Teaching Guide: Smallbrook Water Problem

Standards Addressed

5. Acids, bases, and salts are three classes of compounds that form ions in water solutions. As a basis for understanding this concept:
a. *Students know* the observable properties of acids, bases, and salt solutions.
b. *Students know* acids are hydrogen-ion-donating and bases are hydrogen-ion-accepting substances.
c. *Students know* strong acids and bases fully dissociate and weak acids and bases partially dissociate.
d. *Students know* how to use the pH scale to characterize acid and base solutions.

Safety

Students and teachers are to wear splashproof goggles throughout the lab.

Sodium hydroxide and hydrochloric are caustic materials and should be handled accordingly.

Do not let hydrochloric acids solutions evaporate over long periods of time (over an hour). Hydrogen chloride gas will enter the air in the lab room.

Caution students not to pick up sodium hydroxide with their hands. Sodium hydroxide is hydroscopic, i.e., it will absorb water from the atmosphere and become wet looking. Keep sodium hydroxide pellets in a small sealable jar next to each balance. Students should close the jar immediately after use and place the pellets of sodium hydroxide in the water as soon as possible after weighing.

Estimated Time

Two 55 minutes periods for prelab and lab.

Prerequisite Lab Skills

Calculate molar mass

Convert from grams to moles and moles to grams

Calculate molarity

Use a balance

Write and balance a chemical equation

Use pH paper or a pH meter

Use factor label method for calculations

Students must also know that: The combination of an acid and a base produce a salt and water

Students need to be told or be able to research the pH of natural bodies of water (5.6-6.5)

Materials needed for a class of 36 students working in groups of 4 students per group

Quantity	Item	Quantity	Item
3	Balances, electronic, at	2 pellets	sodium hydroxide (NaOH)

	least ± 0.01g		
18	250mL beakers		Purified Water
27	Beral pipets		pH papers or pH meters[1]
2000mL*	sample of the wetland water	9	10mL graduated cylinders

* Two pellets of NaOH weigh about 0.25g. The molarity of the NaOH solution will be about 0.062M.

To make the wetland water, add 1.8mL of 1.0M HCl to make one liter of solution. You will need about 2L of this solution per class.

Neutralization with the sodium hydroxide solution should occur with the addition of about 60 drops of NaOH.

You could prepare stock solutions of several different "wetland water" solutions. For example, you could have three different solutions by adding 1.2mL of the 1.0M HCl to one stock solution, 1.8mL to another, and 2.2mL to a third stock solution. Label nine beakers with a "code" that students don't know, and write down what students the different solutions.

[1] Students can use Hydrion pH paper, portable pH meters or universal indicator. Universal indicator will change from bright red at pH 2, through many distinguishable color changes, to violet at pH 10. A recipe for making the universal indicator is given below.

> To make 200mL of universal indicator solution, combine the following:
> 10mL methyl orange solution (0.1g methyl orange/100mL water)
> 10mL methyl red solution (0.3g methyl red/100mL ethanol)
> 10mL bromthymol blue solutions (0.6g bromthymol blue/ 100mL ethanol)
> 7mL phenolphthalein solution (1.0g phenolphthalein/100mL 50% ethanol/50% water)
> 110mL ethanol
> 53mL water

Don't make large quantities of universal indicator solution; store solution in a flammable cabinet.

Notes

The Town Hall meeting date is your deadline.
The amount of pay is the maximum grade they will be receiving.

Pre-Lab Questions

1. How can you change the pH of a large amount of water, as in a swimming wetland?
2. How can I keep track of how much chemical I add?

Post-Lab Questions

1. Students will often cite human error as the sources of error, such as, “misreading the balance or graduated cylinder,” “miscounting the drops,” and/or “punching in the wrong numbers on the calculator.”
   Redirect students in your debrief of the lab to think of sources of error as uncertainties in the instruments they use, such as review the meaning of ± 0.01g on a balance, lack of uniformity in drop size. Also see the California Science Standards, High School Investigation and Experimentation Standards 1 b and 1c.
   Productive discussion in the debrief also could include a sense that “something wasn’t right in the lab” such as, “we weighed three pellets but only used two”, or “we spilled a little of the wetland water before titration and didn’t tell anyone.” Acknowledgement of these “mistakes” will help students understand the reasons for the procedure, and the need for careful experimentation.
2. Once students find the answer in a group, they can compare their answer with other groups.
3. Increase the mass of NaOH used.
4. Some reasons why there may be a difference in the number of drops needed to neutralize the swimming wetland water are:
   a. Human error
   b. Samples of wetland water did not have the same molarity of HCl.
   c. Molarity of NaOH solution was different.

Extension

Have students with advanced knowledge do this lab with multiple bases and determine which one would require the smallest quantity.

Give students the prices of the bases and ask them to determine the most cost effective.

Have students do research on what is actually done in acidic lakes.

Do not give the students the step by step procedure but require them to figure it all out for themselves.

Misconceptions

Many students are in an “additive” phase of cognitive development in regards to titrations. They think that if you start with 20mL of any acid, it will take 20mL of any base to neutralize it. They need assistance to understand a more “proportional” understanding of a titration. If you neutralize 100mL of an acid with 3mL of a base, then in a second trial, you use a base that has twice the concentration of the first base, you will need only 1.5mL of the base for neutralization.

Students may think that to neutralize 100mL of acid, you need to add 100mL of base.

Student Evaluation

Student Evaluation:

4	Student answered all prelab questions correctly and in depth, using

	examples or evidence. Student ran the lab and recorded all data and made correct computations. Student's presentation was entertaining, informative and complete. Handouts were well thought out and followed a logical sequence. Student was able to field questions. Student work was neat.
3	Student answered pre lab question correctly. Student ran the lab and recorded all data with correct calculations. Student gave a presentation at the Town Hall meeting. Information presented at the Town Hall meeting was accurate. Student had some difficulty fielding all questions. Handouts were informative, but did not capture interest of other students. Student work was legible.
2	Students answered some pre-lab, but did not have a clear understanding of what would be necessary information. Student did the lab and recorded some data, but did not know how to use the data. Student was present for the presentation but not completely prepared and did not understand the information they were conveying. Student could not answer any questions. Handout was uninformative or possibly contains inaccurate information. Student work was somewhat understandable.
1	Student could not answer all the pre-lab questions. Student was present in the lab and recorded data, much of which may have had incorrect units. Student was unable to really convey any information at the Town Hall meeting. Information presented was inaccurate. Student wasn't even willing to field questions. Handout or presentation information was inadequate or nonexistent. Student work was unintelligible.