**Ocean Acidification:**

**Does pH affect the Dissolution of Calcium Carbonate Shells?**

**PURPOSE**

The purpose of this lesson is to investigate the effect of pH levels on the rate that calcium carbonate (represented by a Tums® tablet) dissolves.

**EXPERIMENTAL DESIGN**

In this experiment, you will test effect of various liquids, ranging in pH, over time on the dissolution of Tums® tablets, which represent the shells of marine organisms, in order to answer the following question:

**Does pH affect the dissolution of calcium carbonate shells?**

**Hypothesis**

After reading through the methods section below, write a hypothesis to answer the question above.

 *Hypothesis*:

**Methods**

1. Select 3 liquids with different pH levels to test: one extremely acidic (white vinegar or lemon juice), one neutral (distilled water) and one basic (soapy water or water with baking soda).
2. Using the pH paper test or Internet research, and record the pH of the 3 liquids in the table.
3. Prepare stopwatch or timer to begin experiment.
4. Drop one Tums® tablet into each of the 3 liquids and begin the timer.
5. Estimate the percentage of each Tums® tablet that dissolves at 5-minutes intervals for 30 minutes. Write your results in the table and include a title for the table.
6. Construct a graph that summarizes your results. Label the axes and include a title and legend.

**Results**

**Table – Title: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

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| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
|  | **Percentage of Tablet that Dissolved (%)** |
| **Time (minutes)** | **0** | **5** | **10** | **15** | **20** | **25** | **30** |
| Liquid Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_pH: \_\_\_\_\_\_\_ |   |   |  |  |  |  |  |
| Liquid Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_pH: \_\_\_\_\_\_\_ |  |  |  |  |  |  |  |
| Liquid Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_pH: \_\_\_\_\_\_\_ |   |   |  |  |  |  |  |
| Liquid Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_pH: \_\_\_\_\_\_\_ |   |   |  |  |  |  |  |

**Graph *-* Title: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

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**Findings**

Write a summary of your results.

**CONCLUSIONS: DEVELOPING EXPLANATIONS FROM EVIDENCE**

1. Was your hypothesis supported by the data or evidence?
2. Explain your rationale for the results.
3. What recommendations do you have for improving the experiment and for further study?
4. How do you think that a more acidic ocean could affect marine ecosystems?

**THE SCIENTISTS’ EXPLANATION**

The acidity of the water is important to the plants and animals that live in the ocean. They require certain pH levels to survive. Although different areas in the oceans have slightly different pH levels, normal ocean pH is slightly basic or alkaline, with the typical ocean pH being close to 8.2 due to the dissolved salts and minerals. Corals and other ocean animals have adapted to live in water in this pH range.

Recently, the pH of the ocean has been changing. As people burn fossil fuels and release carbon dioxide (CO2) into the atmosphere, some of that carbon dioxide is taken up by terrestrial vegetation through photosynthesis and some is absorbed by the oceans. Scientists estimate that the oceans have absorbed as much as 50% of the carbon dioxide produced by burning fossil fuels. If all carbon dioxide emitted from human activity remained in the atmosphere, we would be experiencing climate change much more quickly. Thus, the uptake of carbon dioxide by the oceans is climatically beneficial. However, there are consequences of increased carbon dioxide in the oceans.

When the ocean absorbs carbon dioxide from the air at its surface, the gas changes into an aqueous form (one dissolved in water) and begins to chemically react with water to form carbonic acid (H2CO3). Carbonic acid releases H+ to its surroundings, becoming a bicarbonate ion (HCO3-). The conversion of carbon dioxide and water into bicarbonate produces hydrogen ions and thus results in a decrease in pH. This causes the ocean to become more acidic. Scientists estimate that that ocean acidity has increased by 30% over the past 250 years.

This bicarbonate ion can further break down into carbonate (CO3-2) by releasing the remaining hydrogen. The carbonate (CO3-2) can combine with calcium ions to form calcium carbonate (CaCO3), which is needed by marine invertebrates (such as coral, clams, gastropods, and tiny plankton) to build their shells.

The following chemical equation expresses this series of reactions:

**CO2 + H2O ↔ H2CO3 ↔ HCO3-1 + H+ ↔ CO3-2 + 2H+**

**Carbon Dioxide + Water ↔ Carbonic Acid ↔ Bicarbonate + Hydrogen ↔ Carbonate + Hydrogen**

All of the absorbed carbon dioxide does not follow this order to become carbonate, but rather all of these states exist simultaneously. The proportions of carbonic acid, bicarbonate, and carbonate produced are dependent on many factors, but in general in the oceans, more than 85% of dissolved carbon exists in the form of bicarbonate (HCO3-1).

Ocean acidification has become a very alarming problem for Earth’s oceans, and ultimately, life on Earth. As more carbon dioxide gas is absorbed in the ocean, the pH of the ocean decreases (becoming more acidic), which lowers the availability of the carbonate ions needed by organisms that build shells and dissolves shells. This impact on organisms that build skeletons and shells out of calcium carbonate will profoundly affect ocean ecosystem and food webs.

Scientists estimate that since 1750 the oceanic pH has lowered by about 0.1 units and that it will continue to lower as the oceans absorbs carbon dioxide. Acidity is a problem for coral and other animals that have shells or skeletons made of calcium carbonate (CaCO3) because calcium carbonate dissolves in acid. Thus, lower pH makes it more difficult for these animals to construct their body parts and can dissolve and weaken the parts that they have already created.

Corals and other marine organisms are currently struggling to survive for a number of reasons including increased sea temperatures, over harvesting, pollution, and acidification. These threats impact coral animals, but they also impact the entire food web, including humans who depend on coral reefs for food, materials, coastal protection, and beauty. This impact on organisms that build skeletons and shells out of calcium carbonate will profoundly affect ocean ecosystem and food webs.

See a brief explanation titled *The Other Carbon Dioxide Problem* from NOAA Visualizations at: <http://www.youtube.com/watch?v=9EaLRcVdTbM>. For a more detailed explanation, see the National Research Defense Council’s film *Acid Test: The Global Challenge of Ocean Acidification Movie (22 minutes) at***:** <http://www.nrdc.org/oceans/acidification/aboutthefilm.asp>.