**Vitamin C Analysis**

**GENERAL DISCUSSION:**
Vitamin C, ascorbic acid ($C_6H_8O_6$), is commonly sold in tablet form with a starch binder. Tablets are labeled according to their vitamin C content, not according to their weight. You will chemically analyze vitamin C tablets to determine their actual vitamin C content. The chemical basis for the analysis is the reaction:

$$HC_6H_7O_6(aq) + NaOH(aq) \rightarrow NaC_6H_7O_6(aq) + H_2O(l)$$

An indicator will be used to determine when the reaction reaches its endpoint, the point at which the amount of NaOH added equals the amount of vitamin C originally present. The NaOH solution will be standardized to determine its strength by reacting it with a very pure (primary standard) sample of an acid. Knowing the strength and the volume of the NaOH required to completely react with the vitamin C, you will be able to calculate the quantity of vitamin C present.

The concentration unit used here is molarity, the number of moles of solute dissolved per liter of solution. The operating relationship is

**EXPERIMENT:**

**Supplies:**
- buret and buret stand
- magnetic stirrer
- stir bar and a 250 ml flask
- 150 ml of the NaOH solution in a clean dry 250 ml beaker. Cover the beaker with a watch glass.

Prepare the buret for use according to the directions in the buret discussion on page 103. First drain the deionized water from the buret, rinse with two portions of NaOH solution, then fill to above the top mark, and open the valve to fill the tip with solution. Remember that you read the numbers exactly as they appear on the buret.

**A) STANDARDIZATION:**
Weigh 2 separate samples of potassium hydrogen phthalate ($KHC_8H_4O_4$; abbreviated as KHP; $MM = 204 g/mol$) each weighing between 0.78 and 0.82 g onto weighing paper. Record the weights to the nearest 0.001 g. Add each sample to a marked 250 ml flask. Dissolve each sample in about 50 ml of deionized water. Add 2 drops of phenolphthalein indicator to each flask. Record the initial volume in the buret. (Record all buret volumes to the nearest 0.01 ml.) Make sure the magnetic stirrer is covered with a white surface. Titrate until one drop gives a faint pink color that persists for 30 seconds or so. Record the final volume. Refill the buret and repeat the procedure with the second sample. The ratio of volume of NaOH to mass of KHP should be the same in each titration, and you can use the results of the first run to help you calculate how much NaOH you may quickly add before you need to watch carefully for the color change in the second run.

**B) VITAMIN C ANALYSIS:**
Weigh out two separate samples of one brand of whole vitamin C tablets so that each sample contains between 500 and 800 mg of vitamin C (1, 2, or as many tablets as are needed). The tablets usually weigh more than the dose size because of binders added to help hold the tablet together. Record the brand name, the tablet dose size and the number of tablets used. Place each sample between sheets of weighing paper. Pulverize the tablets using a rolling motion with the stainless steel scoopula from your drawer. Powder the sample by pressing the bottom of a watch glass over the pulverized tablets. Transfer each sample into a rinsed and marked 250 ml flask. Add about 50 ml deionized water and 2 drops of phenolphthalein indicator to each sample. Titrate, following the directions given in the previous section. Dyes in the tablet may cause difficulty in observing the endpoint.
### Data: Standardize NaOH Solution

<table>
<thead>
<tr>
<th></th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Weight of KHP sample (to nearest 0.001 g)</td>
<td>g</td>
<td>g</td>
</tr>
<tr>
<td>2. Initial volume in buret (to nearest 0.01 ml)</td>
<td>ml</td>
<td>ml</td>
</tr>
<tr>
<td>3. Final volume in buret (to nearest 0.01 ml)</td>
<td>ml</td>
<td>ml</td>
</tr>
</tbody>
</table>

### Data: Vitamin C analysis

<table>
<thead>
<tr>
<th>Brand name</th>
<th>Tablet size from label:</th>
<th># of tabs used for each trial:</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Weight of tablet(s) before grinding</td>
<td>g</td>
<td>g</td>
</tr>
<tr>
<td>5. Initial volume in buret (to nearest 0.01 ml)</td>
<td>ml</td>
<td>ml</td>
</tr>
<tr>
<td>6. Final volume in buret (to nearest 0.01 ml)</td>
<td>ml</td>
<td>ml</td>
</tr>
</tbody>
</table>

### Calculations: Molarity of NaOH

<table>
<thead>
<tr>
<th></th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Moles of KHC₈H₄O₄ used (from grams used in # 1 above) (Molecular mass is 204 g/mol)</td>
<td>mol</td>
<td>mol</td>
</tr>
<tr>
<td>8. Liters of NaOH used (from 2 and 3 above. Convert ml to liters, taking care to preserve significant digits)</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>9. Molarity of NaOH (moles of acid / Liters of base)</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>10. Average molarity</td>
<td>M</td>
<td></td>
</tr>
</tbody>
</table>

### Calculations: Vitamin C content

<table>
<thead>
<tr>
<th></th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. Liters of NaOH used (from 5 and 6 above. Convert ml to liters, taking care to preserve significant digits)</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>12. Moles of vitamin C present (use molarity from item 10 and liters used in item 11)</td>
<td>mol</td>
<td>mol</td>
</tr>
<tr>
<td>13. Milligrams of vitamin C in sample (Molecular mass is 176 g/mol) (Use moles from item 12 and this MM for the calculation, then convert to milligrams)</td>
<td>mg</td>
<td>mg</td>
</tr>
<tr>
<td>14. Average milligrams per tablet (mg in sample / # of tablets per sample)</td>
<td>mg</td>
<td></td>
</tr>
<tr>
<td>15. % label correspondence</td>
<td>( \left( \frac{\text{Analysis data} - \text{label data}}{\text{label data}} \right) \times 100 )</td>
<td>%</td>
</tr>
<tr>
<td>16. % binder in tablets</td>
<td>( \left( \frac{\text{weight of tablet} - \text{analysis data}}{\text{weight of tablet}} \right) \times 100 ) (items 4 and 14)</td>
<td>%</td>
</tr>
</tbody>
</table>
1. Assume that a drop has a volume of 0.05 ml. If a titration requires 30.00 ml for completion, what % error will each extra drop over 30.00 ml cause?

2. For a tablet containing 500 mg of vitamin C, calculate how many ml of 0.095 M NaOH is required.

3. For a tablet containing 1000 mg of vitamin C, calculate the minimum strength of the NaOH solution so that the titration would take no more than 45 ml of the NaOH from the buret.

4. The directions on page 1, Part A, tell you how much potassium hydrogen phthalate to weigh out. If the NaOH solution were 0.100 M, what volume range could you expect in the titration depending on whether you took the minimum or maximum amount of the KHP?

5. The structure for ascorbic acid, sometimes given in condensed form as H$_2$C$_6$H$_6$O$_6$, is

![Ascorbic acid structure]

Rewrite the structure showing carbons and hydrogens, rather than the symbolic structure shown. Count the carbons, hydrogens, and oxygens to make sure that your structure corresponds to the formula. The two hydrogens on the OH’s on the ring are the acidic hydrogens. The pK$_a$ for the first H is 4.17, and for the second H, 11.57. The numbers show that the second H does not come off the molecule very easily.