Activity #3

COMPARING CONCENTRATIONS OF CO_2 SOURCES*

Purpose: To use the color indicator bromothymol blue to distinguish the relative concentrations of carbon dioxide gas (CO_2) from four CO_2 sources.

Background Information

From previous laboratory activities you determined that plants, animals, and decomposers are sources for carbon dioxide gas (CO_2). Human activities such as the burning of wood, and fossil fuels like oil, gas, and coal, also are sources for CO_2 release into the atmosphere. The following activity will enable you to answer these questions: What are the relative concentrations of CO_2 gas in human breath as compared to the concentrations of CO_2 in automobile exhaust or in the atmosphere itself?

Once again you will be using the color indicator bromothymol blue to detect the presence of CO_2. CO_2 combines with water of the bromothymol blue solution to form a weak acid called carbonic acid (H_2CO_3). As more and more CO_2 is bubbled in the bromothymol blue solution, more and more carbonic acid is formed. It takes a specific quantity of acid formed (any types of acid) to cause the bromothymol blue solution to change to a green color. It takes an even greater concentration of acid to change bromothymol blue solution to a yellow color.

You could neutralize the yellow acid solution by adding dilute ammonia. A specific amount of ammonia added would eventually cause the yellow solution to turn back to a blue color. If you were to keep count of the number of drops of ammonia added to change the yellow solution back to blue, you would have a means of comparing the relative concentrations of CO_2 from various sources. This method of determining the amount of compound in a solution is known as titration.

Materials

- 1 balloon (empty)
- 1 balloon filled with car exhaust
- 5 test tubes
- 1 test tube rack
- 1 eye dropper
- 1 straw
- soda pop bottle
- 7.5 cm cardboard template for sizing balloon
- pump
- vinegar
- baking soda
- ammonia solution
- bromothymol blue solution
- teaspoon
- protective goggles
- graduated cylinder

*** This lab activity was inspired by article, "The Greenhouse Effect in a View" by Richard Golden and Cary Sneider in The Science Teacher, May 1989.**

<u>Procedures</u> Part I

A - Atmospheric Air

1. Add 10 ml of bromothymol blue solution to each of five test tubes. Label these test tubes A, B, C, D, and E. Record the color of each test tube in the "before" section in Table 3.1 Parts A-E. Predict the color of the bromothymol blue solution for each part, A-E. Record in Table 3.1, Predicted."

2. Get a balloon and straw.

3. Use a pump to inflate your balloon to 7.5 cm. (It's easier to over inflate the balloon, then slowly release the air until it shrinks to the 7.5 cm size). Twist and pinch the neck of the balloon to prevent air from escaping. To be sure the balloon is the right size, insert it into the 7.5 cm cardboard cutout.

4. While still preventing air escaping from the balloon, insert a straw into the neck of the balloon up to the twisted portion. Have your partner seal the opening of the balloon around the straw by pulling the neck of the balloon tightly to one side and pinching it off with their fingers. Practice this technique a few times.

5. Place the other end of the straw into Test Tube A. Gently release air from the balloon by slowly untwisting the balloon's neck. (**Caution**: if this procedure is not followed, solution may bubble out of test tube.) Allow the air to bubble at a steady rate through the bromothymol blue solution. Lightly squeeze <u>all</u> the gas out of the balloon. Record color in Table 3.1, Part A "Atmospheric Air". Be sure to use the same steady release of the collected gas for parts A-D.

B - Human Breath

6. Repeat Steps 2, 3, and 4, except this time inflate your balloon by you blowing into it.

7. Repeat Step 5 but release air into Test Tube B. Record color in Table 3.1, Part B "Human Breath".

C - Car Exhaust

8. Repeat Steps 2, <u>3</u>*, and 4, except this time have your teacher supply you with a balloon filled with car exhaust. Remember to reduce the size of the balloon to 7.5 cm before bubbling its gases into the solution.

9. Repeat Step 5 but release air into Test Tube C. Record color in Table 3.1, Part C "Car Exhaust".

Procedures Continued

D - Concentrated CO_2

10. Repeat Steps 2, 3, and 4, except this time use concentrated CO_2. To obtain concentrated CO_2, put 50 ml of vinegar into a narrow-necked bottle (e.g., soda bottle). Fold a piece of note paper in half. Add one teaspoon of baking soda into the crease of the paper. Gently pour the baking soda from the creased paper into the neck of the bottle. Then, count to five and place the balloon over the bottle and inflate as before to 7.5 cm. Practice putting the balloon over the neck of the bottle before starting.

11. Repeat Step 5, but release air into Test Tube D. Record results in Table 3.1 Part D "Concentrated CO_2".

12. Before proceeding further, empty the contents from the narrow-necked bottle into the sink, rinse twice with tap water, and return the bottle to the "materials" table.

E - Control

13. Test Tube E is the control. Tube E will be used to color compare your results during the titrating of Tubes A - D in Part II of this laboratory activity.

Procedures Part II

1. Obtain ammonia solution and an eye dropper.

2. Reread the latter portion of the "Background Information" to understand the purpose of "titration". You will be adding the ammonia solution **ONE DROP AT A TIME** to test tubes B, C, and D, trying to get the yellow solution back to the blue shade of Test Tube E.

3. Since Test Tube A is already blue, you will **NOT** be adding ammonia solution to it.

4. To test tube B, add ammonia solution **ONE DROP AT A TIME**. Holding the test tube at the top, gently swirl in a circular motion (not up and down or side to side) after each drop to thoroughly mix the solutions. Repeat this procedure after **EACH** drop until the blue shade remains and matches the blue color of Tube E. Hold the tube you are titrating with Tube E up to a white piece of note paper to compare the shades of blue. Have Test Tube B sit for 60 seconds to see if it remains the same shade of blue as Test Tube E **BEFORE** recording your results. Record in Table 3.2 the number of drops required to match the color shade of Tube B with Tube E (referred to as the endpoint in titration). **It is important to add ONLY the specific number of drops required to reach the solution's endpoint.**

Procedures Continued

5. To Tube C, repeat the same procedure as in Step 4. Record your results in Table 3.2.

6. To Tube D, repeat the same procedure as in Step 4. Record your results in Table 3.2.

Table 3.1 - Color Change Data

Part A Atmospheric Air	Part B Human Breath	Part C Car Exhaust	Part D Concentrated CO_2	Part E Control
Color *before* ____ *predicted* ____ *after* ____	Color *before* ____ *predicted* ____ *after* ____	Color *before* ____ *predicted* ____ *after* ____	Color *before* ____ *predicted* ____ *after* ____	Color *before* ____ *predicted* ____ *after* ____

Table 3.2 CO_2 Concentration

Number of drops required to return to color of Test Tube E Table 3.1				
Part A	Part B	Part C	Part D	Part E
				CONTROL

Conclusions

1. What was the purpose for having each balloon the same diameter?____________

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Conclusions Continued

2. From a previous laboratory activity you know that CO_2 exists in the atmosphere (.03% by volume). Why then was there not a color change detected in Test Tube A?

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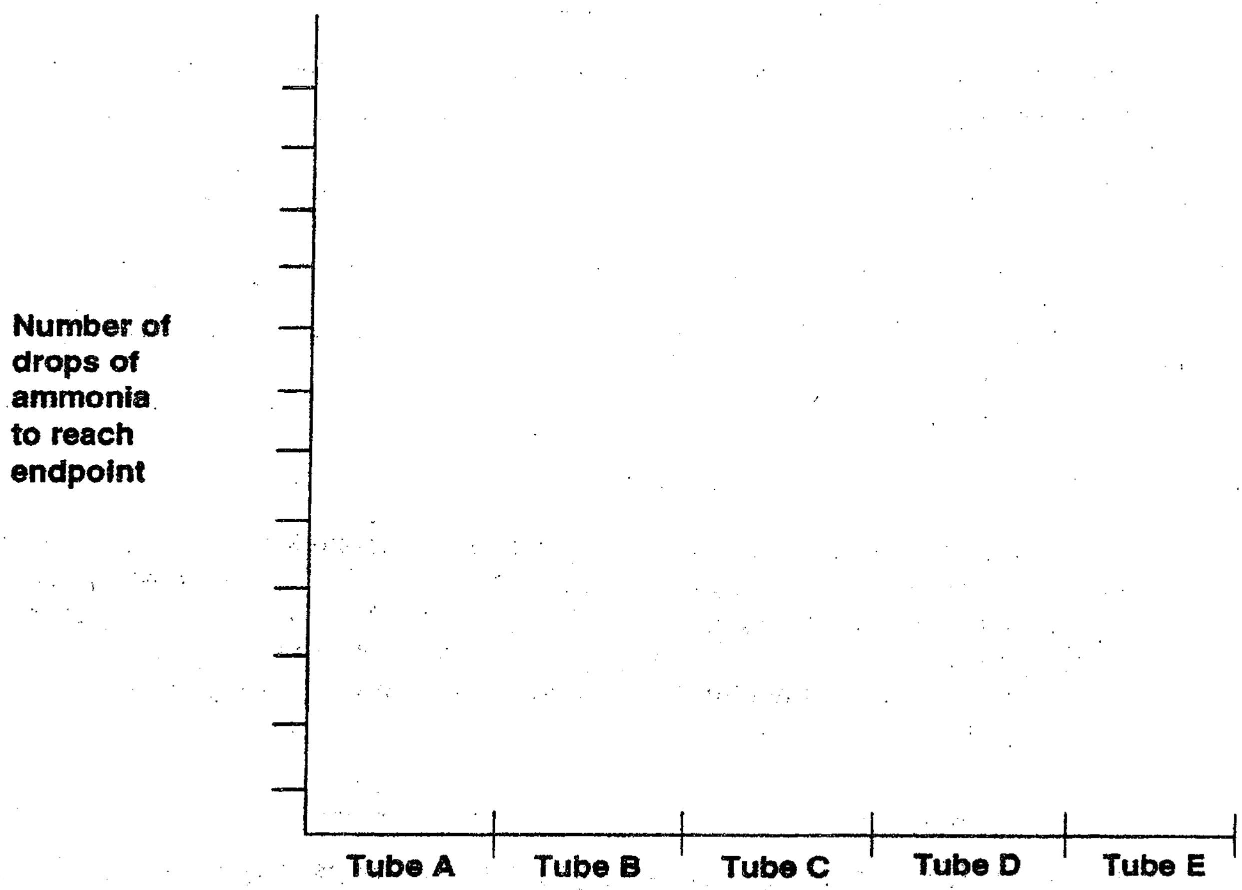
3. Construct a bar graph below using your data from Table 3.2.



Conclusions Continued

4. Which source (atmospheric air, human breath, car exhaust, concentrated CO_2) had the least concentration of CO_2? ______________________________

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5. Which source had the greatest concentration of CO_2? ______________________________

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6. According to your results and this particular titration method used, how may times more concentrated was the CO_2 in car exhaust as compared to the CO_2 concentration in your breath? ______________________________

7. What was the purpose for bubbling concentrated CO_2 into bromothymol blue solution (Test Tube D)? ______________________________

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8. What purpose did Test Tube E serve? ______________________________

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9. On the average, one tree removes 26 pounds of atmospheric Co_2 per year. Burning one gallon of gasoline releases 20 pounds of CO_2. Assume your family car gets 28 miles per gallon (mpg). If your family drove 12,000 miles over the past year, and you wanted to plant enough trees to personally remove the CO_2 your family car emitted into the atmosphere during this one year period. How many trees would you have to plant?

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10. If your family car (question #9 above) only got 14 miles per gallon, how would this effect the number of trees you would have to plant? ______________________________

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Conclusions Continued

11. The human breath contains only CO_2 gas that is acid-forming. However, car exhaust has other acid-forming gases from nitrogen compounds. How might these other gases in car exhaust affected your results in Tube C? ____________

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12. How are you certain Test Tube D has more CO_2 than Test Tube B? __________

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13. What if in this laboratory exercise you determined that human breath and car exhaust had the same concentrations of carbon dioxide gas. Does this mean that an idling car and a human at rest would emit the same quantity of carbon dioxide in a one hour period? Explain your answer. ____________________

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14. Why did you wait five seconds before putting the balloon over the soda bottle when collecting your CO_2 source in Part D? ____________________

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15. Why did you have the straw just off the bottom of the test tube? ____________

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16. Why did you have the same controlled release of air for parts A-D? __________

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17. Design an experiment using bromothymol blue that could detect CO2 in the atmosphere. ____________________

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