Lab: Acid Base Reactions

FOR THE TEACHER

Summary
In this lab, students will witness a reaction between an acid and base. One will be strong, and the other may be weak or strong. There is an element of unknown, and it is up to the student to identify certain characteristics of acid base reactions to adequately complete the lab.

Grade Level
High school

AP Chemistry Curriculum Framework
This lab supports the following units, topics and learning objectives:
- **Unit 4: Chemical Reactions**
  - **Topic 4.6:** Introduction to Titration
    - **SPQ-4.B:** Identify the equivalence point in a titration based on the amounts of the titrant and analyte, assuming the titration reaction goes to completion.

- **Unit 8: Acids and Bases**
  - **Topic 8.2:** pH and pOH of Strong Acids and Bases
    - **SAP-9.B:** Calculate pH and pOH based on concentrations of all species in a solution of a strong acid or a strong base.
  - **Topic 8.5:** Acid-Base Titrations
    - **SAP-9.E:** Explain results from the titration of a mono- or polyprotic acid or base solution, in relation to the properties of the solution and its components.
  - **Topic 8.7:** pH and pKa
    - **SAP-10.A:** Explain the relationship between the predominant form of a weak acid or base in solution at a given pH and the pKa of the conjugate acid or the pKb of the conjugate base.

Objectives
By the end of this lesson, students should be able to
- Know that an indicator is needed for a titration.
- Recognize the significance of the endpoint in a titration.
- Recognize whether the titration they carry out is between a weak and strong or strong and strong acid and base.

Chemistry Topics
This lesson supports students’ understanding of
- Titration
- Acid-base chemistry
- Indicator
- Endpoint
- Strong vs. weak acids/bases

Time
**Teacher Preparation:** one hour
**Lesson:** one class period
Materials
- Buret
- Funnel
- Indicator: phenolphthalein (WA + SB), methyl orange (SA + WB), bromothymol blue (SA + SB)
- 250-mL Erlenmeyer flask
- Beaker (for waste)

Safety
- Always wear safety goggles when handling chemicals in the lab.
- When working with acids and bases, if any solution gets on students’ skin immediately, they should immediately rinse the area with water and alert the teacher.
- Students should wash their hands thoroughly before leaving the lab.
- When students complete the lab, instruct them how to clean up their materials and dispose of any chemicals.

Teacher Notes
- Answers to acid/base categorization:
  - acids = HCl (strong), NH₄Cl (weak), HC₂H₃O₂ (weak)
  - bases= KOH (strong), NaC₂H₃O₂ (weak)
- The four pieces of glassware to identify are: buret, beaker, Erlenmeyer flask, and graduated cylinder.
- The unknown substance will be either HCl or KOH, since all students will be working with one strong substance. They should measure the pH either with litmus paper, pH paper, or a pH probe. You could provide a hint that there is one common characteristic of the acids and bases that all students will be working with as a clue to what their substance is.
- It’s up to you what concentration you provide for each substance. It’s recommended to prepare solutions around 0.25 M.
- When you provide the unknown solutions, make sure you give students an acid if they have a base at their station and a base if they have an acid at their station. Again, it’s up to you what concentrations you prepare, but don’t make them all the same concentrations. You could do a range between 0.15 M and 0.35 M for variety.
- Make sure students use an indicator before titrating. It’s up to them what indicator they choose, but you could recommend they use a variety of indicators to confirm their results.
- The values they should record are: 1. the volume of unknown to titrate. 2. the starting volume in the buret. 3. the ending volume in the buret once the endpoint is reached.
- Measuring the pH at the endpoint will help them confirm whether they titrated strong + strong or strong + weak. SA + SB = pH ~7; SA + WB = pH <7; WA + SB = pH >7.
- You could allot a certain part of the grade for how close to the accepted concentration student arrived at. You can encourage students to repeat the titration up to three times (and using different indicators).

FOR THE STUDENT
Lesson

Background
Write out the balanced equation for the reaction between any acid, HA, and any base, BOH.

If you start with 15.0 mL of HA, what is its concentration if you needed 22.4 mL of 0.56-M BOH to reach the endpoint?

Explain what happens at the endpoint.

You will be working with two of these chemicals today. Under each chemical formula, write A for acid and B for base (yes, they are all either an acid or a base).

HC₂H₃O₂  KOH  HCl  NH₄Cl  NaC₂H₃O₂

Problem
What is the identity and concentration of your unknown solution?

Procedure
You have four pieces of glassware at your station. Identify them, and draw a sketch of each.

1.  2.
3.  4.

Identify the aqueous substance at your station. Do this by putting a small amount (less than 1 mL) in a beaker and running a test on the substance. Record the test you run and any observations in the space provided.

When you have identified your substance, find out from your teacher what the concentration is. Record the data in this space:

You now need to titrate. What additional substance do you need? Be specific!

Obtain a numbered solution from your teacher. Measure less than 10 mL of the solution in a graduated cylinder. Record the sample number and its approximate concentration in the space below. There should be three pieces of data here—make sure to label each value with a unit so you know what each number represents.

Unknown #_____

Calculate the approximate amount of substance you will need from the buret. Show your work in the space provided.

When your teacher has checked your work, you may begin the titration. What should you add before you titrate?

What values do you need to record during the experiment? Record them (yes, PLURAL!) in the space below.

Measure and record the pH of the solution before you reach the endpoint. Measure and record the pH of the solution when you reach the endpoint. Write down any observations during your titration in this space.
Calculate the exact concentration of your unknown solution.

**Conclusion**
What is your unknown solution and its concentration? Briefly describe how you arrived at this final answer.