Lesson Title	Acid / Base Titration
Length of Lesson	110 min (1.25 days)
Created By	David Wilson
Subject	AP Chemistry
Grade Level	10-12
State Standards	3d, 5a
DOK Level	DOK 3 / DOK2
DOK Application	Use / Analyze and Explain
National Standards	9-12: B: Physical Science
Graduate Research Element	Acid / Base theory is a major governing concept in chemistry. My work, specifically involves the proper buffering of systems to ensure a desired pH. In addition, the pKa's of various amino acids I work with must be considered when I develop my experiments. The pH of various amino acids can regulate metal binding, which is essential to my research.

Student Learning Goal:

State Standards: (Chemistry)

3) Develop an understanding of the periodic table.

d) Use stoichiometry to calculate the amount of reactants consumed and products formed. (DOK 3)

5) Compare factors associated with acid/base and oxidation/reduction reactions.

a) Analyze and explain acid/base reactions. (DOK 2)

National Science Standards: (9-12)

B: Physical Science: Chemical Reactions

- A large number of important reactions involve the transfer of either electrons (oxidation/reduction reactions) or hydrogen ions (acid/base reactions) between reacting ions, molecules, or atoms. In other reactions, chemical bonds are broken by heat or light to form very reactive radicals with electrons ready to form new bonds. Radical reactions control many processes such as the presence of ozone and greenhouse gases in the atmosphere, burning and processing of fossil fuels, the formation of polymers, and explosions.

Materials Needed (supplies, hand-outs, resources):

Be Careful and always read the Materials Safety Data Sheet (MSDS) written for chemicals you use. Federal Law requires the vendors of chemicals to provide MSDS sheets for all their chemicals

(All quantities specified here are for approximately one class.)

1) Large bottle of vinegar (50 mL is necessary for each group for each trial.)
2) 1.0 M NaOH solution (approximately 50 mL will be needed for each group for each trial.)
3) 1 buret per group, attached to a ring stand with a buret clamp
4) 1 250 mL beaker of Erlenmeyer flask per group (for the acid / base solution)
5) 1 100 mL beaker per group (for the base to fill the buret)
6) 1 funnel to fill the buret with base.
7) 1 small dropper bottle of phenolphthalein

Lesson Performance Task/Assessment:
Students will

- Titrate an acid with a known concentration of base to calculate the concentration of the acid.
- Calculate the weight percent of acetic acid in vinegar

Lesson Relevance to Performance Task and Students:
This lab is an acid-base titration lab. In this lab students will collect the required skills and data to ultimately calculate the weight percent of acetic acid in vinegar.

Anticipatory Set/Capture Interest:
An introduction to the lab procedure with the required apparatus will serve as the anticipatory set.

Guided Practice:
I will instruct the students in how to perform the lab and what the endpoint will look like. Then they will perform the lab under my guidance.

Independent Practice:
The students will calculate the weight percent of vinegar on their own with only the information provided in the background.

Remediation and/or Enrichment:
Remediation: Individual IEP.
Enrichment: Students will repeat their experiment twice more (three times total) and average their results to determine the standard deviation of their values and the percent error given the true weight percent value.

Check(s) for Understanding:
The students weight percent values will serve as a check for their understanding.

Closure:
I will ask the students to identify other acidic foods, and ask them to identify some unifying characteristics (i.e. sour taste, etc.)

Possible Alternate Subject Integrations:
Biology. Acid-Base chemistry is very important in biological systems.

Teacher Notes:
Reference: CHE-106 Lab Manual used at The University of Southern Mississippi; Woodruff, Frank and Howell, J. Emory. Chemical Principles in the Laboratory. The University of Southern Mississippi. 2000. {This particular lab was copyrighted in 1975.}

An Advanced Study Assignment is attached.

The lab is relatively easy to perform. Be sure all the glassware is cleaned. A basic lab procedure is listed below. Please see the lab manual for a more detailed background.

Procedure:

1) After cleaning the buret well, fill it with 1.0 M NaOH carefully. Make sure the buret stopcock is not dripping. In order to remove the air bubble from the buret tip, you must open the stopcock fully and allow some of the NaOH to run into a beaker. This should dislodge the bubble. You may need to refill the buret. Make a note of the measured location of the meniscus.
2) Aliquot 50 mL of vinegar (from the store) into a 250 mL beaker or Erlenmeyer flask.
3) Add three drops of phenolphthalein.
4) Titrate the vinegar with the NaOH solution to the phenolphthalein endpoint. This should be a very pale pink endpoint.
5) Note quantity of NaOH necessary to perform the titration.
6) Calculate the number of moles of acetic acid in the vinegar. Then, convert that number to the number of grams of acetic acid in vinegar.
7) Calculate the weight percent of acetic acid in vinegar.

Calculations:

Symbols: Molarity of acid = M_A , Molarity of Base = M_B, Volume = V

Molarity of the Acetic Acid in Vinegar

$$M_A V_A = M_B V_B$$

$$M_A = \frac{M_B V_B}{V_A}$$

Moles of the Acetic Acid

$$moles_A = M_A V_A$$

Grams of Acetic Acid

$$grams_{AceticAcid} = moles_{AceticAcid} (MolarMass)_{AceticAcid}$$

Weight % Acetic Acid in Vinegar

$$weight\% = \frac{grams_{AceticAcid}}{grams_{vinegar}} (100)$$