Acid-Base Titration Experiment

Summary

The purpose of this lesson is to introduce students to how acid-base reactions take place. Students will use a spreadsheet and a pH meter to construct a visual model of the progress of an acid-base reaction.
Students will use a digital pH meter to monitor the progress of an acetic acid titration with sodium hydroxide. Students will use a spreadsheet to organize the data they gather and to construct a titration curve. Students will then use the chart to estimate the pH at different stages of a second titration. These estimates will be confirmed experimentally and with calculations.

Time Frame

2 class periods of 45 minutes each

Group Size

Small Groups

Life Skills

Thinking & Reasoning

Materials

- Chemistry textbook
- Digital pH meter
- Desktop computers running Excel or similar software
- 50 ml buret for each group
- 250 ml beaker for each group
- 0.083 molar acetic acid solution
- 0.10 molar NaOH solution
- Phenolphthalein indicator

Student Prior Knowledge

Students should understand the definition of an acid and a base.
Students should be able to use the equilibrium constant to set up equilibrium expressions for acid-base reactions and to calculate concentrations using such expressions.
Students should understand the relationship between pH and acid concentration.
Students should understand safe laboratory procedures for dealing with acids and bases.

Intended Learning Outcomes

- Students will be able to use a digital pH meter and a spreadsheet program to construct a graph showing the progress of an acid-base titration and use that graph to estimate the pH of a reaction at various points during a titration.
- Students will use information from the textbook to construct an equilibrium expression for this reaction. Using this expression, they will calculate volumes of NaOH corresponding to the estimates they made from the graph. Students will also run a second titration to verify experimentally their estimates and calculations.
- Using their experiences from the experiment, students will be able to explain qualitatively what is happening at the beginning of a reaction and before, at, and after the equivalence point of that reaction.

Instructional Procedures

Divide the class into small groups, with no more than 3-4 students per group.
Demonstrate the operation of a buret by discharging small amounts of water into a flask. Explain to the students how to read the buret using the marks on the sides. Issue each group a buret and a flask. Have the students set up their burets and fill them with water. Have each student dispense a small amount of water (2-5 ml) into the flask.
After all students have had the opportunity to practice dispensing water from the buret, take a moment to review safety procedures for dealing with acids and bases, including safe disposal.
Demonstrate the operation of the digital pH meter. Show them how to use the meter without the risk of breaking the electrode.
Issue each group 125 ml of 0.100 molar NaOH solution and 30.0 ml of 0.083 molar acetic acid solution.
Have each group rinse their buret with the NaOH solution and dispose of the waste base properly. Then have them fill their burets to 50 ml with the NaOH solution. Add 1 drop of phenolphthalein indicator to the 30.0 ml of acetic acid solution.
Have each group run a scout titration by adding NaOH incrementally to the acid solution. Have students add the solution 5 ml at a time. Have them record the pH after each addition. If the pH changes dramatically, have them change the procedure and add NaOH 1-2 ml at a time. One student can control the stopcock, one can read the volume, and one can record the pH in a spreadsheet or on paper.
Once the titration is complete, have the students use a spreadsheet to construct an XY Scatter plot of pH versus amount of NaOH added. Have each group save and print their graph.
Ask each group to use their graph to estimate the pH when several different volumes of NaOH have been added (i.e., after 5 ml, 10ml, 12 ml, etc.) Also have them estimate the amount of NaOH solution needed to reach the equivalence point (i.e., pH=7.0).
Instruct each group to set up an equilibrium expression for the reaction and to use it to calculate the true values for the estimates they made in the previous step.
Have each group dispose of the acetic acid and NaOH solution and rinse the beaker.
Issue each group another 30.0 ml of acetic acid solution and have them repeat the titration, taking care to measure the amount of NaOH issued very carefully. Remind them to add the indicator before they start the titration! Have them also find the equivalence point as accurately as they can (i.e., to the nearest 0.1 ml) and record the volume of NaOH needed to reach it.
Have students dispose of their remaining chemicals appropriately.
Have each student in the group write a short report (2-3 paragraphs) of their results. Have them explain any differences between their estimates, the values they calculated, and the values obtained experimentally in the second titration.
Have each group turn in their graph, calculations, and written reports together.

Assessment Plan

Students will turn in a group lab that includes of their titration graph, their calculations, and a short lab report from each team member.
The students' graphs will be assessed based on how well mirror the general characteristics of the graph shown in the book (p. 641).
The calculations will be assessed based on how well the students set up the equilibrium expression and the pH calculations, as well as how accurately their answers match the correct answers.
Reports will be assessed based on how well the students explain any difference between the estimated, calculated, and observed, values for their titration. Reports will also be assessed based on how well the student is able to describe the progress of the reaction in his or her own words. Spelling, grammar, and punctuation will also be considered.

Rubrics

[Acid-Base Titration Experiment]

Bibliography

LeMay, H.E.Jr.; Robblee, K.M.; Beall, H.; Brower, D.C. Chemistry: Connections to our Changing World; Prentice Hall: Upper Saddle River, NJ, 2000; pp 634-642.

Authors

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