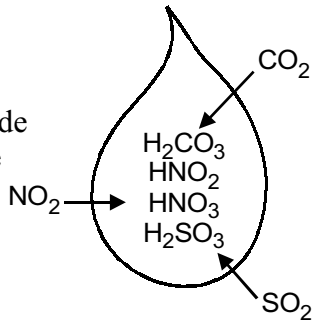
Acid Rain Drops Keep Falling on My Head
Investigating Acid Rain

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

(1) $CO_{2(g)} + H_2O_{(l)} \rightarrow H_2CO_{3(aq)}$



Nitrous acid and nitric acid result from a common air pollutant, nitrogen dioxide (NO_2). Most nitrogen dioxide in our atmosphere is produced from automobile exhaust. Nitrogen dioxide gas dissolves in rain drops and forms nitrous and nitric acid:

(2) $2NO_{2(g)} + H_2O_{(l)} \rightarrow HNO_{2(aq)} + HNO_{3(aq)}$

Sulfurous acid is produced from another air pollutant, sulfur dioxide (SO_2). Most sulfur dioxide gas in the atmosphere results from the burning of coal containing sulfur impurities. Sulfur dioxide dissolves in rain drops and forms sulfurous acid:

(3) $SO_{2(g)} + H_2O_{(l)} \rightarrow H_2SO_{3(aq)}$

In the procedure outlined below, you will first produce and collect the three gases listed above by reacting the solids with HCl. After collecting the gas produced, you will then bubble the gases though water, producing the acids found in acid rain. Using universal indicator, which changes colors to indicate pH, you will monitor the pH change of the water sample.

PURPOSE

In this activity you will describe the pH changes caused when the gases CO_2, SO_2 and NO_2 act as condensation nuclei in the atmosphere.

MATERIALS

- 100 mL distilled water
- solid potassium nitrite, KNO_2
- solid sodium bicarbonate, $NaHCO_3$ (baking soda)
- solid sodium hydrogen sufite, or sodium bisufite, $NaHSO_3$
- 3 thin-stem Beral pipets stretched to make a small opening
- 1 thin-stem Beral pipet with 1.0 M HCl
- 100 mL beaker
- 24 well-plate
- 2 mL universal indicator
- tap water for cleanup
- 3 thin-stem Beral pipets cut to have a large opening
- safety goggles

Safety Alert

1. Students must wear goggles at all times. Potassium nitrite is a strong oxidizer and a fire and explosion risk if heated. Sodium bisulfite is a severe skin irritant as an aqueous solution and moderately toxic.

PROCEDURE

1. Read the background information and make a hypothesis about which gas will cause the greatest change in pH. Record your hypothesis on your student answer page.

2. Obtain and wear safety goggles.

3. Obtain your lab set up consisting of one well plate containing 3 small stem and 3 wide opening Beral pipets. The large opening ones should be named for each solid: $NaNO_2$, $NaHCO_3$ and $NaHSO_3$. The small stem pipets should be named for the gases: CO_2, NO_2 and SO_2. Always set the Beral pipets with the stems pointing upward in your well plate.

4. Take your large opening pipets to the dispensing area and obtain the solid substances. Squeeze the bulb of the pipet to expel all of the air, hold the opening in the solid and release the bulb. Some of the solid will be drawn into your pipet. Do this several times for each solid until you have enough solid to fill the curved end of the bulb. (See figure 1) ***Caution, avoid inhaling dust from the solids.***

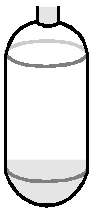
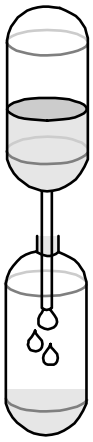
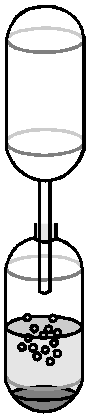


Fig. 1

5. Obtain a small stem 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 the HCl drops do not escape.** One at a time, insert the narrow stem of the HCl pipet into the large opening of the pipet containing the solid. Gently squeeze the HCl pipet to release about 20 drops of HCl into the solid. When finished, remove the HCl pipet and gently swirl reaction pipet to mix them together. **Leave the pipets open end up in your well plate.** (The gases you have produced are denser than the air in the classroom and will remain in the bulb of the pipet.)



6. Obtain the small stem pipet labeled CO_2. Squeeze the air out of the bulb and collect the gas from the reaction pipets by inserting the small stem pipets into the reaction pipet bulb. Slowly release the bulb so that the gas is drawn into the small stem pipet. Place the CO_2 pipet, stem up, in your well plate. Repeat this procedure for the remaining two gases.



7. Fill three wells of your well plate half-way with distilled water. Add ten drops of universal indicator solution to each water well. Comparing the color of the solution to the color chart, determine the initial pH of your water. Record the pH in your data table.

8. Using the CO_2 gas pipet, insert the tip of the pipet into one of the wells filled with water and indicator solution. Slowly bubble the gas through the water, counting the bubbles as they come out of the pipet. Observe the color change and record the corresponding pH after every ten bubbles.

9. Repeat step 8 for the remaining two gases.

10. Dispose of your pipets and clean up your lab area as instructed by your teacher.

Name _____

Period _____

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HYPOTHESIS

DATA AND OBSERVATIONS

Data Table					
Gas	Initial pH	After 10 bubbles	After 10 more bubbles	Final pH	ΔpH
CO_2					
NO_2					
SO_2					

CONCLUSION QUESTIONS

1. For each of the three gases, calculate the change in pH (ΔpH), by subtracting the final pH from the initial pH. Record these values.

2. In the experiment, which gas caused the smallest change in pH?

3. Which gas (or gases) caused the largest change 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 atmospheric nitrogen and oxygen gases to combine to form nitrogen oxides. What two acids in acid rain result from the nitrogen oxides in automobile exhaust?

6. Which gas would produce acid rain from air that is unpolluted?

7. Why is acid rain more of a problem in the northeastern U.S. and Canada than in central Texas?