23D – OCEAN ACIDIFICATION

INQUIRY

How does gaseous carbon dioxide affect the pH of the ocean?

MATERIALS

- Device with SPARKvue software
- pH sensor
- Beaker, 50-mL
- Clear plastic bottle, 2-L
- pH 4 and pH 10 buffer solutions
- Plastic Cup, 9 oz narrow cup
- Plastic Cup, 18 oz wide cup
- Plastic Cup, 9 oz wide cup
- Universal indicator, dropper bottle
- Distilled water, ~ 100 mL
- Carbonated soda water
- Matches
- Tea light candle
- Plastic wrap
- Scissors
- Wash bottle with DI water

BACKGROUND

Water covers about 75% of the Earth's surface, with most of the water in the oceans. The pH of the water on Earth's surface affects living and non-living systems. The pH of water is primarily determined by two factors: the concentration of carbonate ions from weathering, and the absorption of carbon dioxide from the atmosphere.

Gaseous carbon dioxide dissolves in water and reacts to from carbonic acid. The carbonic acid dissociates into bicarbonate ions and hydrogen ions. The bicarbonate ion can dissociate further into carbonate ions and hydrogen ions according to the reactions below:

$$CO_2(g) \leftrightarrow CO_2(aq)$$
$$CO_2(aq) + H_2O(l) \leftrightarrow H_2CO_3(aq)$$
$$H_2CO_3(aq) \leftrightarrow HCO_3^-(aq) + H^+(aq)$$
$$HCO_3^-(aq) \leftrightarrow CO_3^{2-}(aq) + H^+(aq)$$

In this investigation, we will model the effects of atmospheric carbon dioxide on the pH of water.

SAFETY

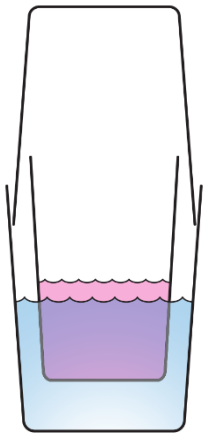
Follow these important safety precautions in addition to your regular classroom procedures:

- Wear safety goggles at all times.

PROCEDURE

Part 1 – Gaseous carbon dioxide

1. Open SPARKvue.
2. Open the 23D Ocean Acidification lab file in SPARKvue.
3. Use the Bluetooth icon to connect the pH sensor.
4. Calibrate the pH sensor with 4 and 10 buffers.
5. Add water to the smaller, most narrow (9-oz.) plastic cup until it is about ¼ full.
6. Add about one milliliter (or 20 drops) of universal indicator. Gently swirl the cup to mix.
7. Start collecting data.
8. Record the initial color and pH of the sample in Table 1 on your answer sheet.
9. Pour carbonated water into the larger (18-oz.) cup until it is about ¼ full.
10. Place the narrow 9-oz. cup into the 18-oz cup. The small cup with the water and indicator will be floating in the carbonated water as shown.
11. Place the wide 9-oz cup upside-down over the 18-oz cup as shown. This will create a dome and keep any gaseous carbon dioxide in the reaction vessel.
12. Swirl the reaction vessel. Be careful not to let the carbonated water splash into the water with indicator.
13. Continue swirling until there is a noticeable change in the color of the indicator.
14. Remove the cup cover. Record the new indicator color and pH in Table 1.



ANALYSIS

Complete the analysis for Part 1 on your answer sheet.

QUESTIONS

Answer the questions for Part 1 on your answer sheet.

PROCEDURE

Part 2 – Burning hydrocarbons

1. Add distilled water to a 50-mL beaker until it is about 1/3 full. Add 20 drops of indicator to the water.
2. Record the initial color and pH of the water in Table 2 on your answer sheet.
3. Cut the top off of a clear, empty 2-L bottle.
4. Obtain a 12-in. x 12-in. piece of plastic wrap. Set the tea light candle and the 50-mL beaker of water next to each other in the center of of the plastic wrap. Light the candle.

PROCEDURE

5. Turn the bottle upside down to cover the candle and beaker as shown. Wrap the bottom and sides of the bottle with plastic wrap to seal any openings.

6. Let the candle burn until the flame goes out on its own.
7. After the candle burns out, look closely at the water in the beaker. Record observations in Table 2.
8. Open the system and retrieve the beaker. Gently swirl the beaker several times.
9. Measure the pH of the water. Record your observations and the pH of the water in the table.
10. Stop collecting data.

ANALYSIS

Complete the analysis for Part 2 on your answer sheet.

QUESTIONS

Answer the questions for Part 2 on your answer sheet.