SI Environmental Science - Full Discipline Demo

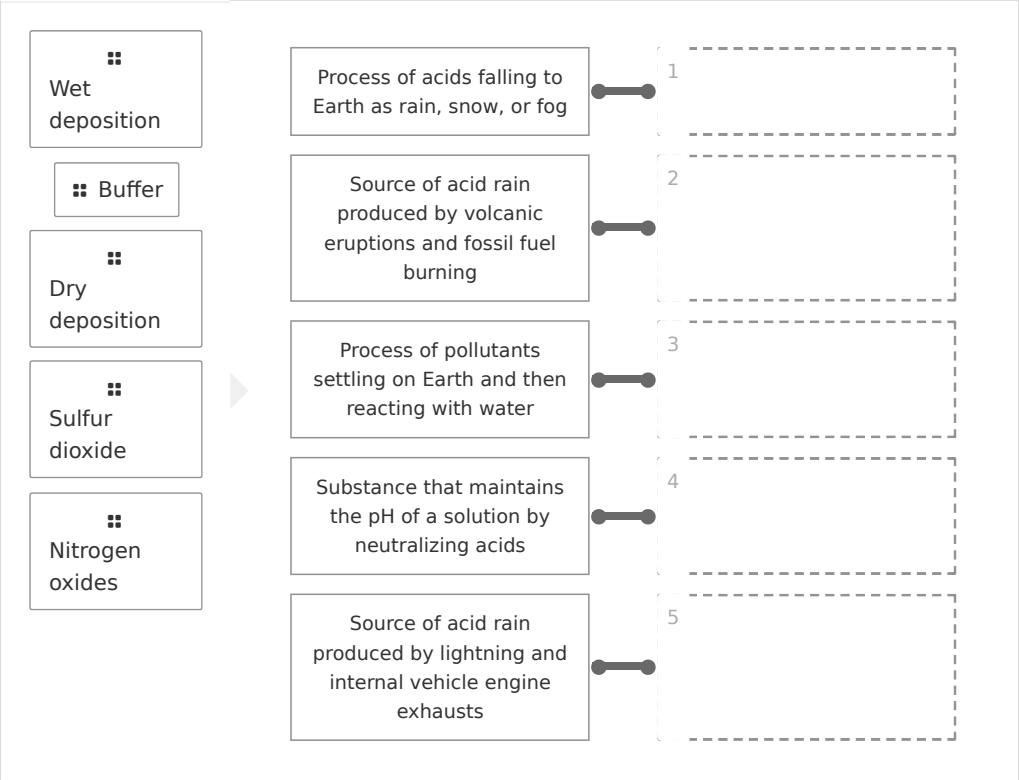
Acid Rain

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Environmental Science - Full Discipline Demo
Course	SI Environmental Science - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Match each term with the best description.

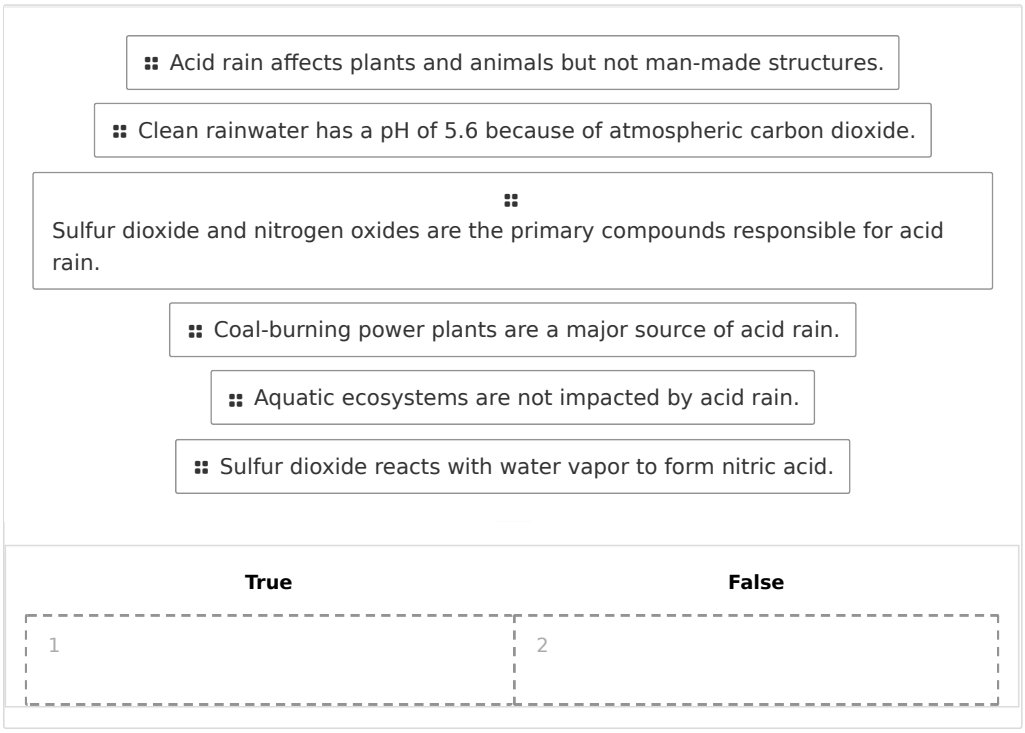


Correct answers:

1 Wet deposition 2 Sulfur dioxide 3 Dry deposition 4 Buffer

5 Nitrogen oxides

Identify each statement as true or false.



Correct answers:

1

Sulfur dioxide and nitrogen oxides are the primary compounds responsible for acid rain.

Coal-burning power plants are a major source of acid rain.

Clean rainwater has a pH of 5.6 because of atmospheric carbon dioxide.

2 Aquatic ecosystems are not impacted by acid rain.

Acid rain affects plants and animals but not man-made structures.

Sulfur dioxide reacts with water vapor to form nitric acid.

Exploration

Acid rain is precipitation with a pH of less than _____ caused by reactions between atmospheric pollutants and water.

- 4.2
- 5.6 ✔
- 7.0
- 8.5

Clean rainwater is slightly acidic due to the chemical reaction of _____ with water vapor.

- carbon dioxide ✔
- nitrogen oxides
- sulfur dioxide
- bromocresol green

Natural sources of sulfur dioxide and nitrogen oxides are the primary cause of acid rain.

- True
- False ✔

_____ is a naturally occurring buffer found in limestone, marble, and mineral-rich soils.

- Nitrogen dioxide
- Sodium dioxide
- Calcium carbonate ✔
- Bromocresol green

Acid deposition negatively affects _____.

- aquatic animals
- forests
- man-made structures
- All of the above ✔

Exercise 1

How does the Petri dish model used in Part 1 of this exercise compare to acid deposition in the natural environment? Include the reactants and products of reactions occurring in both the model and natural environment in your explanation.

The Petri dish model consisted of a NO_2-emitting reaction in the center surrounded by equally spaced water drops radiating outward. As NO_2 gas encountered the water drops, HNO_2 and HNO_3 were produced, lowering the pH of the solution. In the natural environment, pollutants (from both natural and anthropogenic sources) in the form of SO_2 and NO_x gases react with water vapor in the atmosphere to produce H_2SO_3, H_2SO_4, HNO_2, and HNO_3 which fall to Earth as acid rain with a pH of less than 5.6. The reactions occurring in the Petri dish model did not include SO_2. However, the formation of acid from the reaction of gases with water are similar between the model and natural environment.

How was acid deposition confirmed in the Petri dish model in Part 1 of this exercise? Reference Photos 1-5 in your answer.

Acid deposition was confirmed by the pH indicator bromocresol green turning from green to yellow in the drops nearest the center of the dish as first observed in Photo 2. As time elapsed, acid deposition progressed to the middle row of drops as NO_2 gas diffused farther from the center of the dish as seen in Photo 5.

Which type of deposition (wet or dry) was observed in the Petri dish model? Include examples of wet and dry deposition in the natural environment in your explanation.

Dry deposition occurred within the Petri dish model as NO_2 settled onto the water drops and reacted to make them acidic. Wet deposition occurs when pollutants NO_x and SO_2 react with water vapor in the atmosphere and fall to Earth as rain, snow, or fog. Dry deposition occurs when pollutants settle on Earth and then react with surface moisture.

What effect did adding the sodium bicarbonate have in Part 2 of this exercise? Reference Photos 6-10 in your explanation.

Sodium bicarbonate acted as a buffer by preventing the pH from changing in the solution drops on the diagonal axes of the Petri dish. The color of the drops containing sodium bicarbonate remained blue throughout the experiment as noted in Photos 7-10.

Photo 1: Nitrogen Oxides Time 0:00
(SAMPLE ANSWER BELOW)

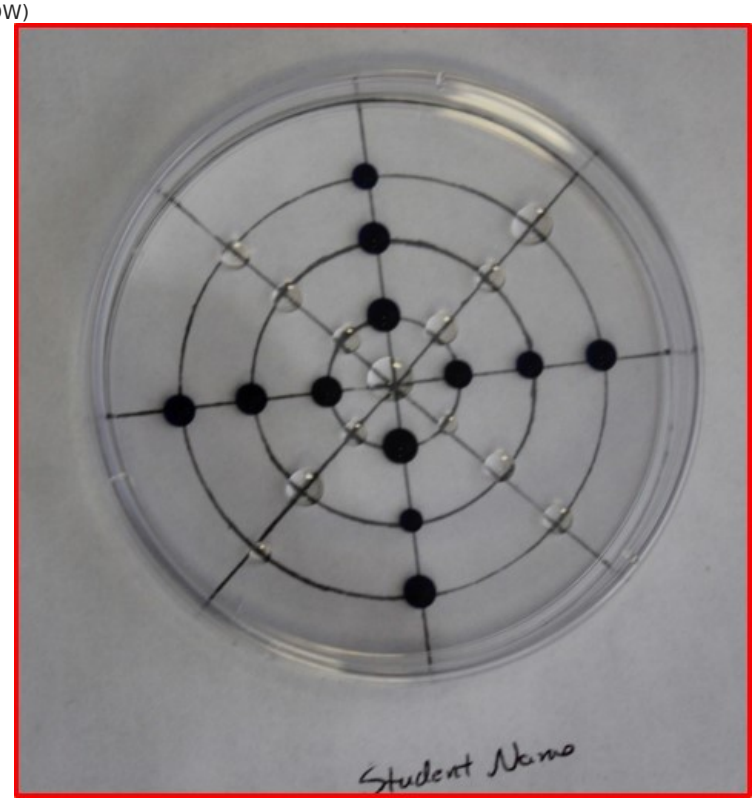


Photo 2: Nitrogen Oxides Time 1:00

(SAMPLE ANSWER BELOW)

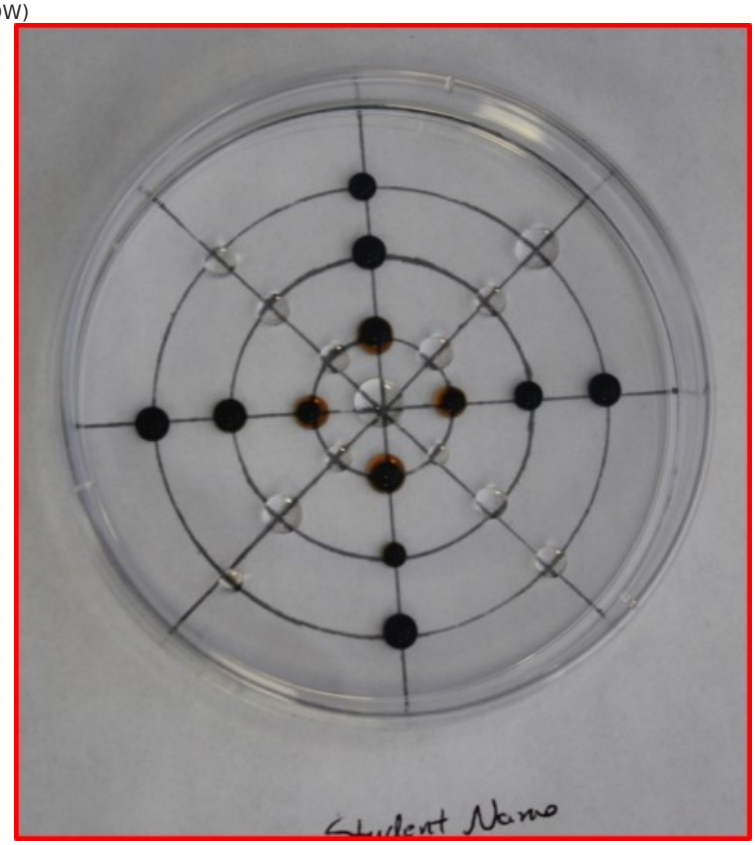


Photo 3: Nitrogen Oxides Time 2:00

(SAMPLE ANSWER BELOW)

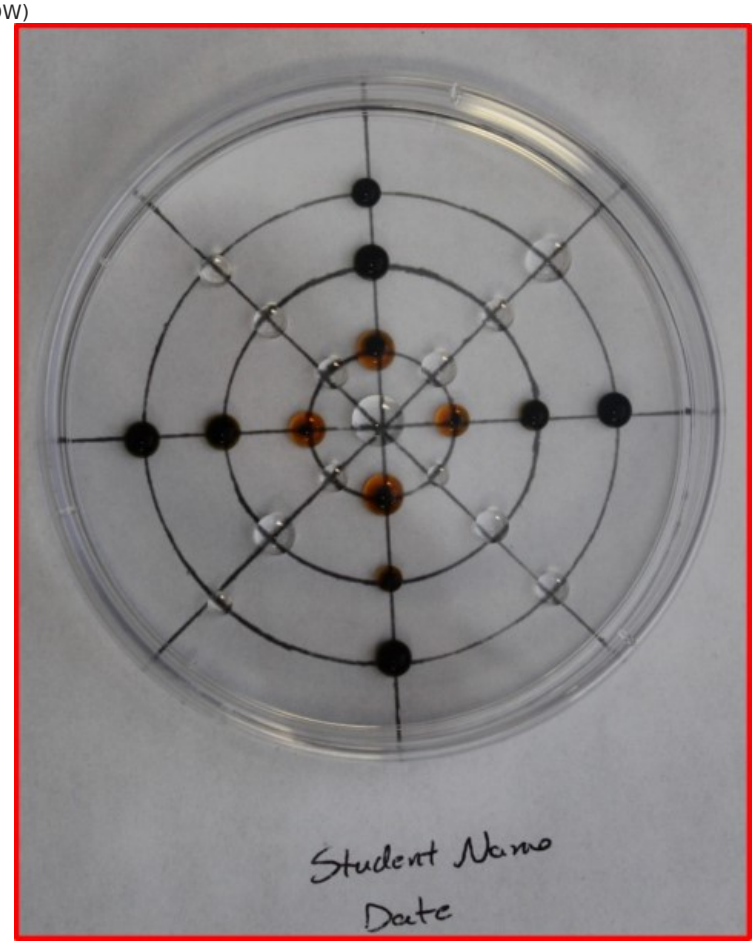


Photo 4: Nitrogen Oxides Time 3:00
(SAMPLE ANSWER BELOW)

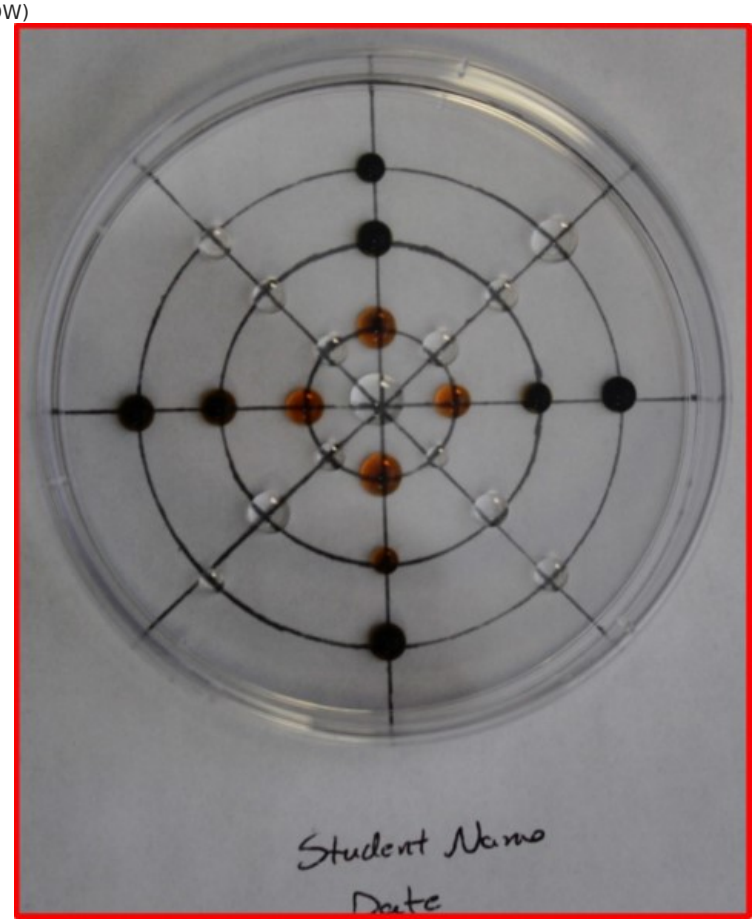


Photo 5: Nitrogen Oxides Time 4:00
(SAMPLE ANSWER BELOW)

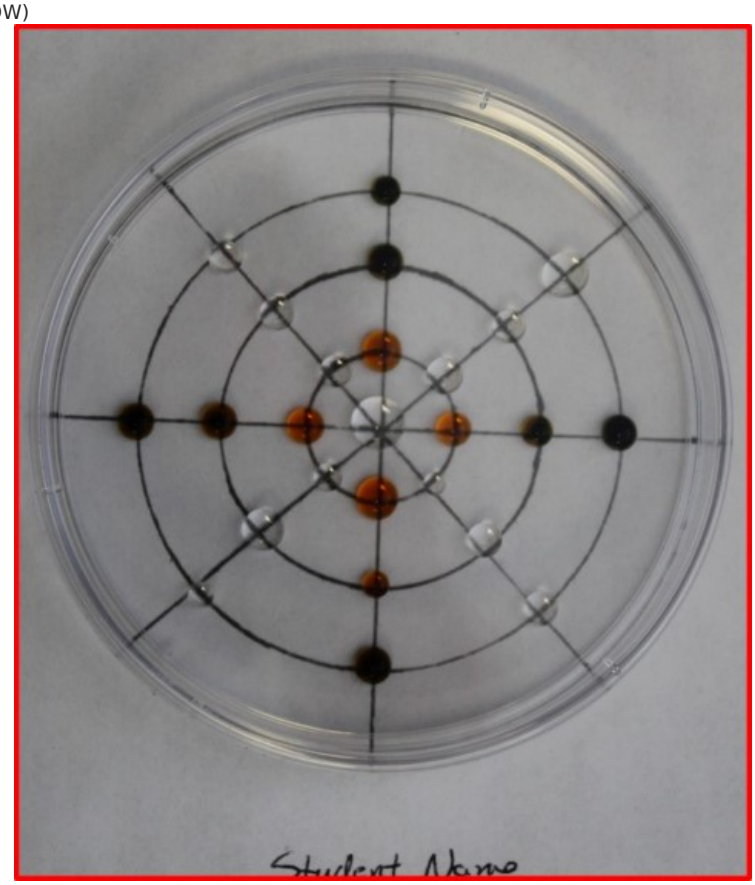


Photo 6: Buffering Effects Time 0:00

(SAMPLE ANSWER BELOW)

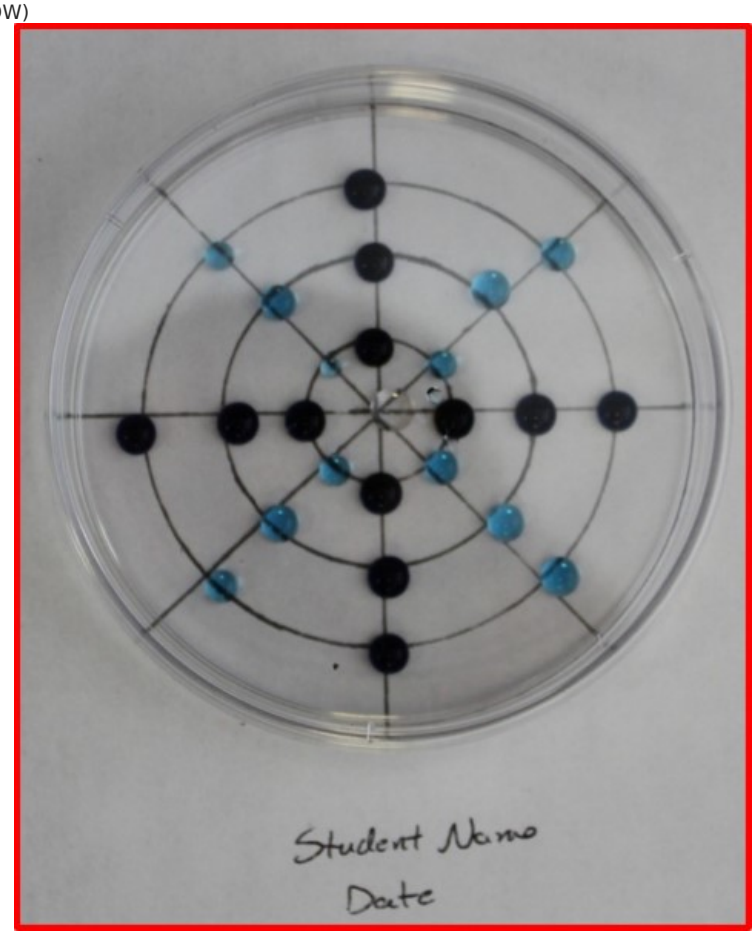


Photo 7: Buffering Effects Time 1:00

(SAMPLE ANSWER BELOW)

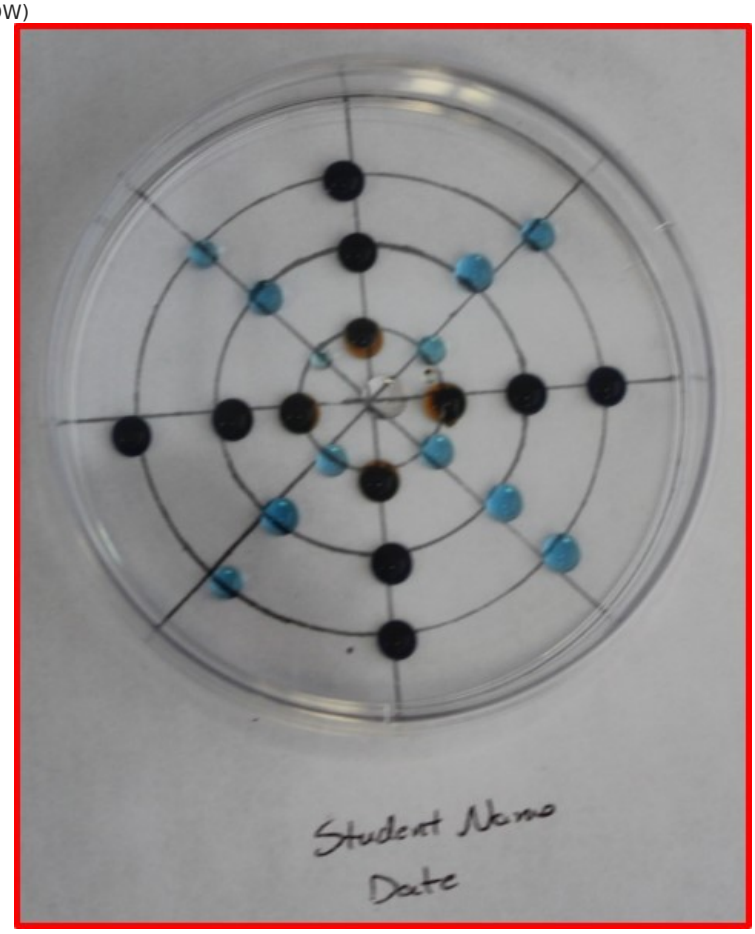


Photo 8: Buffering Effects Time 2:00

(SAMPLE ANSWER BELOW)

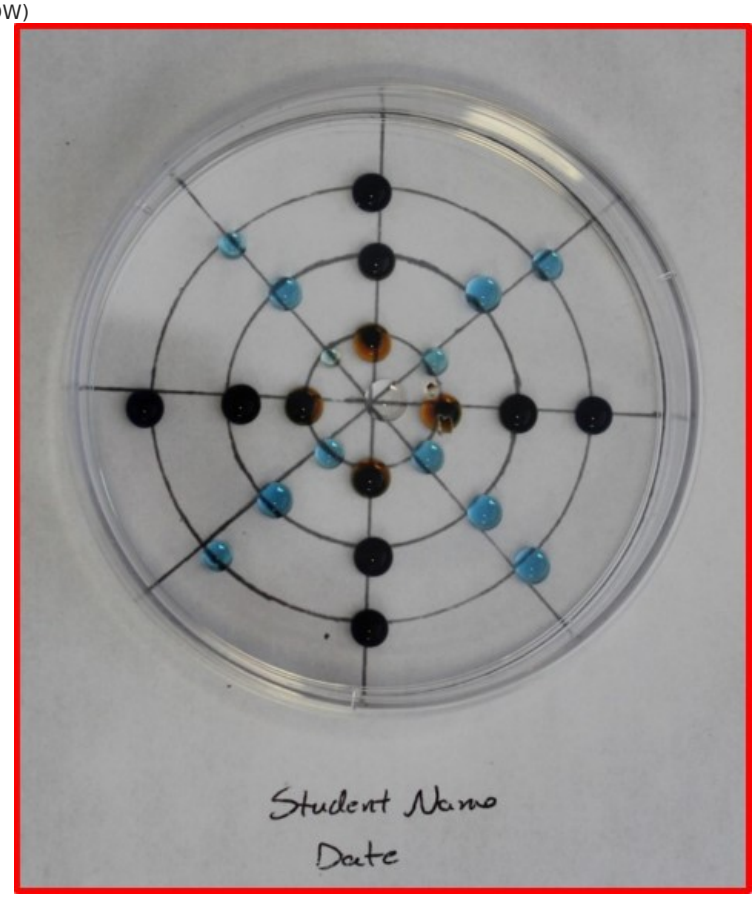
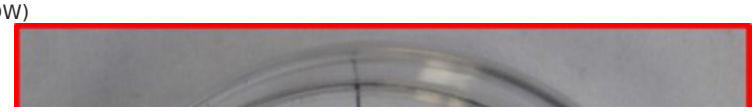


Photo 9: Buffering Effects Time 3:00

(SAMPLE ANSWER BELOW)



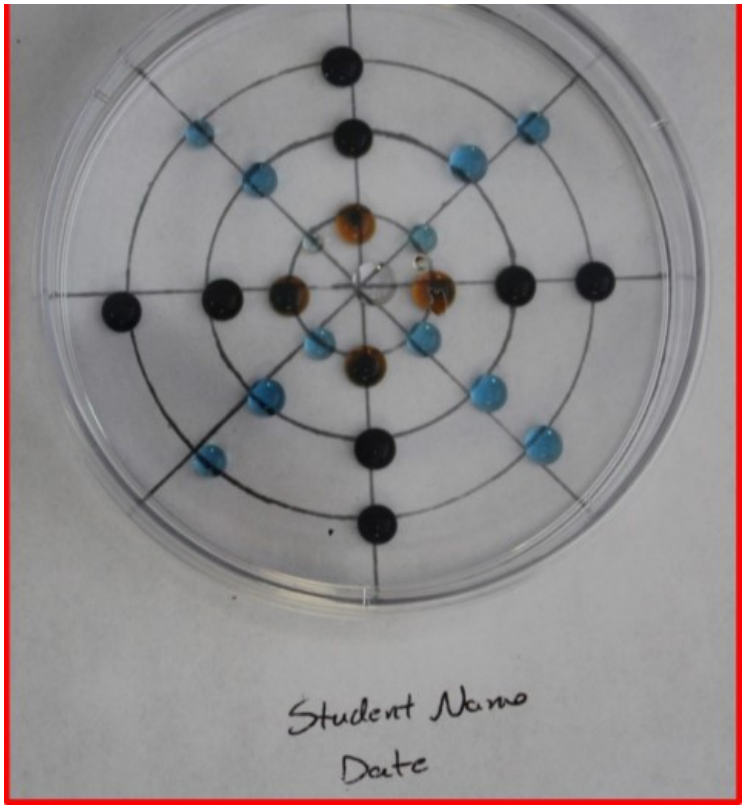
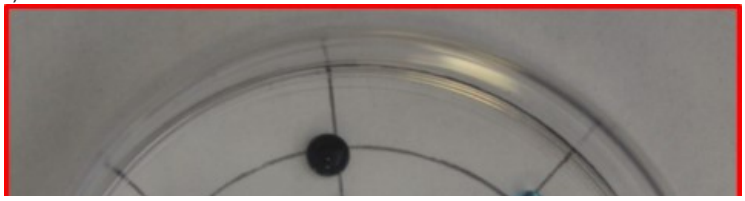
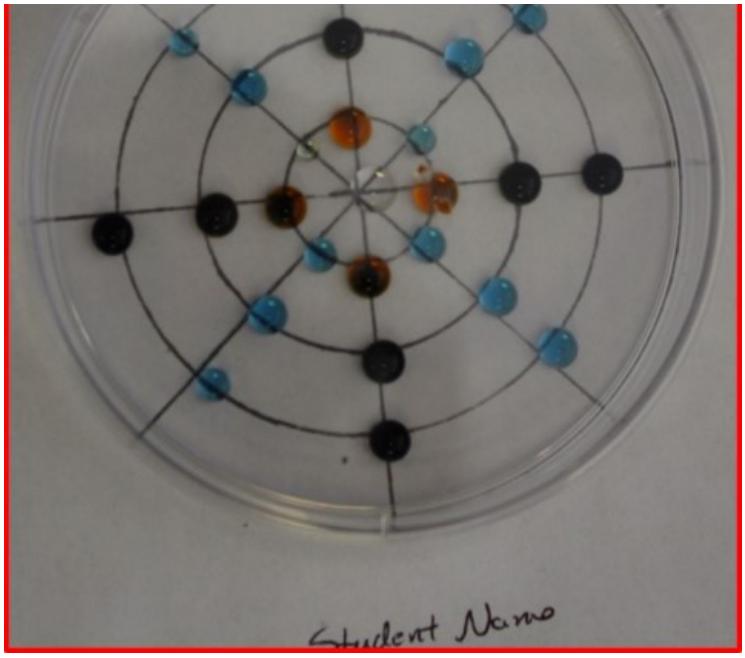


Photo 10: Buffering Effect Time 4:00
(SAMPLE ANSWER BELOW)





Exercise 2

How did acid exposure affect each of the rock samples? Reference the results recorded Data Table 1 in your explanation.

Limestone produced bubbles in vinegar, indicating it reacted with the acid. Limestone dissolved, losing 1.1 g in only 2 hours as recorded in Data Table 1. Granite did not react to acid as no bubbles were produced and the mass after 2 hours was identical to the initial mass in Data Table 1.

Should granite or limestone be selected as a building material in an environment subject to acid rain? Reference the results in Data Table 1 in your explanation.

Granite should be used as a building material in areas subject to acid rain rather than limestone. Granite does not react with weak acids as recorded in Data Table 1.

Did either the granite or the limestone rock samples demonstrate buffering abilities in this exercise? Explain your answer by referencing Data Table 1.

Limestone acted as a buffer by raising the pH of the vinegar solution as evidenced by the bromocresol green solution changing from yellow to green during the two hours the rock was immersed in the vinegar. The pH of the vinegar solution remained acidic in the granite sample cup.

Describe how acid rain effects plants and aquatic organisms in poorly buffered environments.

Acid rain affects plants in poorly buffered environments by leaching nutrients and aluminum from the soil, weakening the plants. Acid fog at higher elevations strips nutrients from the leaves of trees, leading to death. Acid rain lowers the pH of poorly buffered water bodies. Once the pH drops below the critical pH for aquatic organisms, they die. Most organisms have a critical pH above 4.0 and cannot survive at lower pH values.

Data Table 1: Rocks and Vinegar

(SAMPLE ANSWER BELOW)

	Initial mass (g)	Initial solution color	Evidence of reaction	Solution color after 2 hrs	Ending mass (g)

Limestone	26.35	Yellow	Yes, bubbles	Green	25.25
Granite	20.81	Yellow	No	Yellow	20.81

Competency Review

Acid rain is precipitation with a pH of less than 5.6 caused by reactions between atmospheric pollutants and _____.

- carbon dioxide
- nitrogen oxides
- buffers
- water ✔

Calcium carbonate ($CaCO_3$) is a naturally occurring _____ that neutralizes acids.

- buffer ✔
- pollutant
- pH indicator
- gas

_____ reacts with water to form nitric acid.

- Carbon dioxide
- Sulfur dioxide
- Nitrogen dioxide ✔
- Bromocresol green

The burning of fossil fuels is the primary source of pollutants causing acid rain.

- True ✔
- False

Examples of naturally occurring buffers include _____.

- calcium carbonate rich soils
- limestone
- marble
- All of the above ✔

The critical pH level for most aquatic organisms is less than 4.0.

- True
- False ✔

Bromocresol green turns _____ in the presence of nitrous acid.

- blue
- green
- yellow ✔
- red

Sodium bicarbonate functions as a(n) _____ in the exercise modeling acid deposition in a Petri dish.

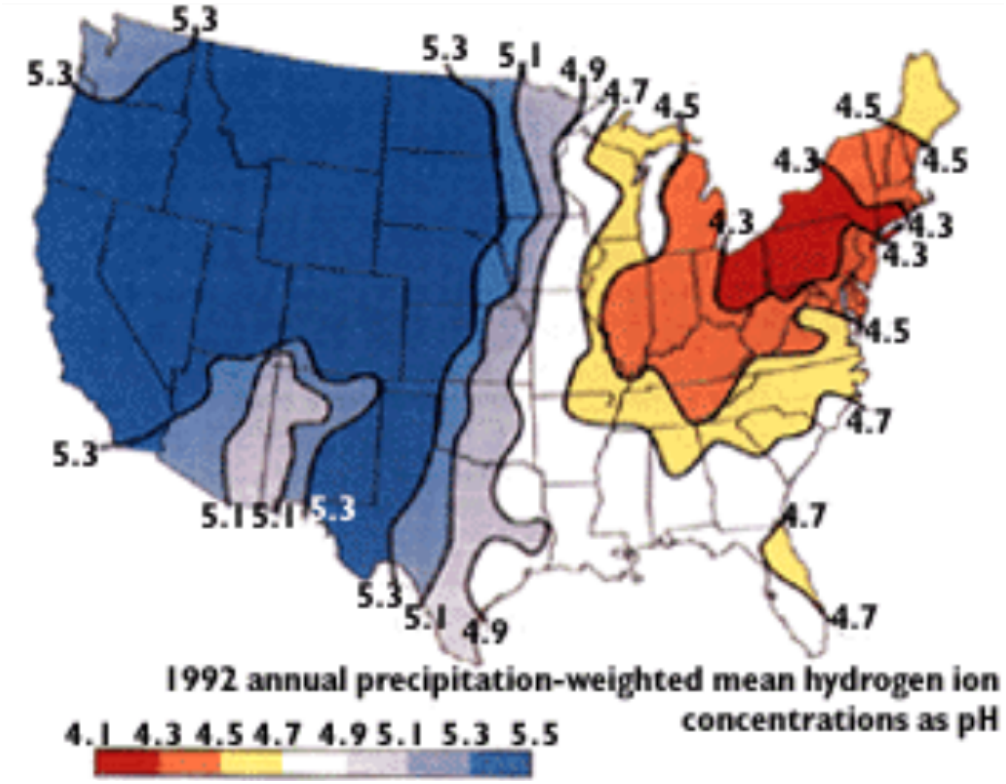
- acid
- pH indicator
- buffer ✔
- pollutant

A limestone rock will _____ when submerged in an acid such as vinegar.

- dissolve
- produce bubbles
- act as a buffer
- All of the above ✔

Extension Questions

Historically, acid rain has been geographically distributed in the Northeastern United States, as illustrated on the map from 1992 below. Apply your knowledge of causes of acid rain to explain this historic distribution pattern.



(SAMPLE ANSWER BELOW)

This pattern of acid rain is caused by the large number of cities, the dense population, and the concentration of power and industrial plants in the Northeast. In addition, the prevailing wind direction brings storms and pollution to the Northeast from the Midwest, and dust from the soil and rocks in the Northeastern United States is less likely to neutralize acidity in the rain.