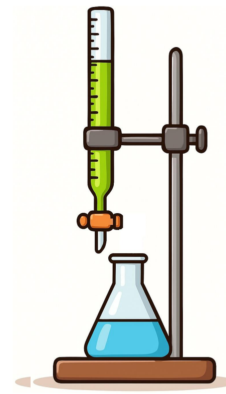
Titration Analysis

Read from **Lesson 2 Part f:** [Titration Analysis] in the **Chemistry Tutorial** Section**, Chapter 16** of **The Physics Classroom**:

Vocabulary (example is a weak acid strong base titration)



* **Titration** is an analytical method used to determine the concentration of an unknown acid or base by reacting it with a known volume and concentration of titrant.
* A **titration curve** plots pH vs. volume of titrant added, revealing key stages of the reaction.
* **Analyte**: the solution with unknown (or given) weak acid, HA, concentration, and volume.
* **Titrant**: a strong base of known concentration added gradually.
* **Equivalence point**: the point where moles of base added = moles of acid originally present (for monoprotic acid). At this point, the acid is completely neutralized.
* **Titration curve**: a plot of pH vs. volume of titrant added; shows a characteristic "steep rise" near equivalence.

- What to note: the pH of the solution as base is gradually added and how to calculate the pH at key points along the curve (before **equivalence**, **at equivalence**, **after equivalence**)

Analysis of a Titration of a Weak Acid with a Strong Base

Before the Equivalence Point

- The solution contains excess HA and its conjugate base A^-.
- Use stoichiometry to find moles of HA and A^-.
- Apply the Henderson-Hasselbalch equation or ICE tables to calculate pH.

At the Equivalence Point

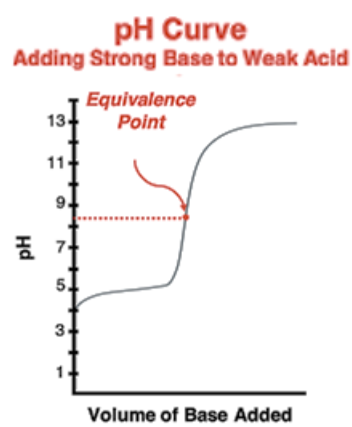
- All HA is neutralized; only A^- remains.
- A^- undergoes hydrolysis: $A^- + H_2O \rightleftharpoons HA + OH^-$
- Use K_b (derived from K_a) and ICE tables to calculate pH.
- pH > 7 due to basic nature of A^-.

After the Equivalence Point

- Excess OH^- dominates the solution.
- Calculate $[OH^-]$ from excess moles and total volume.
- Convert to pOH, then to pH: pH = 14 − pOH

Graph of Titration

- The curve shows a gradual rise in pH before equivalence, a sharp jump at equivalence, and leveling off after.



Solution Equilibria

Part 1 Questions

Paige H. Scale and Al Kaline are performing a weak acid– strong base titration. They begin with **35.00 mL** of a **1.00 M hydrocyanic acid (HCN) (K_a is 6.2×10^{-10})** solution in a flask. They titrate it using a standardized **1.00 M NaOH** solution.

Use this information to answer the following questions about the different stages of the titration and to make a titration curve on the graph. Assume the temperature is 25°C throughout the process.

1. Calculate the number of moles of HCN in the 35.00 mL of a 1.00 M HCN solution.

2. Calculate the $[H_3O^+]$ and then determine the initial pH of the HCN solution (before adding NaOH).

3. After adding 17.50 mL NaOH, calculate the remaining moles of HCN and moles of CN^- formed.

4. Calculate the [HCN] and [CN-] (consider total volume).

5. What is the pH at this point in the titration?

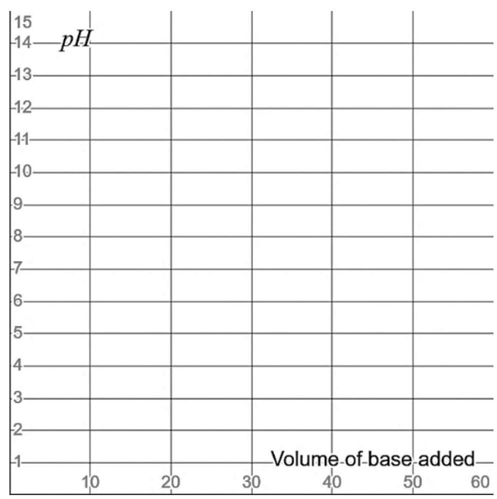
Solution Equilibria

6. At 35.00 mL NaOH added, all acid is neutralized. The flask contains CN^-. Calculate $[CN^-]$ and use hydrolysis to determine pH at equivalence.

7. At 37.00 mL NaOH added, there is excess OH^-. Calculate $[OH^-]$ and pH.

8. At 50.00 mL NaOH added, calculate $[OH^-]$ and pH again.

9. Fill in the data table with the data from your calculations. Plot the points and sketch a best fit curve on the graph. Label the equivalence point.



Data Table:

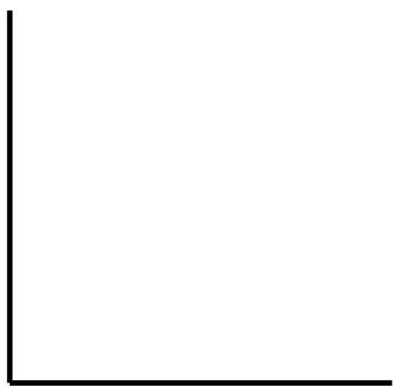
Volume of base added	pH
0 mL	
17.50 mL	
35.00 mL	
37.00 mL	
50.00 mL	

Solution Equilibria

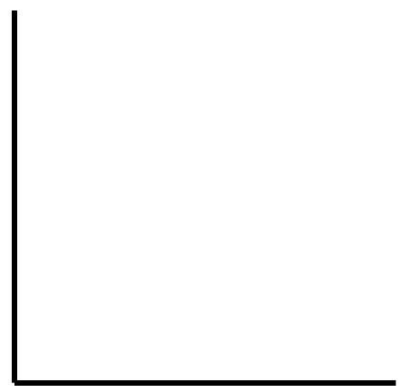
Part 2 Questions

1. Explain in your own words why the pH at the equivalence point in a weak acid + strong base titration is greater than 7.

2. Describe how the titration curve (pH vs volume of titrant) for a weak acid + strong base differs from one for a strong acid + strong base. (Sketch the two curves to help with your description.)



Titration curve (pH vs volume of titrant) for a weak acid + strong base



Titration curve (pH vs volume of titrant) for a strong acid + strong base