**Catalysts and Oxygen**

**HIGH SCHOOL**

**Green Chemistry & Sustainable Science**

*Modified from the activity written by: Beryl Chisholm and Veronica O’Riordan at the 2008 Solutions in Green Chemistry Workshop*

**Teacher Background Information:** This labreplaces MnO2 Manganese Dioxide catalytic reaction.

**Safety Information:**

3% H2O2 May cause skin and eye irritation; Hot plate may cause burns

Wear safety glasses and gloves (in case spattering of 3% H2O2 occurs)

**Educational Goals:** To demonstrate the effect of a catalyst on a chemical

**Student Objectives:** Students will …

* Explain the concept of a catalyst and reaction rates
* Understand how a catalyst can improve the efficiency of a process
* Recognize that a chemical reaction involves reactants and products which may differ from each other
* Recognize that the products of the reaction will be benign

**Materials:**

* 1 x 250 ml beaker
* Tap water
* Thermometer (capable to reading 60˚C)
* Hot plate
* 2 x test tube (25 x 100 mm size works best)
* 10 ml graduated cylinder
* Green food coloring
* Biodegradable liquid dish detergent (7th generation works well)
* 3% hydrogen peroxide (H2O2)
* Vitamin C tablets (equal to 3.40 grams of crushed vitamin C)
* Mortar and pestle

**Time Required:** 1 x 45 – 60-minute class period

**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 of chemical properties

**HS-PS1-5.** Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

**Key terms**: catalysts; reaction rates

**Teacher Prep**

* Introduce the lesson as an inquiry/investigation into chemical reactions.
* Discuss what the students expect from a chemical reaction.
* Discuss catalysts and reaction rates

**Disposal Information:** All materials may be safely disposed of down the drain

**Catalysts and Oxygen: Student Sheet**

**Materials:**

* 1 x 250 ml beaker
* tap water
* thermometer (capable to reading 60˚C)
* hot plate
* 2 x test tube (25 x 100 mm size works best)
* 10 ml graduated cylinder
* Green food colouring
* Biodegradable liquid dish detergent (7th generation works well)
* 3% hydrogen peroxide (H2O2)
* vitamin C tablets (equal to 3.40 grams of crushed vitamin C)
* mortar and pestle

**Procedure:**

1. Read the student data sheet and make sure you are clear about what information you need to collect as you are performing the experiment.
2. Fill the 250-ml beaker halfway with tap water. Place thermometer inside beaker.
3. Place beaker on hot plate, and heat the water so that it maintains a temperature of 60˚C.
4. Measure 10 ml of 3% H2O2 using the 10-ml graduated cylinder. Transfer the H2O2 to one test tube. Label test tube “Test tube A”.
5. Add 2 drops of food coloring to test tube A. Mix well.
6. Add 2 drops of biodegradable liquid dish detergent to test tube A. Mix well.
7. Measure 10 ml of 3% H2O2 using the 10-ml graduated cylinder. Transfer the H2O2 to one test tube. Label test tube “Test tube B”.
8. Add 2 drops of food coloring to test tube B. Mix well.
9. Add 2 drops of biodegradable liquid dish detergent to test tube B. Mix well.
10. Using the mortar and pestle, crush enough vitamin C tablets to obtain 3.40 grams of it.
11. Add the 3.40 grams of crushed vitamin C into test tube B.
12. Place both test tubes into the water beaker (do not get any water into the test tubes).
13. Fill data in table in 2 minute intervals, starting at 0 minutes (before test tubes are placed into water bath).
14. Allow test tubes to sit in water bath for 10 minutes.
15. Remove test tubes and allow to cool in a test tube rack.
16. Turn off hot plate and clean area up.

**Student Data:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Time (min) | Water bath temperature (˚C) | Test Tube | Bubble formation in liquid visible Y/N | Foam formation Y/N | Color of liquid |
| 0 |  | A |  |  |  |
| B |  |  |  |
| 2 |  | A |  |  |  |
| B |  |  |  |
| 4 |  | A |  |  |  |
| B |  |  |  |
| 6 |  | A |  |  |  |
| B |  |  |  |
| 8 |  | A |  |  |  |
| B |  |  |  |
| 10 |  | A |  |  |  |
| B |  |  |  |

**Questions:**

1. A chemical reaction is….
2. The chemical equation for the reactions in both test tubes is:

What are the reactant(s)?

What are the product(s)?

Name the type of chemical reaction that occurs.

Write a balanced equation for the reaction.

1. Which test tube had a catalyst? How do you know?
2. Name the catalyst used in this experiment.
3. What is the role of the catalyst?
4. How does using a catalyst improve the efficiency of a process?
5. Identify the hazards and the necessary safety procedures for this experiment.

**Teacher Answer Key**

**Data:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Time (min) | Water bath temperature (˚C) | Test Tube | Bubble formation in liquid visible Y/N | Foam formation Y/N | Color of liquid |
| 0 | 60 | A | N | N | Dark green |
| B | N | N | Dark green |
| 2 | 60 | A | N | N | Dark green |
| B | Y | N | Dark green |
| 4 | 60 | A | N | N | Dark green |
| B | Y | Y | Dark green |
| 6 | 60 | A | N | N | Dark green |
| B | Y | Y | Lightening of color should be observed by 5 minutes |
| 8 | 60 | A | N | N | Lighter shade of green |
| B | Y | Y | Lighter shade of green |
| 10 | 60 | A | N | N | Lighter shade of green |
| B | Y | Y | Lighter shade of green |

**Questions:**

1. A chemical reaction is….

A reaction in which a new substance is formed.

1. The chemical equation for the reactions in both test tubes is:

**H2O2 🡪 H2O + O2**

What are the reactant(s)? H2O2

What are the product(s)? H2O and O2

Name the type of chemical reaction that occurs. Decomposition

Write a balanced equation for the reaction. 2 H2O2 🡪 2 H2O + O2

1. Which test tube had a catalyst? How do you know?

Test tube B had the catalyst. The decomposition of H2O2 occurred much faster in test tube B than in test tube A because of the presence of the catalyst.

1. Name the catalyst used in this experiment.

Vitamin C

1. What is the role of the catalyst?

Increase the rate of the reaction, does not get consumed, lowers activation energy.

1. How does using a catalyst improve the efficiency of a process?

Since using a catalyst can speed up a reaction, it can save time and energy (i.e. heat input) in a chemical process, especially when working on larger scales.

1. Identify the hazards and the necessary safety procedures for this experiment.

Hazards:

* 3% H2O2 is used
  + May cause skin and eye irritation
  + Do not ingest
* Heat input
  + Hot plate may cause burns

Safety procedures:

* Wear safety glasses and gloves (in case spattering of 3% H2O2 occurs)
* Do not ingest any chemicals
* Do not touch hot plate when its heat is on

*Side note: Although vitamin C is ingested as a daily supplement, ingesting 3.4*