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Kealing Middle School
(modified by Robin Gary, UTOPIA project)

Acid Rain

Subject: Science
Grade level: 6-8, 9-12

Lab Purpose: To observe how four different acids can cause acid rain:

- Carbonic acid, H_2CO_3
- Nitrous acid, HNO_2
- Nitric acid, HNO_3
- Sulfurous acid, H_2SO_3

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 the procedure outlined below, students will first produce these three gases. Then they will bubble the gases though the water, producing the acids found in acid rain. Using a universal indicator, which reveals the pH of the water, they will monitor the acidity of the water.

Acid rain is one of the major factors in karst formation. The acidic water flows through existing fractures in the surface and dissolves away limestone, dolomite, and gypsum enlarging the fractures. This action increases the amount of water that enters the karst drainage system.

Lab 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
3 Beral pipets with small opening	safety goggles
3 Beral pipets with large opening	
1 Beral pipet with 1.0 M HCl	

Lesson Duration: One full class period. Lab materials will need to be prepared before the experiment. Setting up everything but the chemicals before students enter the classroom will give students more time for the experiment.

Objectives:

Chapter 112-

Subchapter B

112.22-

1A- demonstrate safe practices during field and laboratory investigations
2B- collect data by observing and measuring
2C- analyze and interpret information to construct reasonable explanations from direct and indirect evidence
2D- communicate valid conclusions
4A- collect, analyze, and record information using tools
7A- demonstrate that new substances can be made when two or more substances are chemically combined and compare the properties of the new substances to the original substances
7B- classify substances by their physical and chemical properties

112.23-

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

112.24-

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

Subchapter C

112.42-

1A- demonstrate safe practices during field and laboratory investigations
2B- collect data and make measurements with precision
2C- organize, analyze, evaluate, make inferences, and predict trends from data
2D- communicate valid conclusions
8E- research and describe the environmental and economic impact of the end-products of chemical reactions
9A- relate the structure of water to its function as the universal solvent
9B- relate the concentration of ions in a solution to physical and chemical properties such as pH, electrolytic behavior, and reactivity
9C- simulate the effects of acid rain on soil, buildings, statues, or microorganisms

112.44-

1A- demonstrate safe practices during field and laboratory investigations
2B- collect data and make measurements with precision
2C- organize, analyze, evaluate, make inferences, and predict trends from data
2D- communicate valid conclusions
4C- evaluate the impact of human activity such as methods of pest control, hydroponics, organic gardening, or farming on ecosystems
8B- explain how regional changes in the environment may have a global effect

112.45-

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

112.46-

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

112.49-

1A- demonstrate safe practices during field and laboratory investigations
2B- make quantitative observations and measurements with precision
2C- organize, analyze, evaluate, make inferences, and predict trends from data
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. A grading rubric is included to facilitate student evaluation.

Closure: Discussion questions:

- What are some ways to reduce acid rain?
- What impact does acid rain have on our landscape?
- Can you think of any animals that might be particularly sensitive to acid rain?

Assessment or evaluation: Grade students' work according to the evaluation rubric provided.

Extension: This activity is a fantastic introduction to how caves and karst form. It can be a useful segway into both In-Cave fieldtrip activities: ***Mapping Fractures*** and ***Drip Rate Analysis***. The information sheets, ***What is Karst?*** and ***How Caves Form,*** examine the influences of acid rain on karst formation.

Acid Rain Lab Procedure

Lab Materials:

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

Lab 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 named 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 have 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 Lab

Student 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?