Kinetic Approach to Water Flow

**Background**

Reactions can go fast or slow. By determining the rate order for a reaction one can go on to predict what the concentration might be in 10 or 20 seconds or 10 or 20 years. For example the Chlorofluorocarbon molecules (CFC’s) in the atmosphere that threaten the ozone layer change at a very slow rate, or some nuclear decay may take thousands of years. Although this activity does not represent CFC’s concentrations with time or any nuclear decay, it does provide for you the tools to conduct such analysis on real data.

**Objective**

To determine if the water flow through a vertical column is zero, first, or second order with respect to time vs. water remaining. You will work with Excel to analyze the data collected.

**Materials**

- Water
- ring stand
- burette clamp
- 50 mL burette
- 50 ml beaker
- Funnel
- Stopwatch or another timing device
- Computer with access to Excel

**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 of materials and disposal of chemicals.

**Procedure**

1. Clean and thoroughly rinse a 50 mL burette with water before beginning.
2. Fill the burette to the 0.00 mL mark with deionized water assuring no air bubbles are in the tip.
3. Place a 50ml beaker underneath the burette.
4. Open the stopcock while simultaneously starting the stop watch. When the water reaches 5 mL, stop the watch and record the time required to drain 5.00 mL from the burette in the data table.
5. Refill the burette to the 0.00 mL mark (you can reuse the water that was drained in step 4).
6. Open the stopcock while simultaneously starting the stop watch. When the water reaches 5 mL, stop the watch and record the time required to drain 10.00 mL from the burette in the data table.
7. Repeat step 5 and 6, by recording the times to drain 15.00mL, 20.00mL, 25.00mL, 30.00mL, and 35.00mL of water
8. Repeat the process again so that you complete two trials for each volume.

<table>
<thead>
<tr>
<th>Volume used (mL)</th>
<th>5.00mL</th>
<th>10.00mL</th>
<th>15.00mL</th>
<th>20.00mL</th>
<th>25.00mL</th>
<th>30.00mL</th>
<th>35.00mL</th>
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</thead>
<tbody>
<tr>
<td>Time (Trial #1)</td>
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<tr>
<td>Time (Trial #2)</td>
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<td>Average Time</td>
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</tbody>
</table>

**Calculations**

1. Complete the necessary calculations and organize the following data in within an Excel spreadsheet:

<table>
<thead>
<tr>
<th>Volume Drained, mL</th>
<th>Remaining Volume, mL</th>
<th>In Volume remaining</th>
<th>1 / Volume remaining, mL⁻¹</th>
<th>Time₁, sec</th>
<th>Time₂, sec</th>
<th>Time_{average} sec</th>
</tr>
</thead>
</table>

2. Using your data, use Excel to construct graphs of each of the following:

3. Include R² and an equation for a linear fit for each graph prepared.

**Analysis**

1. Based on your results, explain whether the flow of water through a burette is zeroth, first, or second order.
2. Determine the value of the rate constant including the appropriate units.

Extension
Look at the [NOAA Annual Greenhouse Gas Index website](https://www.esrl.noaa.gov/gmd/ccgg/trends/) and examine data for one of the greenhouse gases. Determine the order of the reaction, using the same method outlined in this activity.