**Acid-Base Chemistry: Standardization of a NaOH Solution**

1. Add a sample of KHP with a mass of 0.2-0.4 g to a clean, 250 mL Erlenmeyer flask. Dissolve in 50 mL of distilled water.

2. Add 3-5 drops of phenolphthalein to the flask with the KHP.

3. Titrate the KHP with NaOH(aq) until a faint pink permanent color occurs.

4. Enter your data onto the class spreadsheet for statistical analysis. Can any data be eliminated based on error analysis?



**As a prelab, practice your titration technique and calculations using NaOH and phenolphthalein at**

[**http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/stoichiometry/acid\_base.html**](http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/stoichiometry/acid_base.html)

Standardization of NaOH with KHP: Statistical Analysis of Data Using a TI83 Calculator

In this experiment, you will determine the concentration of NaOH solution by using it to titrate an accurately massed sample of a solid acid, potassium hydrogen phthalate (abbreviated **KHP**). This process is called standardization, and the KHP is referred to as the primary standard. Primary standard substances must have certain properties. They should be available in a state of known purity, should be easy to dry and should not pick up moisture from the air, and should have a high molar mass. The KHP is an organic acid that has two carboxylic acid groups bonded onto a benzene ring. One of the hydrogen ions has been replaced by a potassium ion, leaving only one ionizable hydrogen remaining. The moles of KHP used in each trial is determined by dividing the mass of the KHP sample used by its molar mass of 204.22 g/mole. The moles of NaOH needed to neutralize the sample is equal to the number of moles of KHP used, since the equation for the neutralization reaction shows a 1:1 mole ratio.



The molarity of the NaOH is then determined by dividing the number of moles of NaOH needed to reach the equivalence point by the volume, in liters, of NaOH that was added. Use the sample data below to complete the following statistical analysis of the data using a TI83 Graphing Calculator.

|  |  |  |
| --- | --- | --- |
| **g KHP used** | **mL NaOH used** | **Calculated M NaOH (L4)** |
| 0.8075 | 42.00 |  |
| 0.7447 | 38.50 |  |
| 0.6258 | 31.70 |  |
| 0.6459 | 33.90 |  |
| 0.7206 | 39.55 |  |
| 0.7584 | 38.10 |  |
| 0.7993 | 41.60 |  |
| 0.5561 | 28.80 |  |

**• Preliminary Calculator set-up**

1. Sign out a calculator from your instructor. Turn calculator **ON** (lower left)

2. You must first clear the calculator's memory of any formulas or data that might interfere with your analysis. Press the **STAT** and **ENTER** keys to check(and edit) any data that is stored in the calculator as a "list". (Note: There are 6 or more lists labeled L1 to L6. Use the right arrow key to view these hidden lists.) To clear data from the statistics menu, press the **STAT** and **4** keys to select "ClrList". Then press the following six keys to clear lists L1 and L2: **2nd 1 , 2nd 2 ENTER** The data in the other lists can be cleared in a similar way by selecting them with the **2nd** key and their appropriate number key. Lists can also be cleared individually by pressing the **STAT** and **ENTER** keys, then moving the cursor to the top of the list to highlight the label, then pressing the **CLEAR** and **ENTER** keys. The data above can now be typed into the blank lists, L1 and L2.

3. Sometimes it may be convenient to share data, programs, etc. between two calculators. The data for the standardization of the NaOH with KHP found above has already been entered into lists L1 and L2 of the teacher’s TI-83 calculator. By linking other calculators to the one with the stored data, the information can be quickly shared. **Linking:** Locate the link port at the center bottom edge of both the sending and receiving TI-83s. Connect the link cable to both units. Be sure to firmly insert the cable fully into each port. This is usually the *first connection to check* when having difficulties with TI to TI links or TI to CBL links. **Set the receiving calculator:** Press **[2nd] [LINK]** and arrow over to the (Receive) option. Press **[ENTER].** You should see (Waiting...) displayed on the screen. The calculator will stay in his mode until the sending TI completes its transmission, or until you abort the sequence.



2:(All-) displays a transmit list with no items selected. Select items to be transmitted by arraying down to them and pressing **[ENTER]**. A second press of [ENTER] **deselects** that item. Arrow up/down to check that for selection. Only items with the () mark besides them will be transmitted.

 Select lists L1 and L2 to be transmitted from the sending calculator. When the items for transmission are selected , arrow over to the transmit option and press **[ENTER]**.

5. The name of each transmitted item appears on the screen of each unit. If there is already an item in the receiving unit that has the same name as an item being transmitted, you will have the option of overwriting the item, renaming it, omitting it from the transmission, or completely halting all transmissions. When given these options on the receiving calculator, select “Overwrite” for each list. This will copy the data, but not affect any other settings on the receiving calculator. The word (DONE) will be displayed on both units when transmission is complete.

**•Making Corrections / Modifications to a List**

1. In order to calculate the molarity of the NaOH, you will need to first take the masses of the KHP samples entered in list L1 and divide by the molar mass of KHP. Then divide the quotient by the volumes of NaOH entered in list L2, and multiply by 1000 mL per L.

2. Press the **STAT** and **ENTER** keys to modify the lists of data. Move the cursor to highlight the label L3 at the top of the list. At the bottom of the screen, “L3 =” will appear. Press the **2nd L1**  **/ 204.22** keys in order to calculate the moles of the KHP values. For L4, calculate the molarity of the NaOH by entering the formula “L4 = **( 2nd L3 / 2nd L2 ) \* 1000**”.

**•Applying the Q Test to Exclude Data**

Identify any suspect molarity values of NaOH that appear to be too high or too low, when compared to the rest of the group. Then use the Q Test to determine if any of the group data should be rejected because any measurement exceeds the 90% confidence level that the difference in experimental values was caused by random, probable error.

Q (exp) = | suspect value - nearest value |

 largest value - smallest value

**Table of Q-Test values at the 90% confidence level:**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| n | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Q 90% | 0.94 | 0.76 | 0.64 | 0.56 | 0.51 | 0.47 | 0.44 | 0.41 |

If Q (exp) > 90% confidence level value, then the suspect value can be rejected and the group data should be deleted. If this is the case, then check the next value that also may be suspect. However, only one data point may be rejected by the Q Test from any set of measurements. When results are divergent, additional measurements to provide a more reliable average should be performed. For accuracy, the more data points the better!

**Work for Q tests:**

 **Rejected Group data # \_\_\_\_\_\_\_\_\_\_\_\_**

For all remaining sets of group data, record the calculated molarity values of NaOH from list L4 in the data chart above. Then use the STAT CALC feature to run "**1-Var Stats**" **2nd L4** for list L4 in order to determine the average molarity (mean of x), standard deviation (Sx), and median values for these molarities. Fill in the chart below:

|  |  |
| --- | --- |
|  | **Calculated M NaOH** |
| **average (mean)** |  |
| **standard deviation** |  |
| **median** |  |

The theoretical value for the molarity of the NaOH solution is based upon the mass of solid NaOH that was used to prepare the solution. If 8.025 g NaOH was used to prepare 2.000 L of solution in a volumetric flask, then calculate the percent error for the average molarity of NaOH determined by the class. Discuss the possible sources of error.

% error = experimental value - theoretical value x 100

 theoretical value

**Work for % error:**