Lab: Lethal Dose

FOR THE TEACHER

Summary
In this lab, students will perform several simple titrations to calculate the concentration of potentially “lethal” medicyclopophic acid.

Grade Level
High School

AP Chemistry Curriculum Framework
This laboratory experiment supports the following units, topics, and learning objectives:

- **Unit 4: Chemical Reactions**
  - **Topic 4.2:** Net Ionic Equations
    - **TRA-1.B:** Represent changes in matter with a balanced chemical or net ionic equation: a. For physical changes. b. For given information about the identity of the reactants and/or product. c. For ions in a given chemical reaction.
  - **Topic 4.5:** Stoichiometry
    - **SPQ-4.A:** Explain changes in the amounts of reactants and products based on the balanced reaction equation for a chemical process.
  - **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 lab, students should be able to

- Perform a titration
- Calculate the molarity of an unknown substance

Chemistry Topics
This lab supports students’ understanding of

- Acids & Bases
- Titrations
- Concentration
- Molarity

Time
**Teacher Preparation:** 30 minutes
**Lesson:** 1 block (95 min) or 2 periods (45 min each)
Materials
- HCl Solutions: 0.1M, 0.3 M, 0.5 M, 0.8 M, 1.0 M
- 0.5 M NaOH
- Phenolphthalein indicator
- 50 mL burette (multiple per group if available), burette clamp, ring stand
- Erlenmeyer flasks (3-125mL per group)
- Pipet
- Graduated cylinder

Safety
- Always wear safety goggles when handling chemicals in the lab.
- 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.
- When working with acids, if any solution gets on students’ skin, they should immediately alert you and thoroughly flush their skin with water.
- When working with acids and bases, if any solution gets on your skin immediately rinse the area with water.

Teacher Notes
- This lab would be good to do with an introductory level chemistry class, or when first introducing the technique of titrations and the calculations that accompany them.
- “Medicycloprophic acid” is used as a fake name for the “lethal” solution. Note that this is not the real name of an acid!
- Each Medicycloprophic acid (HCl solution) should be placed in a container labeled with a number or a Letter (example: Acid A, B, C, D, E).
- Plan the amount of HCl solution to make based on the number of student groups in the class and the number of burettes used by each group (10mL of the acid is needed for each titration, and each HCl solution will be titrated three times).
- Students need to know how to use stoichiometry/dimensional analysis to solve this problem, but since the reaction involves HCl and NaOH to produce NaCl and H2O, the molar ratios are 1 to 1. Therefore, stoichiometry doesn’t technically have to be used and students can use the formula MaVa = MbVb. M stands for molarity, V stands for volume, a is for acid, and b is for base. Students will solve for Ma as they will be given the Mb and through titration will experimentally determine the volumes of the acids and base used. This should be discussed with students prior to the lab.
- Students use three Erlenmeyer flasks for each of the Medicycloprophic acid solutions (for three trials with each).
- Upon completion of each titration have students thoroughly wash the Erlenmeyers before using the next unknown Medicycloprophic acid solution.
- Have students fill the burette(s) to the 0 mL mark at the start of the first trial, and use the data table to record initial and final values for each titration. Students should subtract the values to calculate the volume of solution used in each trial. Student can refill the burette as needed.
- Possible extension – ask students to analyze their results to justify whether medicycloprophic acid is strong or weak (they would have to know to take the pH at the endpoint).
FOR THE STUDENT
Lesson

Calculating a Lethal Dose

Purpose
You will use the technique of titrating to investigate five samples of medicycloprophic acid, each of unknown concentration and determine their respective molarities.

Background
For those allergic to medicycloprophic acid, when given a certain dosage it can be fatal. Using a titration you can determine if any of the samples provided are considered lethal.

Materials
- Medicycloprophic acid (5 samples, labeled as A, B, C, D, E)
- 0.5 M NaOH
- Phenolphthalein indicator
- 50 mL burette
- 3 – 250mL Erlenmeyer flasks
- Pipet
- Graduated cylinder

Safety
- Always wear safety goggles when handling chemicals in the lab.
- Wash your hands thoroughly before leaving the lab.
- Follow the teacher’s instructions for cleanup and disposal of chemicals.
- When working with acids, if any solution gets on your skin, immediately alert the teacher and thoroughly flush your skin with water.

Procedure
1. Fill the 50 mL burette to the 0 mL mark with 0.5 M NaOH.
2. Using a graduated cylinder and pipet carefully measure 10 mL of one of the medicycloprophic acid solutions and place in a 125 mL Erlenmeyer flask. (Note: It doesn’t matter which sample you test first!)
3. Add 2 drops of the phenolphthalein indicator to the acid solution.
4. Record the initial value for the volume of NaOH in the data table.
5. Carefully begin the titration by adding the 0.5M NaOH to the meducycloprophic solution slowly, dropwise.
6. The equivalence point will occur when the solution has a very light pink color. Be sure to swirl the flask and slow the addition of NaOH when you being to see pink indications in the solution.
7. Record the final volume of NaOH.
8. Subtract the initial value of NaOH from the final value to determine the volume actually used in the titration.
9. Repeat steps 2-8 two more times for each acid sample.
10. Calculate the average amount of NaOH used for each sample of acid, and record this value in the data table. The average should be used in your final calculations.
11. Repeat the entire process for remaining medicycloprophic acid solutions.
### Data Table

<table>
<thead>
<tr>
<th>Sample</th>
<th>Titration Trials</th>
<th>Final Calculated Concentration of Acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid A</td>
<td>$V_1$ (NaOH)</td>
<td>$V_2$ (NaOH)</td>
</tr>
<tr>
<td>Trial 1</td>
<td></td>
<td></td>
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<tr>
<td>Trial 2</td>
<td></td>
<td></td>
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<tr>
<td>Trial 3</td>
<td></td>
<td></td>
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<tr>
<td>Average volume used:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acid B</td>
<td>$V_1$ (NaOH)</td>
<td>$V_2$ (NaOH)</td>
</tr>
<tr>
<td>Trial 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average volume used:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acid C</td>
<td>$V_1$ (NaOH)</td>
<td>$V_2$ (NaOH)</td>
</tr>
<tr>
<td>Trial 1</td>
<td></td>
<td></td>
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<tr>
<td>Trial 2</td>
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<tr>
<td>Trial 3</td>
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<td></td>
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<tr>
<td>Average volume used:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acid D</td>
<td>$V_1$ (NaOH)</td>
<td>$V_2$ (NaOH)</td>
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<tr>
<td>Trial 1</td>
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<td>Trial 2</td>
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<tr>
<td>Trial 3</td>
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<td></td>
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<tr>
<td>Average volume used:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acid E</td>
<td>$V_1$ (NaOH)</td>
<td>$V_2$ (NaOH)</td>
</tr>
<tr>
<td>Trial 1</td>
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<td>Trial 2</td>
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<tr>
<td>Trial 3</td>
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<td></td>
</tr>
<tr>
<td>Average volume used:</td>
<td></td>
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</tbody>
</table>

### Calculations
What is the molarity of each solution tested? Organize and show your calculations for each solution below. Record your final concentration value for each acid sample in the data table column “final concentration.”

### Analysis
Which sample(s) of medicycloprophic acid are considered a lethal dosage if the lethal dose is any concentration above 0.75M?