



Lesson 4: Where in the World is Carbon Dioxide?

Student Guide

Carbon dioxide (CO₂) provides the bubble in your soda pop and the "rise" in your baked goods. But it is also a very significant greenhouse gas. CO₂ is important in maintaining the earth's average temperature of about 15°C (59°F). The CO₂ traps infrared energy emitted from the earth's surface and warms the atmosphere. Without water vapor, CO₂, and methane (the three most important naturally produced greenhouse gases), the earth's surface would be about -18°C (0°F). At this temperature, it is doubtful that complex life as we know it would ever have evolved.

Where does CO₂ come from? Plants and animals give it off when they extract energy from their food during cellular respiration. CO₂ bubbles out of the earth in soda springs, explodes out of volcanoes, and is released when organic matter burns (such as during forest fires).

- Anything that releases CO₂ into the atmosphere (living, dead, or non-living) is considered a source.
- Anything that absorbs and holds CO₂ from the air or water is considered a sink (because, like a sink in your home, it acts as a "holding reservoir").

In this multiple-part activity, you will explore various sources of carbon dioxide (CO₂) using the chemical indicator bromothymol blue (BTB).

- Part 1: You will detect CO₂ through the BTB reaction by using a pure CO₂ gas made from the reaction of baking soda and vinegar.
- Part 2: You will collect and detect relative CO₂ concentrations from a number of natural and human sources.
- Part 3: You will use a simple titration procedure to quantify the amounts of CO₂ that you collected.

If you're not using a laboratory table, cover your desk with newspapers!

PART 1

Use a chemical indicator (bromothymol blue - BTB) to detect the presence of CO₂.

Work in teams of two.



Materials

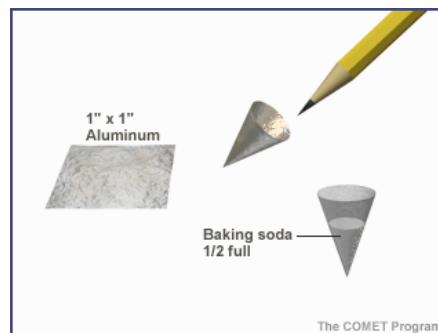
Gather three test tubes, a test tube rack, a test tube stopper with a length of tubing attached, a length of masking tape, BTB solution, vinegar, baking soda, a cotton ball, and the data chart.

Data Chart					
Sample code	Sample source	Starting color of liquid in tube	Color after treatment	Rank (1 = most acid)	Number of drops to return to blue
A					
B					
C					
D					

Procedure

1. Use a small piece of masking tape to label two of the test tubes A and B (a third will be unlabeled). Fill tubes A and B approximately 1/3 full with the BTB solution.
2. Record the color of the solution in test tubes A and B on the data chart. Tube A will be the control, tube B will be the treatment. Place the tubes in the rack.
3. Fill the unlabeled tube approximately 1/4 full of vinegar.
4. Using the foil, make a small "boat" for the baking soda - fill 1/2 full of baking soda.

The 'boat' should be small enough to easily fit into the test tube and float on the vinegar.

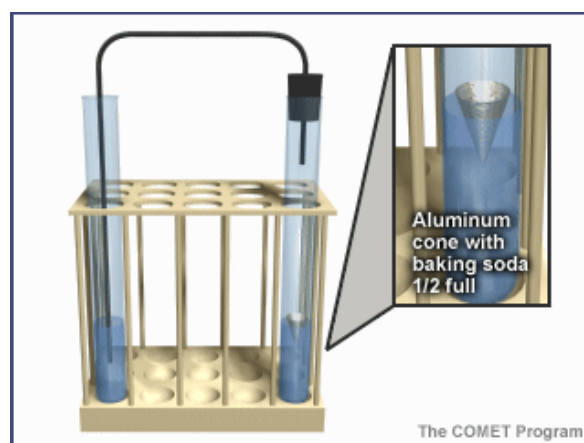




- Carefully slide the foil boat inside the unlabeled vinegar test tube (it is useful to tilt the tube at an angle to accomplish this)
- Plug the tube with the stopper and tubing.



- Place the free end of the tubing in tube B, making sure the end of the tubing reaches the bottom of the tube.



- Place a cotton ball into the neck of Tube B.
- Mix the vinegar and soda together by GENTLY swirling the tube from side-to-side. Don't shake it upside down! Gas bubbles will begin to bubble rapidly out of the tubing into the BTB solution in tube B.
- After a minute or so, note the color of tubes A and B on the data chart.

Keep test tubes A and B for Parts 2 and 3 of this activity.

Observations and Questions

- Is there a difference in color between tubes A and B?
- What was the role of tube A in this experiment?
- Why might an indicator like BTB be useful in scientific experimentation?



PART 2

In this part, you will collect samples of CO₂ from various sources (air, animals, and fossil fuel). Your teacher will provide the fossil fuel sample. Use a different colored balloon for each sample. Note which color balloon contains which sample by writing on the balloon with a marker. Use the balloon template provided to make sure all of your balloon samples are approximately the same size.

Work in teams of two.

Materials

Begin by collecting two empty balloons, one balloon full of car exhaust (the fossil fuel sample from the teacher), three test tubes, a test tube rack, a supply of BTB, a balloon size template, three straws, and three cotton balls.

Preparation

Outside Air (Sample C)

1. Blow up one of the balloons to stretch out the rubber.
2. Using the pump, fill the balloon with outside air until its circumference is the same size as the balloon template.
3. Secure the balloon with a twist tie. It is important to tie very tightly or use two ties.
4. Label this 'Balloon C.'

Animals (Sample D)

1. Blow up the second balloon to stretch out the rubber.
2. Blow up the balloon once more, using your breath, until its circumference is the same size as the template.
3. Secure the balloon with a twist tie (or two).
4. Label this 'Balloon D.'

Fossil Fuels (Sample E)



Your teacher will provide you with a balloon filled with car exhaust. You will probably need to let some of the air out of the balloon to size it to the template. Do this carefully. **BE VERY CAREFUL NOT TO INHALE THE EXHAUST.**

Label this 'Balloon E.'

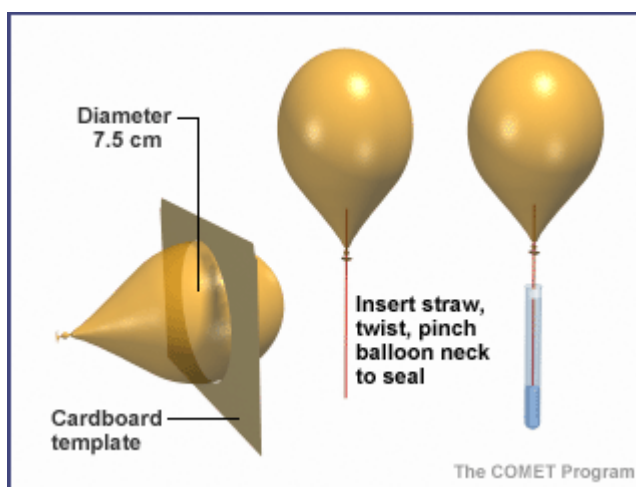
After you have collected the samples, fill out the column on the data chart asking where the sample is from.

Procedure

To detect the CO₂ in each of the three samples, you will bubble the gases through a BTB solution as you did in Part 1.

1. Place three empty test tubes in the test tube rack.
2. Using masking tape and a marker, label each test tube (C, D, and E).
3. Fill each of the empty test tubes approximately 1/3 full of BTB. You may want to use the funnel to make this task easier.
4. Begin with the outside air sample (Balloon C). Insert the straw inside the neck of Balloon C and secure it with a twist tie. Do not remove the first twist tie (holding the balloon closed) at this time.

5. Insert the other end of the straw into the BTB solution in test tube C. Insert a cotton ball into the top of the test tube to help hold the straw in place.



6. Gently release air from the balloon by slowly untwisting the neck. Allow the air to bubble out at a steady rate until the balloon is empty. **BE VERY CAREFUL TO ALLOW A SLOW AND STEADY GAS RELEASE.**
7. Observe the color change (if any) and compare the color to CONTROL test tube A (From Part 1). Record your observations on the data chart.



- Repeat steps 4 to 8 for each of the remaining balloons.
- Compare the results of the test tubes. Arrange the test tubes in order by color (yellow to blue). Hint: It may be useful to hold a blank sheet of white paper behind the test tubes to better observe color differences. Record your observations.
- Keep the samples for part three below.

Observations and Questions

See the end of Part 3.

PART 3

In this part, you'll determine the relative concentrations of CO₂ from samples collected in Parts 1 and 2.

Hint: Make sure your test tubes have equal amounts of liquid solution (some may have bubbled out). A pipette or eye dropper can be used to remove excess liquid.

Materials

You should already have five test tubes, labeled A through E from Parts 1 and 2. Collect a small dropper bottle of household ammonia.

Procedure

- Using the small dropper bottle, carefully add drops of diluted ammonia to each test tube, except for test tube A. Stir the solution after each drop. Count the drops it takes to return each sample solution to the starting color (see control test tube A for comparison). The number of drops of ammonia needed to turn the solution blue again is directly related to the amount of CO₂ it required to change the BTB color in the first place.
- Record the results on the data chart.

Observations and Questions for Parts 2 and 3

- Which source of carbon dioxide was the strongest?



2. How much stronger is the strongest than the second strongest? (Divide the number of drops needed to change the strongest by the number of drops used to change the second strongest.)
3. How much stronger is the strongest than the weakest? (Divide the number of drops used to change the strongest by the number of drops used to change the weakest.)
4. Does the carbon dioxide act more like vinegar or ammonia?
5. What does carbon dioxide do in the greenhouse effect?
6. What does this activity have to do with what you have studied so far? Be specific! List at least three things.

Assessment Ideas

- In this activity, you have examined several sources of CO₂. If you wished to reduce the amount of CO₂ increase in the atmosphere, which source would be most important to control? Explain why. Would there be problems with such controls? If so, what might they be?