Vandal in the Chem Lab!: Teacher Guide

Subject: Physical Science or Chemistry.
Grade Level: High School (9^{th}-12^{th}) on Block Schedule. Can be adapted to fit a shorter class period.

Case Summary

Can you identify paper based upon the pH of the paper? Paper has been around since ancient Egypt during the third millennium BC. Paper is typically made from cellulose fibers that come from wood pulp. Earlier types of paper were made from linen or cotton. Cellulose fibers break down when exposed to acids. This is why so many papers today are made "acid-free". Art conservators must learn how to treat artwork on paper and deal with these acidic conditions so that the artwork is not lost.

Credits

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This case was adapted from *Acids, Bases, and Paper Lab* (Smith, et al., 2013).
Smith, T., Commander, J., Schulte, E., Etre, K., and Stein, R. (2013). *Acids, bases, and paper lab*. Presented at The Science Behind Art Conservation Teacher Workshop, Emory University, July 8-12, 2013.

Learning Objectives

1. Define and describe acids and bases.
2. Use a pH pen to identify the pH level of different types of paper.
3. Use pH paper and a pH scale to identify whether a paper is an acid or a base.
4. Graph the values of pH from the different papers versus time.
5. Explain the process of acid-base neutralization.

Georgia Performance Standards

SCSh3. Students will identify and investigate problems scientifically.

a. Suggest reasonable hypotheses for identified problems.
b. Develop procedures for solving scientific problems.
c. Collect, organize and record appropriate data.
d. Graphically compare and analyze data points and/or summary statistics.
e. Develop reasonable conclusions based on data collected.
f. Evaluate whether conclusions are reasonable by reviewing the process and checking against other available information.

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SCSh4. Students will use tools and instruments for observing, measuring, and manipulating scientific equipment and materials.

a. Develop and use systematic procedures for recording and organizing information.
b. Use technology to produce tables and graphs.
c. Use technology to develop, test, and revise experimental or mathematical models.

SPS6. Students will investigate the properties of solutions.

a. Describe solutions in terms of solute/solvent, conductivity, and concentration.
b. Observe factors affecting the rate a solute dissolves in a specific solvent.
c. Demonstrate that solubility is related to temperature by constructing a solubility curve.
d. Compare and contrast the components and properties of acids and bases.
e. Determine whether common household substances are acidic, basic, or neutral.

Assessment

- The students are to turn in the box charts for scene 1 and scene 2. Both box charts should include key terms and items that are discussed in class with the teacher. The box charts can be taken as a completion/participation grade.
- The lab handout will also need to be completed by each student and assessed. Chart 1 (Step 2, part I) is worth 10 points. Chart 2 (Step 5 part II) is worth 30 points. Step 8 (part II) is worth 5 points. Chart 3 (Step 12, part II) is worth 5 points. Step 13 (part II) is worth 10 points. The Graph is worth 30 points.
- The total points for the complete assignment is 90 points.

Implementation Strategy

The case was implemented using a block class schedule (110 class minutes). Scene 1 and 2 were completed in one block class schedule.

Day 1:

- Scene 1 was passed out and read by student volunteers and then the teacher passed out the box chart for the students to fill in.
- The teacher acted as the facilitator and recorded all box chart suggestions on the white board.
- The first scene and box chart took a total of 30 to 40 class minutes to read and complete the box chart.
- The second scene was passed out to the students and read by student volunteers.
- The second scene box chart was completed by the students and the teacher acted as the facilitator and recorded all box chart suggestions on the white board.
- The second scene and box chart took a total of 40 to 50 class minutes to read and complete.
- Both box charts were turned in to the teacher at the end of the class period for an assessment grade.

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Day 2:

- The second day was dedicated to the completion of the pH paper identification lab.
- Part I will take about 20 minutes to complete.
- Part II will take about 70 to 80 minutes to complete in class.
- The lab handout and graph will need to be completed for homework if not completed in class.
- The students will need to be grouped into groups of 4 to 5 students per group.
- Enough materials will need to be provided to equip each group with supplies to complete the lab activity.
- The groups can then be divided according to group roles of leader, recorder, time-keeper, organizer, and ambassador.
- The teacher will need to be available to answer questions and may wish to limit the number of questions that the lab groups can ask or the teacher may allow each group a specific number of questions that they can ask (spy) on another group.

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Facilitator Guide:
Sample box chart from Scene 1 and Scene 2.

Box Chart

Scene 1 Facts/Data	**Learning Issues**	**Action Plan**
Small pieces of paper all over the floor. Paper is brown and yellow. Class locked over the weekend. Teacher had to unlock the door on Monday.	How did the paper get on the floor? How does the paper get ripped and on the ground if door is locked?	Need to find out what books/texts the paper came from. Were there animals, bugs, or other things in the classroom. Could someone have unlocked the classroom door before the teacher came in on Monday.

Box Chart

Scene 2 Facts/Data	**Learning Issues**	**Action Plan**
Acids react with fibers causing papers to turn colors. Janitor used old newspaper. Student was reading an old book. School telephone directory missing two pages. Art teacher assigned a paper art project.	Who could have left the papers on the chemistry classroom floor?	Conduct the pH paper lab to determine what type of paper was left on the classroom floor.

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Vandal in the Chem Lab!: Scene 1

The science lab has been locked all weekend. Upon coming to school on Monday, the high school chemistry teacher unlocked the lab and entered the room. When the lights were turned on, the teacher looked around the room and noticed that the floor was covered in small pieces of paper that were brown and yellow in color. The teacher picked up the pieces of paper and noticed that each piece of paper had text written on it. The paper pieces appeared to be old and brittle. Some of the pieces of paper had marks that appeared to be part of a drawing on the paper.

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Box Chart

Scene 1 Facts/Data	Learning Issues	Action Plan

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Case Title: Scene 2

The teacher wondered where the paper that was covering her classroom floor had come from and decided to conduct an experiment to determine who had left the paper on her classroom floor. She remembered talking to an art conservator who explained that paper could be damaged from acids. Acids react with the cellulose fibers in paper in a process called hydrolysis, which breaks down the fibers causing the paper to turn brown and become brittle.

The chemistry teacher began to do some investigating to determine who had been the last person in her classroom who could have spread the paper all over her floor. The teacher remembered that one of her students named Johnny had been reading an old book during 7^{th} period Chemistry. The old book had yellow pages and appeared to be very brittle. She also remembered that the janitor used old newspaper and window cleaner to clean the windows in the classroom every evening. The janitor had access to her classroom all evening. The teacher also remembered that the art teacher had given an art project assignment that required students to create a piece of art work made out of paper. The paper that the students were to use was yellow in color. The school secretary also told the teacher that someone had removed several pages from the school office telephone directory. Each of these papers could have been the paper that the teacher found scattered around her classroom the next morning. The teacher decided to use her Chemistry students to help her identify which type of paper had been left in her classroom.

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Box Chart

Scene 2 Facts/Data	Learning Issues	Action Plan

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Acids, Bases, and Paper Identification Lab

Part 1:
Record your results from Part 1 of the pH and Paper Activity Below.

Paper Type (10 points total)	pH from pH pen mark	Observations for comparison
Unknown sample		
Johnny's old book		
Janitors Newspaper		
Art Teacher's paper		
Telephone book paper		

Part 2:

1. Record your results from Part 2 Below (30 points).

Paper	10 min.	20 min.	30 min.	40 min.	50 min.	60 min.
#1 Unknown						
#2 Old Book						
#3 Newspaper						
#4 Art paper						
#5 Telephone						

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2. Using graph paper, students are to graph the pH values for each type of paper sample versus the time.

3. pH of dissolved $CaCO_3$ solution :

4. After 10 minutes, test the pH of the water in the test tube. Record your observations in the chart below:

Type of Paper	After $CaCO_3$ solution pH reading
#1 Unknown sample	
#2 Johnny's old book	
#3 Janitor's newspaper	
#4 Art Teacher's paper	
#5 Office Telephone Directory	

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5. Compare the acidity of each paper type in part I and part II with the acidity from the Calcium carbonate solution to identify the unknown type of paper that was discovered in the Chemistry teacher's classroom. In the space below, identify the unknown paper and give the reason based upon your lab results for why you chose that particular paper as what the teacher found in her classroom. (Hint: Use your lab data to support the answer that you chose).

Useful Resources

History of Paper/Paper Making
http://www.hqpapermaker.com/paper-history/
http://www.hrc.utexas.edu/educator/modules/gutenberg/invention/papermaking/
http://paper.lib.uiowa.edu/european.php

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