**A Twist On Titrations**
Developed by Nicole Hume, 07/2017

**Teacher notes:**

This lab uses temperature rather than pH or indicator to determine the endpoint of a neutralization reaction. The reaction will reach a maximum temperature when the acid has been neutralized by the base. This lab can be used in different ways. You can follow up a traditional acid/base titration with this lab and compare the results. You can also use this lab in a unit on energy. You can use energy to determine when a reaction has reached completion.

If students know how to use a pipet, you can have them pipet the acid into a beaker.

Ideally stir plates will be used (available through Science Express) to keep the solution mixed as the reaction takes place.

All solutions should be prepared at least one day in advance and left sitting in the classroom so that their initial temperatures are consistent.

**2016 Chemistry Standards:**

C.1.3 Recognize observable macroscopic indicators of chemical changes.

All of Standard 4: Reactions and Stoichiometry

C.6.3 Classify chemical reactions and phase changes as exothermic or endothermic based on enthalpy values.

C.6.4 Perform calculations involving… temperature changes.

C.7.3 Describe the concentration of solutes in a solution in terms of molarity.

C.8.1 Classify solutions as acids or bases and describe their characteristic properties.

C.8.2 Compare and contrast the strength of acids and bases in solutions.

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| **Science Express equipment to order** | **Other Materials** |
| Set of 12 Stir plates (stir bars included) | Beaker OR Erlenmeyer flask |
| Set of 12 Vernier Temperature probes | 25 mL Pipet OR 50mL graduated cylinder |
| Vernier Interface (Choose ONE): | Ring stand, Buret and clamp |
|  Set of 12 Laptops AND Set of 12 Go Links | 1.00 M NaOH (250-mL per group) |
|  Set of 12 LabQuests | ≈ 2 M hydrochloric acid (150-mL per group) |
|  Set of 12 LabQuest 2’s | ≈ 2 M acetic acid (150-mL per group) |

## A Twist on Titrations

**Purpose:**  The purpose of this lab is to use temperature to determine the end point of a neutralization reaction between sodium hydroxide and an acid.

**Materials:**

Vernier temperature probe and interface

Stir plate and stir bar

Beaker or Erlenmeyer flask (You need to be able to insert both the temperature probe and the tip of the buret into the Erlenmeyer flask. If you cannot, use a beaker.)

25 mL Pipet or 50 mL graduated cylinder as directed by your teacher

Ring stand, Buret and clamp

200 mL per group of 1.00 M NaOH

150 mL per group of hydrochloric acid

150 mL per group of acetic acid

**Procedure:**

1. Properly clean your buret and pipet, as instructed by your teacher.
2. Rinse the buret with three 20-mL portions of NaOH and be sure to run NaOH through the buret tip. Then fill the buret with NaOH.
3. Record the initial volume of NaOH in the buret.
4. Set up your equipment so that your flask or beaker is on the stir plate with a stir bar.
5. Pipet 25 mL of acid into the flask or beaker.
6. Turn the stir plate on and stir slowly so that the liquid does not splash onto the sides of the container.
7. Insert the temperature probe into the flask or beaker.
8. Record the initial temperature.
9. Add 1 -2 mL of NaOH. Record the buret reading and the temperature.
10. Repeat step 9 until you have added 25 mL of NaOH to the flask or beaker.
11. Clean the pipet and beaker, rinse and dry the flask or beaker and the temperature probe.
12. Fill the buret with NaOH to at least the 30 mL mark.
13. Repeat steps 3-11 using acetic acid.

**Data:**

 **25.0 mL HCl**
\* Calculate the volume added after completing the experiment.

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| **Buret Reading** | **Volume NaOH added\*** | **Temperature (℃)** |
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 **25.0 mL Acetic Acid**
\* Calculate the volume added after completing the experiment.

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| **Buret Reading** | **Volume** **NaOH added\*** | **Temperature (℃)** |
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### Calculations:

1. Make a plot of temperature on the Y axis and volume of base on the X axis for each data set.
2. Draw a straight line of best fit through the data points that have a positive slope and a separate line of best fit through the data points that have a negative slope.
3. The point at which the two lines intersect is the maximum temperature. This is the amount of base needed to neutralize the acid.
4. Using a balanced chemical reaction, the known molarity of the base, the volume of base needed for neutralization, and the volume of acid, calculate the concentration of both the HCl and the acetic acid.

**Questions:**

1. What was the calculated molarity of the HCl? What was the calculated molarity of the acetic acid?
2. What are some sources of error for this experiment?
3. How would the data have been different if the reaction had been endothermic?