Objective:
In Part 1 the student will perform an acid-base titration to calculate the concentration of the base and record the pH data for use during Part 2, the ChemSense animation of the reaction. Students will be able to construct a model that describes neutralization as a process of hydroxide ions reacting with hydrogen ions to create water molecules. As the water molecules from, the pH of the solution, shown in an adjacent graph, decreases.

Target student audience:
All levels of chemistry students

ChemSense User Level:
Advanced

ChemSense Tools used:
Animation, peer feed-back

Specialized Tools needed:
Vernier or other computer-linked pH probes

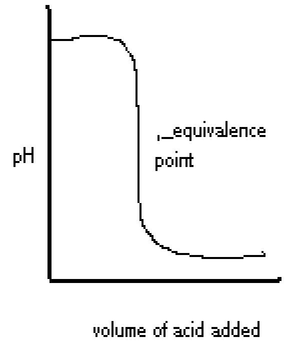
Classroom Implementation
Time: Wet lab: 1hour, Computer animation: 1.5 hours
Student Grouping: Pairs
Activity Type: Part 1 Wet Lab, Part 2 Animation

Chemistry Concepts in Activity:
California State Standards in Chemistry
5.0 The student understands acids, bases, and salts are three classes of compound that form ions in water solutions.
5.d The student knows how to use the pH scale to characterize acid and base solutions.
ChemSense Concentration: When materials combine to undergo chemical reactions, large collections of molecules mix, colliding with one another. Changes in concentration affect the number of collisions that can take place between the different substances.

California State Standard in Investigation and Experimentation
7.a The student selects and uses appropriate tools and technology (such as computer-linked probes, spread sheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.

Prerequisite Chemistry Concepts:
When a strong acid and a strong base react to neutralization, the two products are water and a salt. The pH of the solution as the acid and base react will change. The base solution contains an excess of hydroxide ions (OH^-), so the pH is above 7. As acid is added, the number of excess hydroxide ions in solution decreases as they reaction with hydrogen ions to form water molecules. At the equivalence point the moles of acid equal the moles of base, so there is no excess of either hydroxide or hydrogen ions and the pH

is 7. It is important for students to understand that the equivalence point in an acid-base titration is defined by the stoichiometry, not by the pH. If further addition of acid occurs, an excess of hydrogen ions occurs and the solution becomes acidic with a pH below 7.



The neutralization curve for the reaction will show minor changes in pH except near the equivalence point. Chemical indicators are chosen to change color near the expected pH of the equivalence point.

The concentration of the unknown base can be calculated using the formula (molarity of acid) x (volume of acid) = (molarity of base) x (volume of base) or $M_AV_A = M_BV_B$ because at the equivalence point the moles of acid equal the moles of base.

Inquiry Skills (linked to NSES):

ACTIVITY Summary:
After performing an acid base titration, the student will be able to accurately show the correlation between the change in pH and the neutralization of a base with an acid to form water molecules and a soluble salt.

Sources:
Vernier Titration Lab

Application:
Doing the macroscopic titration experiment with a color change indicator will give students a better understanding of the changing nature of the chemicals in solution. The animation activity will allow them to demonstrate their understanding on a molecular basis, and the foundation for understanding cellular activity in biology will be established.

ACTIVITY:
Part 1: Titration of an Unknown Molarity Base with a Known Molarity Acid

Materials Needed per class of 30 students working in pairs

750 mL 0.1 *M* HCl	750 mL 0.80 *M* NaOH
phenolphthalein indicator	15 flasks

15 ring stands & butterfly clamps	15 burets labeled HCl
15 burets labeled NaOH	15 funnels labeled HCl
15 funnels labeled NaOH	30 pairs of goggles
30 aprons	15 Pasco® pH probes and hand held devices

Safety

Goggles and aprons must be worn at all times. When filling burets they must be taken off the butterfly clamps and held below eye level.

Procedure

1. Put on your laboratory apron and safety goggles.
2. Fill a buret to the 0mL level with acid and clamp it on the ring stand. Fill the other buret to the 0mL level with base and clamp it in place.
3. Put two drops of the phenolphthalein indicator into the flask. Use the buret to deliver 50 mL of base to the flask.
4. Insert the Vernier® or Pasco® pH probe into the flask and begin recording pH data.
5. Gradually dispense some of the HCl acid solution into the titration flask. Swirl the flask constantly. Continue adding the acid slowly, noting any changes in your data table. After each addition of HCl, record data and observations in your data table.
6. As the equivalence point is approached add the acid drop by drop. Stop the titration for 30 seconds when a single drop changes the indicator color. Record the volume of acid at this point as the Equivalence Point.
7. Add an additional volume, in small amounts of acid and record the change in pH.
8. Print a copy of the graph generated by the pH probe.
9. Before leaving the laboratory, clean up all materials and wash your hands thoroughly.

Data and Observations

Record your data and observations in table form here.

Questions and Calculations

1. When performing the titration, why should the flask be constantly swirled?
2. Calculate the volume of HCl needed to reach the equivalence point.
3. Calculate the molarity of the base using the equation

(molarity of acid) x (volume of acid) = (molarity of base) x (volume of base) or

$M_AV_A = M_BV_B$

4. Explain the shape of the graph generated by the neutralization reaction. Indicate on the graph where hydroxide ions are in excess, where hydroxide ions equal hydrogen ions, and where hydrogen ions are in excess.
5. Write a balanced equation for the neutralization reaction between HCl and NaOH.

Conclusion

Part 2: Animation of the Neutralization of a Base with an Acid

Purpose:
The student will visualize and represent the change in pH during a neutralization reaction.

Goal:
The student will be able to accurately show the correlation between the change in pH and the neutralization of a base with an acid to form water molecules and a soluble salt.

Procedure:
1. Review your data and observations from Part 1. Using the pH as a guide, note the places in the reaction where there are an excess of hydroxide ions. Note the places where the number of hydroxide and hydrogen ions are equal. Note the places where there is an excess of hydrogen ions.
2. Sketch a hydroxide ion, a hydrogen ion, and a water molecule.
3. Log on to the ChemSense program and open up the Neutralization folder for your class period.
4. Use the ChemSense animation tool to make a split-screen animation. One side should show a graph of the change in pH vs. volume of acid added. The other side should show the formation of water molecules during the titration of a base solution with an acid. Include the buret and flask. The animation should have at least 40 frames. Use text to describe what is going on.
5. Show your work to your instructor. Send a message to a classmate that addresses the content of his or her animation.
6. Save your work to your account folder.

Rubric for scoring:

Rubric Score	Level of Competence	Expectation Level
4	Mastery	Animation has smooth transitions between frames. Artwork accurately represents the formation of water molecules from the ions. The change in the pH curve is consistent with the formation of water molecules. Axes are accurately labeled and the curve represents the pH Text addresses the chemical reaction.
3	Skilled	Animation may not be smooth and molecular shapes may have minor errors. The change in the pH curve is consistent with the formation of water molecules. Axes are accurately labeled, but the curve does not accurately represent the pH. Text addresses the chemical reaction.

2	Proficient	Animation is not smooth, but water molecules are accurate. The change in pH may not be consistent with the change in the formation of water molecules. Axes are not accurately labeled, or the curve does not accurately represent the formation of water molecules. Text may not address the neutralization reaction.
1	Introductory	Animation may not be smooth. The water molecules may not be accurate, and the change in pH may not coincide with the formation of water molecules. Axes are not accurately labeled, and the curve does not accurately represent the change in pH. Text may not address the neutralization reaction.
0	Incomplete	Animation may have smooth transitions between frames, but the artwork does not accurately represents the formation of water molecules. The change in pH does not coincide with the formation of water molecules. Axes are not accurately. Text may not address the neutralization reaction.