Connected Chemistry

Acids & Bases Unit

Lesson 6: Titration

Student's Lesson at a Glance

Lesson Summary

This lesson contains two activities that are designed to follow up the titration lab. These activities help students interpret titration curves and explore known and unknown concentrations of acid and base solutions.

SWBAT (Students Will Be Able To)

- Identify the components of a titration curve
- Use a titration curve to determine the acidity or basicity of the titrand and titrants used in a titration experiment

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in **bold**. Additional words that will expand your scientific vocabulary are in *italics*.

CCC Reminder

- Make sure to read the titration lab the night before you complete the lab. Make notes in the margin if you have questions. By preparing ahead of time for the lab, this will make completing the lab easier.
- Handle all acids and bases in lab with care. Make sure to follow your teacher's instructions so that the lab is conducted safely.
- Titrations can be challenging to do because it requires a steady hand and patience to get the desired results. Do not rush through the procedure. Go slowly so that you can accurately see the pH indicator gradually change color as you add the base to the acid.
- You will be constructing a titration curve graph. Make sure you accurately record the data collected in lab so that you can easily construct your graph.
- Make sure that you accurately label graphs and do not confuse what belongs on the x- and y-axis for the titration graphs. The volume of the titrant is placed on the x-axis while the pH is on the y-axis.
- Ions will have halos in the simulation. When drawing keys for sketches, make sure to include ions and neutral atoms.
- Hydroxide and hydronium are easily confused when naming ions. Hydroxide ion's formula is written as OH^- and hydronium's is H_3O^+.
- Volume and concentration are not the same thing. Concentration can be measured as the amount of moles of acid or base that has dissociated into the solution per volume (moles solute per liters of solution). Volume is a measure of the three-dimensional space a solution occupies.

Notes

Homework

Upcoming Quizzes/Tests

Activity 1: Connecting

Many people suffer from heartburn (or acid reflux disease). Heartburn occurs when stomach acid moves towards the esophagus. The stomach acid causes irritation to this sensitive area. To combat the stomach acid, people suffering from heartburn often take antacids, like Tums™, Rolaids™, and Pepto-Bismol™. All of these antacids have ingredients to neutralize the stomach acid so that the acid is less irritating. Recall that neutralization reactions are reactions between acids and bases that completely consume both the acid and base and form a salt. The reaction below is a **neutralization reaction**:

HCl (aq)	+	NaOH (aq)	→	NaCl (aq)	+	H_2O (l)
(acid)		(base)		(sodium chloride)		(water)

In the laboratory, chemists use neutralization reactions to determine the concentration of unknown solutions with an aqueous solution called a **pH indicator**. The pH indicator solution is sensitive to pH changes. The pH indicator solution undergoes a color change when added to solutions that are basic or acidic. In this activity, you will use a pH indicator to help you perform a technique called **titration**. Titration is the gradual addition of a standard solution (either an acid or a base) of known concentration called the **titrant** to a different solution of unknown concentration (either a base or an acid) called the **titrand** until the acid and bases are neutralized.

1. Based on what you already know, predict what will happen to the pH of an unknown acid if you add a very small amount of an acid to a base.

2. What would happen if you add a large amount of acid to a base?

3. Why do you think the word "neutralization" is used to describe a neutralization reaction?

4. A person taking antacid creates a neutralization reaction between the antacid and stomach acid. What does this imply about what type of ingredients are used to make the antacid?

5. If a titration results in the complete neutralization of both the acid and the base in a solution, what would you expect the resultant pH of the products to be?

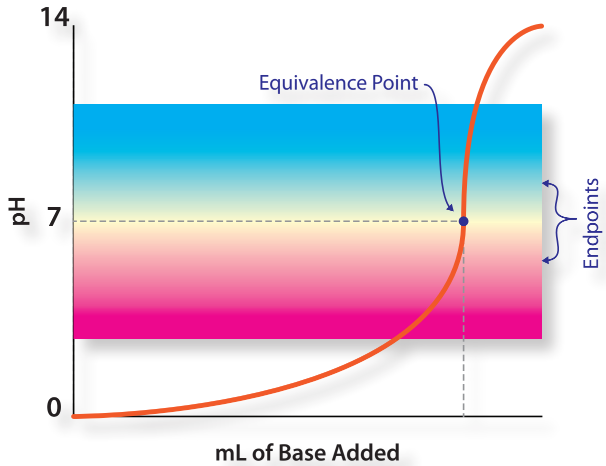
Activity 2: Titration Wet Lab

For this experiment, the concentration of the aqueous HCl solution is unknown. A pH indicator will be added to the HCl to indicate when the neutralization reaction is complete. The resulting products will be H_2O and NaCl. During this lab, you will create a titration curve from the data generated in the experiment, determine the amount of titrant needed to reach equivalence point, and determine the value of the pH at equivalence point.

Activity 3: Creating and Interpreting Titration Curves

Teacher Facilitated Discussion

Use the graph you created from the data you gathered in the titration lab or the graph provided to you by your teacher. This graph is called a **titration curve**. A titration curve is drawn by plotting data obtained during a titration experiment. When constructing the titration curve, the titrant volume is placed on the x-axis and pH on the y-axis. The titration curve serves to characterize the unknown solution.



1. Based on the passage above, what is the titrant in the experiment you performed?

When the solution of known concentration and the solution of unknown concentration are reacted to the point where the number of moles of acid and the number of moles of base are equal, the **equivalence point** is reached. The equivalence point of a strong acid or a strong base will occur at a pH of 7 when the base and acid are fully neutralized. For combinations of weak acids and strong bases, weak bases and strong acids, and weak bases and weak acids, the equivalence point does not occur at a pH of 7.

On the titration curve, the equivalence point is the point on a titration graph when the moles of base is equal to the starting amount of acid. This is seen in the graph where the slope of the line is undefined.

The **endpoint** of the reaction is when the pH indicator changes color. The colors produced in the solution are specific to what indicator is being used. To help visualize where this occurs, the color for thymol blue indicator has been overlaid on the titration graph above. Acids are indicated by a pink colored solution, while bases are blue. Color is a macroscopic observation. Most titration experiments require the use of a pH probe to measure the pH before, during, and when the endpoint of the reaction is reached to help validate the results.

2. What does the term "equivalent" mean?

3. On your graph, what are the coordinates of your equivalence point? What is its pH?

Activity 4: Simulating Titration

Demonstration: *Use Simulation 6,* ***Set 1***

This is a simulation of what occurred in the titration lab. Follow along as your teacher demonstrates it.

1. How does the addition of the base (titrant) by your teacher affect the unknown acid solution?

2. When you performed the titration lab, what color represented each level of the pH scale?

3. On the macroscopic level, why does the color change not occur immediately after you add the base to the acid?

You have seen the equivalence point represented on a graph. How would you represent the equivalence point on a submicroscopic scale?

4. Sketch what you think the equivalence point looks like on the submicroscopic level. Include a description of your sketch and a key.

Sketch the Equivalence Point	Describe your sketch
Key	

- *Your teacher will now add enough base to take the unknown solution to the equivalence point.*
- *You can change which graph is displayed by clicking the button on the top right corner of the graph display.*

5. Was your prediction correct? If not, how would you change your sketch to accurately represent the equivalence point?

6. After the equivalence point is reached, what do you observe happening on a submicroscopic level to the unknown acid solution?

7. On the macroscopic level, what physical observations can be made before reaching the equivalence point, at the equivalence point, and after reaching the equivalence point in the unknown solution?

Lesson Reflection Question

8. Why do you think chemists conduct titration experiments? Give one example of a real-life scenario in which a scientist might use a titration. *Be sure to explain your answer with evidence.*