

# ACID RAIN

## LAB ENV 1.PALM

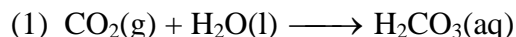
From *Science with Handhelds*, Vernier Software & Technology, 2002.

## INTRODUCTION

In this experiment, you will observe the formation of four acids that occur in acid rain:

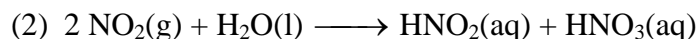
- carbonic acid,  $\text{H}_2\text{CO}_3$
- nitrous acid,  $\text{HNO}_2$
- nitric acid,  $\text{HNO}_3$
- sulfurous acid,  $\text{H}_2\text{SO}_3$

Carbonic acid occurs when carbon dioxide gas dissolves in rain droplets of unpolluted air:

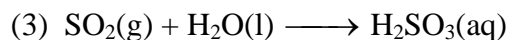


Nitrous acid and nitric acid result from a common air pollutant, nitrogen dioxide ( $\text{NO}_2$ ). Most nitrogen dioxide in our atmosphere is produced from automobile exhaust.

Nitrogen dioxide gas dissolves in raindrops and forms nitrous and nitric acid:



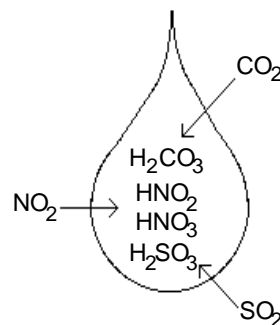
Sulfurous acid is produced from another air pollutant, sulfur dioxide ( $\text{SO}_2$ ). Most sulfur dioxide gas in the atmosphere results from burning coal containing sulfur impurities. Sulfur dioxide dissolves in rain drops and forms sulfurous acid:



In the procedure outlined below, you will first produce these three gases. You will then bubble the gases through water, producing the acids found in acid rain. The acidity of the water will be monitored with a pH Sensor.

## PURPOSE

The purpose of this experiment is to simulate the formation of acid rain by generating three gaseous oxides,  $\text{CO}_2$ ,  $\text{SO}_2$ , and  $\text{NO}_2$ , and bubbling them through water to produce three acidic solutions. The relative strengths of the resulting solutions will be determined by comparing pH values.



## EQUIPMENT/MATERIALS

LabPro interface	solid $\text{NaNO}_2$
Palm handheld	solid $\text{NaHCO}_3$
Data Pro program	solid $\text{NaHSO}_3$
pH Sensor	1 Beral pipet with 1.0 M HCl
wash bottle with deionized water	3 Beral pipets with a 2 cm stem
100 mL beaker	3 Beral pipets with a 15 cm stem
20 × 150 mm test tube	utility clamp
ring stand	tap water

## SAFETY

- Always wear an apron and goggles in the lab.
- Handle the hydrochloric acid with care. It can cause painful burns if it comes in contact with the skin.
- Avoid inhaling dust from the solids used,  $\text{NaNO}_2$ ,  $\text{NaHCO}_3$ , and  $\text{NaHSO}_3$ .

## PROCEDURE

1. Obtain and wear goggles.
2. Obtain three short-stem and three long-stem Beral pipets. Label the short-stem pipets with the formula of the solid they will contain: " $\text{NaHCO}_3$ ", " $\text{NaNO}_2$ ", and " $\text{NaHSO}_3$ ". Label the long-stem pipets with the formula of the gas they will contain: " $\text{CO}_2$ ", " $\text{NO}_2$ " and " $\text{SO}_2$ ". You can use a 100 mL beaker to support the pipets.
3. Obtain a beaker containing solid  $\text{NaHCO}_3$ . Squeeze the bulb of the pipet labeled " $\text{NaHCO}_3$ " to expel the air, and place the open end of the pipet into the solid  $\text{NaHCO}_3$ . When you release the bulb, solid  $\text{NaHCO}_3$  will be drawn up into the pipet. Continue to draw solid into the pipet until there is enough to fill the curved end of the bulb, as shown in Figure 1.
4. Repeat the Step 3 procedure to add solid  $\text{NaNO}_2$  and  $\text{NaHSO}_3$  to the other two Beral pipets. **CAUTION:** *Avoid inhaling dust from these solids.*
5. Obtain a Beral pipet with 1.0 M HCl from your teacher. **CAUTION:** *HCl is a strong acid. Gently hold the pipet with the stem pointing up, so that HCl drops do not escape.* Insert the narrow stem of the HCl pipet into the larger opening of the pipet containing the solid  $\text{NaHCO}_3$ , as shown in Figure 2. Gently squeeze the HCl pipet to add about 20 drops of HCl solution to the solid  $\text{NaHCO}_3$ . When finished, remove the HCl pipet. Gently swirl the pipet that



Figure 1

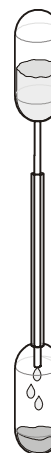


Figure 2

contains  $\text{NaHCO}_3$  and  $\text{HCl}$ . Carbon dioxide,  $\text{CO}_2$ , is generated in this pipet. Place it in the 100 mL beaker, with the stem up, to prevent spillage.

- Repeat the procedure in Step 5 by adding  $\text{HCl}$  to the pipet containing solid  $\text{NaHSO}_3$ . Sulfur dioxide,  $\text{SO}_2$ , is generated in this pipet.
- Repeat the procedure in Step 5 by adding  $\text{HCl}$  to the pipet containing solid  $\text{NaNO}_2$ . Nitrogen dioxide,  $\text{NO}_2$ , is generated in this pipet. When you have finished this step, return the  $\text{HCl}$  pipet to your teacher. Leave the three gas-generating pipets in the 100 mL beaker until Step 10.
- Plug the pH Sensor into Channel 1 of the LabPro interface. Connect the handheld to the LabPro using the interface cable. Firmly press in the cable ends.
- Use a utility clamp to attach a  $20 \times 150$  mm test tube to the ring stand. Add about 4 mL of tap water to the test tube. Remove the pH Sensor from the pH storage solution, rinse it off with distilled water, and place it into the tap water in the test tube.
- Squeeze all of the air from the bulb of the long-stem pipet labeled " $\text{CO}_2$ ". Keep the bulb completely collapsed and insert the long stem of the pipet down into the gas-generating pipet labeled " $\text{NaHCO}_3$ ", as shown in Figure 3. Be sure the tip of the long-stem pipet remains above the liquid in the gas-generating pipet. Release the pressure on the bulb so that it draws gas up into it. Store the long-stem pipet and the gas-generating pipet in the 100 mL beaker.
- Repeat the procedure in Step 10 using the pipets labeled " $\text{NaNO}_2$ " and " $\text{NO}_2$ ".
- Repeat the procedure in Step 10 using the pipets labeled " $\text{NaHSO}_3$ " and " $\text{SO}_2$ ".
- Press the power button on the handheld to turn it on. To start Data Pro, tap the Data Pro icon on the Applications screen. Choose New from the Data Pro menu or tap **New** to reset the program.



Figure 3

14. Set up the handheld and interface for a pH Sensor.
  - a. If the handheld displays PH in CH 1, proceed directly to Step 15. If it does not, continue with this step to set up your sensor manually.
  - b. On the Main screen, tap .
  - c. Tap  to select Channel 1.
  - d. Press the Scroll buttons on the handheld to scroll through the list of sensors.
  - e. Select PH from the list of sensors.
  - f. Tap  to return to the Main screen.
15. Insert the long-stem pipet labeled "CO<sub>2</sub>" into the test tube, alongside the pH Sensor, so that its tip extends into the water to the bottom of the test tube, as shown in Figure 4.
16. Tap  to begin collecting data. After 15 seconds have elapsed, gently squeeze the bulb of the pipet so that bubbles of CO<sub>2</sub> *slowly* bubble up through the solution. Use both hands to squeeze *all* of the gas from the bulb. Data collection will end after 2 minutes.
17. When data collection is complete after 2 minutes, a graph of pH vs. time will be displayed. To examine the data pairs on the displayed graph, tap  or any data point. As you move the examine line, the pH values of each data point are displayed to the right of the graph. Determine the initial pH (before CO<sub>2</sub> was added) and record this value. Then determine the final pH value (after CO<sub>2</sub> was added and pH stabilized) and record this value (round to the nearest 0.01 pH unit).
18. On the Graph screen, tap  to store your data so that it can be viewed later.
19. Rinse the pH Sensor thoroughly with distilled water and return it to the pH storage solution. Discard the contents of the test tube as directed by your teacher. Rinse the test tube *thoroughly* with tap water. Add 4 mL of tap water to the test tube. Place the pH Sensor in the test tube and check to see that the input display shows a pH value that is about the same as the previous initial pH. If not, rinse the test tube again.
20. Repeat the data collection using Steps 16 – 19 for NO<sub>2</sub>.

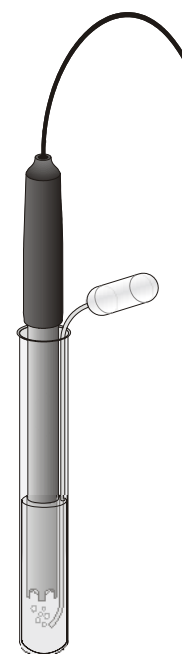


Figure 4

21. Repeat the data collection using Steps 16 – 17 for  $\text{SO}_2$ . **Important:** Do not store this run as you did in the first two runs—proceed directly to Step 22 after you complete Step 17.
22. When you are finished, rinse the pH Sensor with distilled water and return it to the pH storage solution. Return the six pipets to the location designated by your teacher.
23. To view a graph of pH vs. volume showing all three data runs, tap Run3 (above the graph), and choose All Runs. All three runs will now be displayed on the same graph axes. Each point of Run 1 is plotted with an open square, each point of Run 2 is plotted with a closed square, and each point of Run 3 is plotted with an open triangle.
24. (optional) Print a copy of the graph displayed in Step 23. Label each run as  $\text{CO}_2$ ,  $\text{NO}_2$ , or  $\text{SO}_2$ .

**DATA SHEET**

Name \_\_\_\_\_

Name \_\_\_\_\_

Period \_\_\_\_\_ Class \_\_\_\_\_

Date \_\_\_\_\_

**ACID RAIN****DATA TABLE**

Gas	Initial pH	Final pH	Change in pH ( pH)
CO <sub>2</sub>			
NO <sub>2</sub>			
SO <sub>2</sub>			

**PROCESSING THE DATA**

1. For each of the three gases, calculate the change in pH ( $\Delta\text{pH}$ ), by subtracting the final pH from the initial pH. Record these values in the Data and Calculations table.
2. In this experiment, which gas caused the smallest drop in pH?
3. Which gas (or gases) caused the largest drop in pH?
4. Coal from western states such as Montana and Wyoming is known to have a lower percentage of sulfur impurities than coal found in the eastern United States. How would burning low-sulfur coal lower the level of acidity in rainfall? Use specific information about gases and acids to answer the question.

5. High temperatures in the automobile engine cause nitrogen and oxygen gases from the air to combine to form nitrogen oxides. What two acids in acid rain result from the nitrogen oxides in automobile exhaust?
  
6. Which gas and resulting acid in this experiment would cause rainfall in *unpolluted* air to have a pH value less than 7 (sometimes as low as 5.6)?
  
7. Why would acidity levels usually be lower (pH higher) in actual rainfall than the acidity levels you observed in this experiment? Rainfall in the United States generally has a pH between 4.5 and 6.0.