

PROTOCOL 9. MEASURING DISSOLVED CARBON DIOXIDE

Objective

To measure carbon dioxide concentrations in water.

Background

Through the process of respiration, plants, animals, and microorganisms break down organic compounds to obtain the energy needed to sustain life. Carbon dioxide (CO₂) is produced as a waste product.

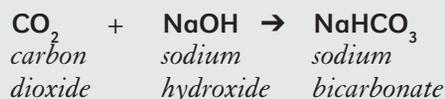
Respiration:



In aquatic systems, the dissolved CO₂ concentration can be used as an indicator of the rate of respiration vs. photosynthesis. Plants produce CO₂ as a waste product of respiration, but they also use CO₂ to build food through the process of photosynthesis. While respiration occurs 24 hours per day, photosynthesis occurs only in the light. Ponds that are rich in plant life therefore have swings in CO₂ concentration over the course of the day and night.

Bacteria and fungi produce CO₂ when they break down organic wastes. In water containing a lot of organic matter, microbes grow and reproduce rapidly. As a result, they use up a lot of oxygen and produce high CO₂ concentrations. Fish tend to avoid water with CO₂ concentrations of 1–6 mg/L, and higher concentrations can kill them.

This protocol measures CO₂ concentrations in water, based on the same chemical reactions used in packaged test kits (such as LaMotte #7297-DR or Hach #143601). If the sample contains CO₂, it is acidic. As you add drops of NaOH, this base neutralizes the acid according to the following chemical reaction:



You stop adding NaOH when the solution turns pink, which occurs at a pH of 8.3.

Materials (per student group)

- 50 mL buret or “Poor Man’s Buret” (e.g., Flinn #AP8752)
- Ring stand with buret clamp
- 100 mL flask or beaker
- 50 mL water sample
- 2 drops phenolphthalein indicator solution (1%)
- 50 mL 0.02 N NaOH solution
- Goggles
- Gloves

NOTE: Samples should be analyzed promptly after collection because the concentration of dissolved CO₂ is likely to change over time. If you will be collecting samples in the field for analysis in the lab, fill the sample bottles completely (leaving no room for air), keep them on ice, and perform the lab analyses as soon as possible after sampling.

Procedure

1. Wearing goggles and gloves, attach the buret to the ring stand so that it is suspended over the beaker or flask. Fill the buret with 50 mL NaOH solution.
2. Gently pour 50 mL of your sample into the beaker or flask, being careful not to shake the sample or to create bubbles.
3. If your lab table is a dark color, place a piece of white paper under the beaker so that you will be able to see color change in the solution.
4. Add two drops phenolphthalein indicator solution. If a pink or red color develops, there is no dissolved carbon dioxide. If no color develops, go on to the next step.
5. One drop at a time, add NaOH solution and gently swirl the sample. Continue until a light pink color develops and does not disappear when swirled.
6. Read on the buret how many mL of NaOH solution have been used.

Analysis

Use the following equation to calculate the CO₂ concentration in your solution:

$$\text{CO}_2 \text{ concentration} = \text{_____ mL NaOH} \times 17.6 = \text{_____ mg CO}_2/\text{L}$$

(17.6 converts from mL NaOH to mg CO₂/L. In case you're interested in the math, here's how it is derived):

$$\frac{\text{mL NaOH}}{50 \text{ mL sample}} \times \frac{0.02 \text{ mol NaOH}}{\text{L}} \times \frac{1 \text{ mol CO}_2}{\text{mol NaOH}} \times \frac{44 \text{ g CO}_2}{\text{mol}} \times \frac{1000 \text{ mg}}{\text{g}} = \text{mg CO}_2/\text{L}$$

The final step is to interpret these results. Your interpretations will depend on your particular experiment. How do your data compare with the predictions you made at the beginning of your experiment?

If you tested water from a lake or stream, keep in mind that fish and other aquatic organisms tend to avoid water with CO₂ concentrations of 1–6 mg/L, and higher concentrations can kill them. In waters with high CO₂ concentrations, the dissolved oxygen concentrations tend to be low. How would you explain this correlation?