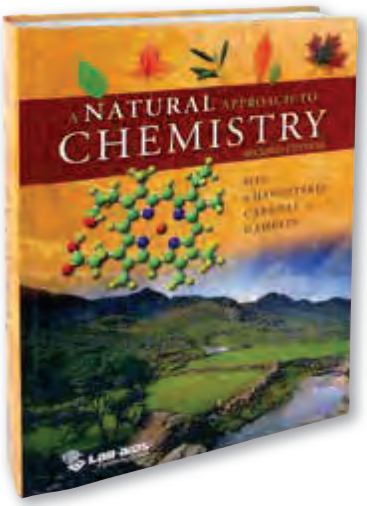
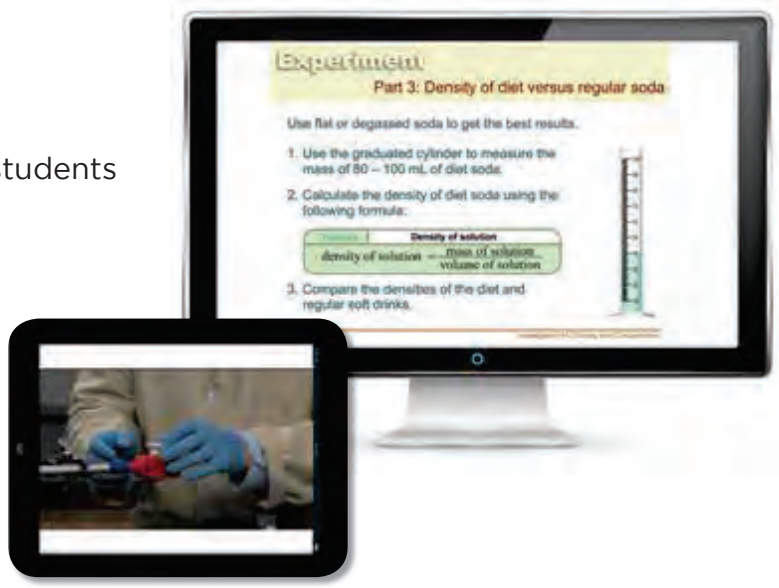
A NATURAL APPROACH TO CHEMISTRY SECOND EDITION



The central premise of **A NATURAL APPROACH TO CHEMISTRY** is that chemistry is all around each of us, every day. Chemistry is us. We eat chemistry. We drink chemistry. Chemistry is the complex choreography of atoms and molecules that sustain life. Chemistry is both how we create the materials of human technology, and also how the natural world builds and renews itself.



ACCESS TO TEACHER'S ONLINE PORTAL

- Assign homework and communicate with students
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STEM LITERACY
REFILLABLE ADD A GROUP

A NATURAL APPROACH TO CHEMISTRY, SECOND EDITION	ITEM NO.
COMPLETE EQUIPMENT PACKAGE (FOR A GROUP OF 4, UNLIMITED SECTIONS) (includes: Lab-Master System, atomic structure model, molecular modeling kit, condensation apparatus, spectroscopy cards, dimensional analysis cards, laboratory hardware and glassware)	NAC-M01
A NATURAL APPROACH TO CHEMISTRY, SECOND EDITION ONLINE PORTAL FOR STUDENTS (includes: Student Book, Lab Investigations Manual, Lab Investigation videos and podcasts)	NAC-2OLSP-1
A NATURAL APPROACH TO CHEMISTRY, SECOND EDITION ONLINE PORTAL FOR TEACHERS (includes: Teacher Edition, Student Book, Lab Investigations Manual, PowerPoint slides, assessments, Differentiated Skill Sheets, lab investigation videos and podcasts)	NAC-2OLTP-7
STUDENT BOOK BUNDLE (Student Book in hardcover and Laboratory Investigations Manual in softcover)	NAC-2SBLM
TEACHER EDITION (printed)	NAC-2TE
LAB-MASTER SYSTEM (includes: spectrophotometer, heater, temperature probe, and voltage probe)	NAC-LM-TS
CORE CHEMICALS EQUIPMENT PACKAGE FOR ONE GROUP OF 4 STUDENTS	NAC-CS1
BULK CHEMICALS EQUIPMENT PACKAGE FOR 6 GROUPS OF 4 STUDENTS (lasts 6 class periods)	NAC-CB1
SCIENCE LAB NOTEBOOK (bulk pricing available)	SLN-1

Materials needed for embedded labs and activities are part of the Complete Equipment Package

Name:_____ Section:_____ Date:_____ A Natural Approach to Chemistry

13B: Titration of Vinegar

How can we determine how much acetic acid is in vinegar?
How accurate is the advertised amount of acetic acid in vinegar?

The acetic acid in vinegar comes from the apples or grapes used to make it. Commercial vinegar contains mostly water, and it is advertised as approximately 5% acetic acid by mass. In this investigation we will titrate vinegar with standardized NaOH. Titration is a process used to determine the moles of an acid or base in an aqueous solution. We will slowly add drops of NaOH to the vinegar, and our solution will change color when the ratio of acid to base is close to the same. To form water, we need equal amounts of acid and base. Titrations use indicators to signal when the endpoint is near.

Materials
- Vinegar (normal strength)
- Erlenmeyer flask
- Distilled water
- Phenolphthalein indicator
- 50 mL graduated cylinder
- 10 mL graduated cylinder
- Beral pipet
- Dropper bottle of 1.0 M NaOH
- Mass balance

The acid–base reaction carried out in this experiment is

$$CH_3COOH(aq) + NaOH(aq) \rightarrow H_2O(l) + NaCH_3COO(aq)$$

Our goal is to completely "neutralize" the acetic acid (CH_3COOH). If we add just the right amount of NaOH to the solution, we will end up with water (H_2O) and salt ($NaCH_3COO$, sodium acetate). When the solution is neutral, we can say that the endpoint has been reached.

At the equivalent point, also called the endpoint, the moles of acid are equal to the moles of base. This is the most important aspect of the titration process.

Part 1: Titration procedure

1. Weigh a clean, dry 125 mL Erlenmeyer flask.
2. Measure 1.6 mL of vinegar in a small graduated cylinder, and add it to the Erlenmeyer flask
3. Weigh the flask and the vinegar so that you can calculate the exact mass of vinegar you are titrating.
4. Add approximately 25 mL of distilled water to the flask. Swirl to mix.
5. Add 3–4 drops of phenolphthalein indicator to the vinegar. Swirl to mix.
6. Using a beral pipet, calibrate the number of drops in one milliliter. You may have done this before by counting how many drops it takes to reach the 1.0 mL mark on a graduated cylinder. This is very important. It allows you to estimate the volume you use to titrate. Once you know how many drops are in one milliliter, you can begin.
7. Add drops of NaOH slowly to your Erlenmeyer flask. Swirl to mix after each drop.

8. You are looking for a pink color that persists throughout the solution for 30 to 60 s. To accomplish this, you must swirl often and add your drops slowly. One drop can cause you to go too far. If your solution is too pink and does not go away, this means you have gone too far past your "endpoint" and your solution is now basic. You actually want your solution to be neutral.
9. Repeat Steps 1–8 three times to obtain a reliable and (hopefully) reproducible result.
10. Rinse your titration down the sink with water and clean your glassware.

Part 2: Thinking about it

1. What does the pink color tell you about your titration?
2. How can you determine the volume of the base you used? Explain.

Part 3: Calculations

1. Enter your data in Table 1. For comparison, gather some other data from other groups.

Table 1. Titration data

Mass of vinegar (g)	Volume of NaOH (mL)	Moles of NaOH	Moles of acetic acid	Percent by mass of acetic acid

2. Determine the number of moles of NaOH you used to titrate your vinegar using the molarity formula, $M = X \text{ moles} / \text{(volume in liters)}$.
3. The mole ratio is one to one based on the chemical reaction. Knowing the moles of NaOH allows you to find the moles of acetic acid.
4. Next, convert the moles of acetic acid to grams of acetic acid (CH_3COOH) using the molar mass. Show your calculations and enter your results on Table 1.
5. Lastly, determine the percent by mass of acetic acid:
6. Record your value in Table 1. Determine the percent by mass of each of your trials.

$$\%\text{ by mass} = \frac{\text{mass of } CH_3COOH}{\text{mass of vinegar}} \times 100$$

Part 4: What did you learn?

a. Is it true that commercial vinegar is approximately 5% by mass? Explain.
b. List two sources of experimental error that may have affected your results.
c. If you overtitrated and your solution was too pink, how would this affect your percent by mass of acetic acid? Explain.
d. Show the Lewis structure of acetic acid (CH_3COOH).
e. Which hydrogen atom is the one that is lost when acetic acid reacts with the base (NaOH)?
f. When the endpoint of your titration is reached, what should be true about the number of moles of acidand the number of moles of base? Explain.