Acid Rain

Subject: Science (Chemistry, Environmental Science, Earth Science, Aquatic Science)

Grade level: 6-12

Rationale or Purpose: This lab explores the creation of acid rain using carbonic, nitrous, nitric, and sulfurous acids.

Materials:

- Distilled water
- solid $NaNO_2$ (or KNO_2)
- 100 ml beaker
- solid $NaHCO_3$
- micro-chem plate
- solid $NaHSO_3$
- universal indicator
- tap water for cleanup
- safety goggles
- 3 Beral pipets with small opening
- 3 Beral pipets with large opening
- 1 Beral pipet with 1.0 M HCl

Lesson Duration: 50 minutes. Lab materials will need to be prepared in advance.

Objectives:

- Science 112.22 (1A), demonstrate safe practices during field and lab investigations
- Science 112.22 (2B), collect data by observing and measuring
- Science 112.22 (2C), analyze and interpret information to construct reasonable explanations
- Science 112.22 (2D), communicate valid conclusions
- Science 112.22 (4A), collect, analyze, and record information using tools
- Science 112.22 (7A), demonstrate that new substances can be made from two or more substances
- Science 112.22 (7B), classify substances by their physical and chemical properties

- Science 112.23 (1A), demonstrate safe practices during field and laboratory investigations
- Science 112.23 (2B), collect data by observing and measuring
- Science 112.23 (2C), organize, analyze, make inferences, and predict trends from evidence
- Science 112.23 (2D), communicate valid conclusions
- Science 112.23 (4A), collect, analyze, and record information to explain a phenomenon using tools

- Science 112.24 (1A), demonstrate safe practices during field and laboratory investigations
- Science 112.24 (2B), collect data by observing and measuring
- Science 112.24 (2C), organize, analyze, make inferences, and predict trends from evidence
- Science 112.24 (2D), communicate valid conclusions
- Science 112.24 (4A), collect, analyze, and record information to explain a phenomenon using tools
- Science 112.24 (4B), collect and analyze information to recognize patterns such as rates of change

- Science 112.42 (1A), demonstrate safe practices during field and laboratory investigations
- Science 112.42 (2B), collect data and make measurements with precision
- Science 112.42 (2C), organize, analyze, evaluate, make inferences, and predict trends from data

- Science 112.42 (2D), communicate valid conclusions
- Science 112.42 (8E), research and describe the environmental and economic impact of the end-products of chemical reactions
- Science 112.42 (9A), relate the structure of water to its function as the universal solvent
- Science 112.42 (9B), relate the concentration of ions in solution to physical and chemical properties
- Science 112.42 (9C), simulate the effects of acid rain on soil, buildings, statues, or microorganisms

- Science112.44 (1A), demonstrate safe practices during field and laboratory investigations
- Science112.44 (2B), collect data and make measurements with precision
- Science112.44 (2C), organize, analyze, evaluate, make inferences, and predict trends from data
- Science112.44 (2D), communicate valid conclusions
- Science112.44 (4C), evaluate the impact on ecosystems by human activity
- Science112.44 (8B), explain how regional changes in the environment may have a global effect

- Science 112.45 (1A), demonstrate safe practices during field and laboratory investigations
- Science 112.45 (2B), collect data and make measurements with precision
- Science 112.45 (2D), organize, analyze, evaluate, make inferences, and predict trends from data
- Science 112.45 (2E), communicate valid conclusions
- Science 112.45 (14D), describe effects of acids and bases on an ecological system

- Science 112.46 (1A), demonstrate safe practices during field and laboratory investigations
- Science 112.46 (2B), collect data and make measurements with precision
- Science 112.46 (2D), organize, analyze, evaluate, make inferences, and predict trends from data
- Science 112.46 (2E), communicate valid conclusions
- Science 112.46 (8C), identify and describe a local or global issue affecting an aquatic system

- Science 112.49 (1A), demonstrate safe practices during field and laboratory investigations
- Science 112.49 (2B), make quantitative observations and measurements with precision
- Science 112.49 (2C), organize, analyze, evaluate, make inferences, and predict trends from data
- Science 112.49 (2D), communicate valid conclusions

Activity:

Step 1: Obtain all lab materials.

Step 2: Make enough copies of the Acid Rain Lab Procedure so that each lab table has enough for the student teams.

Step 3: Make enough copies of the student data sheet for each student.

Step 4: Hand out student data sheets and go over concepts listed under the Lab Background section. Acid rain is a major factor in karst formation. The more acidic the water is entering the karst drainage system, the faster the dissolution of limestone, gypsum, or dolomite.

Step 5: Tell students to find their lab stations and begin the lab.

Step 6: Monitor students as they obtain the solid substances for the lab. Make sure their faces are far enough away from the samples as to avoid inhaling the dust.

Step 7: Either collect completed data sheets after students are done or allow students to take them home and finish the Processing Data section.

Modification: None.

Student Product: Students will fill out the Student Data Sheet.

Closure: Orally discuss ways to reduce acid rain, the impact acid rain has on our landscape, and any organisms that might be particularly sensitive to acid rain.

Assessment or evaluation: An evaluation rubric is provided.

Extension: This activity could work as an introductory lab for many environmental issues. Also, because acid rain dissolves carbonate rocks, thereby forming karst aquifers, this activity could introduce groundwater.

Original source: Lynn Kirby, Kealing Middle School
Modified by Robin Havens Gary and Dennis Ruez, Jr.
Environmental Science Institute, The University of Texas at Austin

Acid Rain
Lab Procedure

Materials

- Distilled water
- solid $NaNO_2$ (or KNO_2)
- 100 ml beaker
- solid $NaHCO_3$
- micro-chem plate
- solid $NaHSO_3$
- universal indicator
- tap water for cleanup
- safety goggles
- 3 Beral pipets with small opening
- 3 Beral pipets with large opening
- 1 Beral pipet with 1.0 M HCl

Procedure

1. Obtain and wear safety goggles and aprons or lab coats.
2. Obtain your lab set up of one micro-chem plate containing 3 of each type of Beral pipets. Check and make sure the large opening ones are labeled for each solid; $NaNO_2$, $NaHCO_3$ and $NaHSO_3$. Check and make sure the small opening ones are labeled for the gases; CO_2, NO_2 and SO_2. Always set the Beral pipets with the open-end upright in your chem.-plate.
3. Take your large opening pipets to the front lab table and obtain the solid substances. Squeeze the bulb of the pipet to expel all of the air, hold in the solid and release the bulb. Some of the solid will be sucked into your pipet. Do this several times for each solid until you have enough solid to fill the curved end of the bulb. ***Caution: avoid inhaling dust from the solids.***
4. Obtain a small opening Beral pipet with 1.0 M HCl from the 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 larger opening of the pipet containing the solids. Gently squeeze the HCl pipet to release about 20 drops of HCl into the solid. When finished, remove the HCl pipet and gently swirl the pipet containing the solid to mix them together. **Leave the pipets open end up in your micro-chem plate.** (The gases you produced are denser than the air in the classroom and will remain in the bulb of the pipet.)
5. Collect the gas from the pipets by inserting the small opening pipets while holding the bulb squished between your fingers. Slowly release the pressure so that the gas is sucked into the gas pipet. Be careful to use the correct pipets for the correct gas and also be careful to only collect the gas. Place the gas pipet open end up into your micro-chem plate.
6. Fill three wells of your micro-chem plate half way with distilled water. Measure the pH of the water by adding ten drops of indicator solution. Record this as the initial pH of your experiment.
7. Take your first gas sample and insert the tip of the pipet into one of the wells filled with water. Slowly bubble the gas through the water. Take a pH reading after every ten bubbles. Record this information.
8. Repeat for the other two gas samples.

Name: _____ *Date:* _____

Acid Rain

Data Sheet

Lab Background:

Carbonic acid occurs 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 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 this lab, you will first produce these three gases. You will then bubble the gases though the water, producing the acids found in acid rain. Using a universal indicator, which reveals the pH of the water, you will monitor the acidity of the water.

Acid Data Table

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

Processing the Data

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 in the Acid Data Table.

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

3. Which gas (or gases) caused the largest drop of 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 would produce acid rain from air that is unpolluted?

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

Name: _____ ***Date:*** _____

Acid Rain

Evaluation Rubric

Circle the points awarded. The most possible is on the far right.

Data table				
safety during lab	0	5	10	14
data collection	0	12	24	36
Processing the data				
1.	0	3	6	9
2.	0	-	-	5
3.	0	-	-	5
4.	0	3	6	9
5.	0	-	4	8
6.	0	-	-	5
7.	0	3	6	9

Total _____