The Base Hydrolysis of Ethyl Acetate

The reaction of ethyl acetate and hydroxide ions yields ethanol and acetate ions, as shown below.

\[
\text{CH}_3\text{COOC}_2\text{H}_5 \text{ (aq) + OH}^- \text{ (aq) } \rightarrow \text{CH}_3\text{CH}_2\text{OH (aq) + CH}_3\text{COO}^- \text{ (aq)}
\]

The progress of this reaction can be observed by monitoring the conductivity of the reaction mixture. Although the reactants and products each contain an ion, the OH\(^-\) ion has a higher ionic mobility than the CH\(_3\)COO\(^-\) ion. This results in a net decrease in the conductivity of the reaction mixture as the reaction proceeds.

Ethyl acetate is the major active ingredient in commercial acetone-free, nail-polish removers. The molar concentration of CH\(_3\)COOC\(_2\)H\(_5\) in this product is 0.10 M. You can successfully use one of these over-the-counter products in this experiment. The primary objective of this experiment is to conduct a series of reactions from which you will determine the rate law expression for the base hydrolysis of ethyl acetate.

**OBJECTIVES**

In this experiment, you will

- Conduct the base hydrolysis of ethyl acetate under various conditions.
- Calculate the rate law constant, \(k\), for the reaction.
- Determine the rate law expression for the reaction.

**MATERIALS**

- Vernier computer interface computer
- Vernier Conductivity Probe
- Vernier Stir Station
- or magnetic stirrer and ring stand
- stirring bar or Microstirrer
- utility clamp
- 0.010 M sodium hydroxide, NaOH, solution
- 0.10 M ethyl acetate, CH\(_3\)COOC\(_2\)H\(_5\), solution
- distilled water
- 10 mL graduated cylinder
- two 50 mL graduated cylinders
- 250 mL beaker
- two 100 mL beakers
PROCEDURE

1. Obtain and wear goggles.

2. Connect a Conductivity Probe to Channel 1 of the Vernier computer interface. Connect the interface to the computer using the proper cable.

3. Set the toggle switch on the Conductivity Probe to the 0–2000 µS/cm range.

4. Start the Logger Pro program on your computer. Open the file “29 Ethyl Acetate” from the Advanced Chemistry with Vernier folder.

5. Obtain the materials you will need to conduct this experiment.
   - Two 50 mL graduated cylinders
   - One 10 mL graduated cylinder
   - 100 mL beaker in which to conduct the reaction
   - Approximately 90–100 mL of 0.010 M NaOH solution in a 250 mL beaker
   - Approximately 10 mL of 0.10 M CH₃COOC₂H₅ solution in a second 100 mL beaker
   - Distilled water (75-80 mL)

6. During the experiment you will conduct three trials. This step describes the process for conducting Trial 1. When you repeat this process, use the correct volumes for each trial based on the table below.

<table>
<thead>
<tr>
<th>Trial</th>
<th>NaOH (mL)</th>
<th>CH₃COOC₂H₅ (mL)</th>
<th>H₂O (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20.0</td>
<td>2.0</td>
<td>28.0</td>
</tr>
<tr>
<td>2</td>
<td>40.0</td>
<td>2.0</td>
<td>8.0</td>
</tr>
<tr>
<td>3</td>
<td>20.0</td>
<td>4.0</td>
<td>26.0</td>
</tr>
</tbody>
</table>

   a. Use a utility clamp to connect the Conductivity Probe to the post of a Stir Station or a ring stand as shown in Figure 1.
   b. Measure 20.0 mL of NaOH solution and 28.0 mL of distilled water into a 100 mL beaker. Carefully place a stirring bar in the beaker of solution. Place the beaker on the platform of the Stir Station, or on the magnetic stirrer.
   c. Position the Conductivity Probe in the 100 mL beaker so that the opening near the tip of the probe is completely immersed in the solution and the stirring bar will not strike the probe. Record the initial conductivity of the NaOH solution in your data table, but do not start the data collection.
   d. Turn on the Stir Station to setting 5 or 6 (moderate stirring, small vortex).
   e. Measure out 2.0 mL of CH₃COOC₂H₅ solution.
   f. Click ▶Collect to begin data collection. Add the 2.0 mL of CH₃COOC₂H₅ solution to the beaker of NaOH solution. Data will be collected for five minutes.

7. When the data collection is complete, dispose of the contents of the beaker as directed. Rinse and clean the beaker and the Conductivity Probe for the second trial.
8. Examine the graph of your data. The graph will show a gradual, nonlinear, conductivity decrease. Click and drag the cursor across a linear section of the graph over 20–30 s during the first minute. Click on the Linear Regression button, \( \text{Linear Regression} \), to calculate the best-fit line equation. Record the slope, in your data table, as the initial rate of the Trial 1.

9. Repeat Steps 6–8 to conduct Trials 2 and 3.

**DATA TABLE**

<table>
<thead>
<tr>
<th>Trial</th>
<th>[NaOH]</th>
<th>[CH(_3)COOC(_2)H(_5)]</th>
<th>Initial conductivity of NaOH solution (µS/cm)</th>
<th>Initial rate (µS/cm)/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DATA ANALYSIS**

1. What is the order of the reaction in sodium hydroxide and ethyl acetate? Explain how you determined order for each reactant.

2. Write the rate law expression for the reaction.

3. Convert conductivity to molar concentration by using the initial conductivity of the NaOH solution as a conversion factor. Convert each initial rate into the units: moles/L/s. For example, if the initial conductivity of the NaOH solution was 2000 µS/cm and initial rate was 5.0 µS/cm/s, you would convert the rate to moles/L/s by completing the following calculation: Rate = 5.0 µS/cm/s \( \times \) [(0.005 mol/L)/(2000 µS/cm)] = \( 1.25 \times 10^{-5} \) mol/L/s. Use these new values to calculate the rate constant, \( k \).
This copy does not include:

- Safety information
- Essential instructor background information
- Directions for preparing solutions
- Important tips for successfully doing these labs