles comprised of oxygen gas were quickly released, overfilling the test tube. This means that some liquid has transformed into gas.

(c) Before we added the enzyme, the reaction was occuring at an extremely slow rate. I could tell because when water was added to H2O2, the temperature did not increase. According to Mr. Chisholm, if a sealed bottle of hydrogen peroxide was left alone, it would take years for it to decompose.

(d) When we added the enzyme, the reaction rate increased significantly, as indicated by the temperature increase of the solution from 23.5 degrees Celsius to 29.1 degrees Celsius in 15 seconds. Additionally, the reaction seemed to have subsided after 30 seconds, when the temperature reached its peak of 29.9 degrees Celsius, and then slowly decreased. Mr. Chisholm stated in class that catalase is the fastest enzyme in the body.

(e) Catalase speeds up the reaction through the induced fit model. The substrate, hydrogen peroxide, fits into the enzyme's active site, matching its shape, size, and charge. The R groups of the amino acids in catalase's active site are polar, which helps attract and stabilize the substrate during binding.

This causes the enzyme to change shape slightly, putting stress on the bonds in the hydrogen peroxide molecule, making them unstable and lowering the activation energy required for the reaction, as shown in the energy hill diagram below. The bonds break, producing water and oxygen. Once these products are formed, they no longer fit the active site, so they are released, and the enzyme is free to catalyze another reaction.



(f) When the H_2O_2 bonds are broken, more stable water and oxygen gas molecules are reformed. This results in an overall exothermic reaction, which explains where the heat energy came from.

(g) The gas was oxygen. I know that because when Mr. Chisholm placed a glowing match into the test tube, the flames got bigger, indicating a high concentration of oxygen.

(h) The formula for the reaction is:

$$2\,H_2O_2 \longrightarrow 2\,H_2O + O_2$$

The products are not very harmful to cells. Water is a universal solvent, and facilitates many reactions necessary for life, such as hydrolysis. Oxygen is neccesary for processes like cellular respiration, which is the process that generates ATP. Hence, the liver is a very important organ in the body, as it metabolizes drugs and waste products into molecules that can be utilized by the body.

(i) The reaction is advantageous in peroxisomes is because they provide the optimal environment for the enzymes that facilitate the decomposition of hydrogen peroxide. Additionally, peroxisomes isolate the inside from the rest of the cell. There, hydrogen peroxide is made and instantly broken down in the peroxisome, so it does not have a chance to damage the cell.

Question 3

(a)

1. Boiled liver juice: Enzymes, when subjected to high temperatures, undergo denaturation, which is when they lose their shape and function. This is because heat increases the kinetic energy of molecules causing them to vibrate more, which disrupts the hydrogen bonds that hold the protein in shape. Even when the temperature lowers back down, the shape will not return to normal. Catalase enzymes stop working properly at around 40 degrees Celsius, so boiling them at 100 degrees will completely destroy their function. This is reflected in our data, indicating no temperature increase at all.

2. Liver juice in acid: Similarly, most enzymes denature under a low pH environment, as the abundance of H^+ ions can disrupt the hydrogen bonds in the amino acids. This explains why barely any reaction occured.

3. Liver juice in base: Most enzymes also denature under a high pH environment, as the abundance of OH^- ions can disrupt the hydrogen bonds in the amino acids. This explains why barely any reaction occured.

4. Liver juice in salt: Although the reaction was slower compared to our base (plain liver juice + H_2O_2), the reaction proceeded as normal. It seems that the 15 percent salt solution was not enough to denature the enzymes — an interesting result.

5. Liver juice with boiled H_2O_2: The boiled H_2O_2 reacted faster because some water molecules in the aqueous solution are removed when boiled, while H_2O_2 stays intact, thus increasing the overall concentration of H_2O_2. Enzymes work better when there is a higher concentration of substrate, as they are more likely to collide with the active site, and there are more available bonds to be broken and reformed.

(b) The set of data on liver juice with 15% salt solution surprised me. I expected the salt to denature the enzymes by disrupting the hydrogen bonds. However, the reaction proceeded as normal, albeit at a slower rate. A potential explanation of this could be that

(c) This test confirms two things:

1. Higher concentrations of substrate increases rate of reaction.
2. Hydrogen peroxide does not change properties at high temperatures.

(d) Our data showed that boiled hydrogen peroxide peaked at 43°C, compared to 29.9°C for the unboiled hydrogen peroxide. This is because the boiling point of water is 100°C, while that of hydrogen peroxide is around 150°C. When the 3% hydrogen peroxide solution was boiled, some of the water evaporated, increasing the concentration of hydrogen peroxide. As a result, the likelihood of hydrogen peroxide molecules colliding with the enzyme's active site increased (less water molecules get in the way), and more hydrogen peroxide molecules were available to be broken down into water and oxygen, leading to a higher reaction rate and a higher peak temperature.

Question 4

(a) I expected the highest concentration of hydrogen peroxide to provide the greatest increase in temperature because there are more substrate molecules available to collide with the enzyme's active site. This means a higher total potential energy stored in bonds that could be converted into heat as new stable bonds form. Additionally, the higher concentration of hydrogen peroxide means fewer water molecules are present to interfere with these collisions.

(b) The data supports this hypothesis. The temperature peaked at 43°C for the 10% hydrogen peroxide solution, which was the highest observed. As the concentration decreased, the peak temperatures also decreased: 37°C for 6%, 30°C for 3%, and 26.9°C for 1.5%.