Effect of Catalase on Hydrogen Peroxide

Introduction:
Metabolism is the sum total of chemical reactions in the body that are necessary to the maintenance of life. Enzymes are biological catalysts that can speed up, and control, chemical reactions that would otherwise virtually never occur at normal body temperature, 37°C. Thousands of chemical reactions are occurring in the human body every moment of life, and each of these reactions is controlled by a particular enzyme.

Enzymes are extremely efficient. Some of the chemical reactions that take place in the body produce toxic by-products, which must be quickly degraded or converted. For example, certain reactions in the liver produce hydrogen peroxide, which is extremely poisonous. Under the influence of an enzyme called catalase, the hydrogen peroxide is broken down into water and oxygen. Catalase acts quickly; one molecule of it can deal with six million molecules of hydrogen peroxide in one minute. This same reaction can be catalyzed by iron. However, to achieve the same speed there would need to be about six tons of iron.

Enzymes have five important properties that you should know:

1. They are always proteins.
2. They are specific in their action. Each enzyme controls one particular reaction, or type of reaction. Thus sucrase degrades sucrose and only sucrose (table sugar).
3. They are not altered by the reaction. This means that an enzyme can be used repeatedly. It also means that enzymes appear neither in the reactants nor in the products of a chemical equation.
4. They are destroyed by heat. This is because enzymes are proteins, and all proteins are destroyed by heat. Destruction of protein by heat (or under any extreme conditions of pH or salt concentration) is called denaturation.
5. They are sensitive to pH. The term pH refers to the degree of acidity and alkalinity of a solution. Most intracellular enzymes work best in neutral conditions, i.e. conditions that are neither acidic nor alkaline.

In this experiment you will investigate the action of catalase, from a small piece of beef liver, on hydrogen peroxide, under varying conditions.

Procedure:
1. Obtain 2 test tubes. Pour a 3% hydrogen peroxide solution into one of them to a depth of about 2 cm. Caution: hydrogen peroxide is corrosive and can irritate the skin. Pour water into the other test tube to a depth of about 2 cm.
2. Drop a small piece of liver into each test tube. Liver contains considerable catalase. Watch the reaction and record your observations in a data table.
3. Repeat the experiment using a piece of liver which has been boiled for three minutes. Record your observations.
4. Repeat the experiment using uncooked pieces of muscle and potato to find out if catalase occurs elsewhere.
5. Pour approximately 2 cm of 0.1 M acetic acid solution into a test tube. Add 2 cm of hydrogen peroxide. With litmus paper, get an approximate pH for the solution. Drop a small piece of liver into the test tube. Record your observations in the data table.
6. Repeat the experiment above using a 0.1M ammonium hydroxide solution. Again add a small amount of H₂O₂. Test your solution for pH. Again, record your observations.

Conclusions: Write a paragraph explaining the role enzymes play in biochemical reactions. Include a discussion of activation energy, optimal conditions, and specificity.
Analysis Questions:

1. The primary reaction catalyzed by catalase is the decomposition of hydrogen peroxide to form water and oxygen, which occurs spontaneously, but not at a very rapid rate. Write a balanced equation for this reaction. (Remember that catalase is not a reactant or a product and can be written over the arrow separating the reactant from the products.)

2. Explain why, in your first trial, you used two test tubes, one with hydrogen peroxide and one with water.

3. What effect did boiling the liver have on the reaction? Why?

4. Explain the results you obtained using a piece of muscle and a piece of potato.

5. What effect did acetic acid have on the reaction? Why? What effect did ammonium hydroxide have on the reaction?