Exothermic and Endothermic Reactions

**HIGH SCHOOL**

**Green Chemistry & Sustainable Science**

Teacher Background Information:

Many teachers use the calcium chloride and ammonium nitrate reaction to show exothermic and endothermic reactions.This method uses a catalase, a common [enzyme](http://en.wikipedia.org/wiki/Enzyme) found in nearly all living organisms. When catalase is exposed to oxygen, it [catalyzes](http://en.wikipedia.org/wiki/Catalyst) the decomposition of [hydrogen peroxide](http://en.wikipedia.org/wiki/Hydrogen_peroxide) to [water](http://en.wikipedia.org/wiki/Water) and [oxygen](http://en.wikipedia.org/wiki/Oxygen). Catalase has one of the highest [turnover numbers](http://en.wikipedia.org/wiki/Turnover_number) of all enzymes; one molecule of catalase can convert millions of molecules of hydrogen peroxide to water and oxygen per second. In this procedure we will use liver, but you can easily substitute a potato, kiwi, peaches or many other forms of catalase in your classroom.

Safety Information:

* Safety glasses should be used whenever working in the lab.
* Students should take care when handling the hydrogen peroxide.
* The solid catalase source should be removed and discarded in a garbage can. The remainder of waste is non-hazardous.

**Learning Objectives:** Students will identify…

* Exothermic (heat given out) reactions
* Endothermic (heat taken in) reactions

**Key Terms**: Thermodynamics, energy changes, catalase

Materials (per lab group):

* 3 grams Pixy Stix or Fun Dip (citric acid)
* 2 pea-sized pieces of liver (chicken or beef work well)
* 5 mL of 3% H2O2 (hydrogen peroxide)
* 15 mL of H2O (water)
* 10-mL graduated cylinder
* 3 (16 x 125 mm) test tubes
* Thermometer
* 2 wooden splints
* Matches
* Stopwatch or time-keeping device
* Test tube rack
* Permanent marker
* Paper towels

**Time Required:**  45–60 minutes

NGSS Standards Met:

* **HS-PS1-2.** Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns in chemical properties.
* **HS-PS1-4.** Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
* **HS-PS3-1.** Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

Teacher Preparation:

1. Wear gloves to tear the liver into pea-sized pieces. Prepare enough liver for the entire class.
2. Set out all materials for student access.
3. Write on the board the guiding questions for each of the lab activities:

* Part 1: How does temperature change during the process of hydrogen peroxide decomposition?
* Part 2: How does temperature change during the process of citric acid reacting with water?

Keys for Success:

Discuss with students that reactions don’t just rearrange matter and state. There can be energy changes as well when a reaction occurs.

Disposal Information:

Solid catalase source should be removed and discarded in a garbage can. The remainder of the waste is non-hazardous and safe for disposal down the drain.

Exothermic and Endothermic Reactions Student Lab

Part 1: Decomposition of Hydrogen Peroxide

Materials:

Collect the following materials:

* 2 pea-sized liver pieces
* 5 mL of H2O2 (hydrogen peroxide)
* 5 mL of H2O (water)
* 2 (16 x 125 mm) test tubes
* Test tube rack
* 10-mL graduated cylinder
* Thermometer
* 2 wooden splints
* Matches
* Stopwatch or time-keeping device
* Permanent marker
* Paper towel

Procedure:

1. Label two test tubes A and B with a marker and place in the test tube rack.
2. Measure 5 mL of H2O (water) and pour it into test tube A.
3. Measure 5 mL of H2O2 (hydrogen peroxide) and pour it into test tube B.
4. Place a thermometer in test tube A.
5. Record test tube A’s starting temperature in Data Table I.
6. Add one piece of liver to test tube A.
7. One partner should record the temperature at 30-second intervals in Data Table II for 3 minutes. Another partner should carefully lower a glowing splint into test tube A right after adding the liver and record observations in Data Table I. *(Note: Glowing splint🡪 light a splint with a match, make sure an orange glow is visible, then blow the flame out. Make sure the wooden splint is glowing before lowering it into the test tube.)*
8. Record the ending temperature in Data Table I.
9. Wipe the thermometer clean with a paper towel and place it in test tube B.
10. Record test tube B’s starting temperature in Data Table I.
11. Add one piece of liver to test tube B.
12. One partner should record the temperature at 30-second intervals in Data Table II for 3 minutes. Another partner should carefully lower a glowing splint into test tube B right after adding the liver and record observations in Data Table I.
13. Record the final temperature in Data Table I.
14. Clean up and return all non-disposable materials (waste materials are non-hazardous; solids can be discarded in the trash, and liquids in the sink.)

Data:

Data Table I

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Starting temperature in °C | Observations after adding liver | Ending temperature in °C | Glowing splint results |
| Test tube A  H2O |  |  |  |  |
| Test tube B  H2O2 |  |  |  |  |

Data Table II

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Starting temperature in ˚C | 30 sec. | 60 sec. | 90 sec. | 120 sec. | 150 sec. | 180 sec. |
| Test tube A  H2O |  |  |  |  |  |  |  |
| Test tube B  H2O2 |  |  |  |  |  |  |  |

Starting temperature with water: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ˚C

Ending temperature with water: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ˚C

Starting temperature with hydrogen peroxide: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ˚C

Ending temperature with hydrogen peroxide: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ˚C

Questions:

1. Did an exothermic or endothermic reaction occur in test tube A? How do you know?
2. Did an exothermic or endothermic reaction occur in text tube B? How do you know?
3. Explain how temperature changes during the process of decomposing hydrogen peroxide.

Exothermic and Endothermic Reactions

**Student Lab**

Part 2: Citric Acid and Water

Materials:

* 1 test tube (16 x 125 mm or larger works well)
* Test tube rack
* 3 grams of Pixy Stix or Fun Dip
* Thermometer
* 10 mL of water (room temperature)
* 10-mL graduated cylinder

Procedure:

1. Measure 10 mL of water and pour it into a test tube.
2. Place the test tube in the test tube rack.
3. Place a thermometer into the water and record the starting temperature in Data Table III.
4. Quickly add all of the candy. The candy does not need to fully dissolve in the water.
5. Record in Data Table III the temperature changes at 10-second intervals for 60 seconds, then at 30-second intervals until 180 seconds is reached.
6. Record final temperature.
7. Clean up and return all non-disposable materials (waste materials are non-hazardous; solids can be discarded in the trash, and liquids in the sink.)

Data:

Data Table III

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Starting temp. | 10 sec. | 20 sec. | 30 sec. | 40 sec. | 50 sec. | 60 sec. | 90 sec. | 120 sec. | 150 sec. | 180 sec. |
| Water temperature in °C |  |  |  |  |  |  |  |  |  |  |  |

Starting temperature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ˚C

Ending temperature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ˚C

Questions:

1. Was the reaction that occurred in the test tube exothermic or endothermic? How do you know?
2. Explain how the temperature changes during the process of citric acid reacting with water.

Conclusion:

Define Exothermic and Endothermic reactions and describe how this experiment demonstrates one or both of these terms.