**Standard Solutions**

Benson Long

*Department of Chemistry and Biochemistry, Queens College – CUNY*

*CHEM 131.1, 07, Fall 2012*

*Instructor: Freida Zavrov*

**ABSTRACT**

A standard solution is a solution with a known concentration and is created to have an accurate molarity. Solutions are standardized because many solutions are hygroscopic and their concentration will change and become less accurate over time. Standard solutions of potassium hydrogen phthalate (KHP) and ferrous ammonium sulfate hexahydrate (FAS) were created. These standardized solutions were used to standardize stock solutions of sodium hydroxide (NaOH) and potassium permanganate (KMnO4). There will be a color change in the solutions when the equivalence point is reached and standardization is completed.

1. **INTRODUCTION**

The purpose of this experiment was to learn about standard solutions and how to create them. Standard solutions are created by standardizing stock solutions. Two standard solutions were produced with acid/base and oxidation/reduction reactions. Acid/base reactions were used between potassium hydrogen phthalate and sodium hydroxide because the reactants are neutralized and a salt and sometimes H2O can be formed. Oxidation/reduction reactions were used between ferrous ammonium sulfate and potassium permanganate because aqueous iron (II) reacts with aqueous permanganate to change the color of the solution. Both of these reactions are measured with titration and show us when the reaction is complete or has reached its end point.

1. **EXPERIMENTAL**

For the first part of the experiment involving acid/base reactions, a 100 mL volumetric flask was obtained from the stockroom. 2.021 grams of KHP was weighed using a small sheet of paper and an electronic balance and placed into a clean and empty beaker. 20 mL of H2O was measured using a 100 mL graduated cylinder and the H2O was poured into the beaker containing KHP. The KHP was transferred to the volumetric flask and about 30 mL of distilled H2O was added into the volumetric flask after rinsing the beaker to pick up remainder KHP. Once the volumetric flask was filled a little more than half of the flask, a parafilm was placed on top and the mixture was inverted to dissolve the KHP. Once the KHP fully dissolved, the standard KHP solution was prepared for a neutralization reaction.

Two burettes were set up. The burettes were rinsed with distilled water and the stopcocks were tested. One burette was filled with NaOH to the 50 mL mark and the other burette was filled with KHP to the 50 mL mark. 25 mL of the standard KHP solution was taken from the burette and added into an Erlenmeyer flask. Then NaOH was added drop by drop into the flask with KHP until a permanent pink color appeared which indicated that the end point was reached. The volume of NaOH used for the titration was recorded. The titration was repeated a second time but with a larger volume of KHP.

For the second part of the experiment, a 100 mL volumetric flask was obtained from the stockroom. This time, 4 grams of FAS was weighed using an electronic balance and a small sheet of paper. The 4 grams of FAS was placed into a clean and empty beaker. 25 mL of distilled H2O was added to the beaker to dissolve the FAS. Since not all of it was dissolved, more water was added to the beaker and the mixture of FAS and H2O was transferred to the 100 mL volumetric flask. The flask was covered with a parafilm when enough H2O was added until the volume reached the indicated line. The standard ferrous ammonium sulfate solution was prepared for the titration process.

Two burettes were set up at the beginning of the lab. The burettes were cleaned with distilled H2O and the stopcocks were tested to see if there was a steady stream. The stopcocks were closed before each burette was filled with the standard FAS solution and potassium permanganate. Each burette was filled to the brim to 50 mL of each solution. An Erlenmeyer flask was obtained and 25 mL of the Fas solution was placed into the flask. Another 15 mL of 3 M sulfuric acid was added to the 25 mL FAS solution so there are H+ ions that allow the oxidation/reduction reaction to occur. The Erlenmeyer flask was moved to the other burette where the potassium permanganate was and potassium permanganate was added into the FAS solution drop by drop until a persisting red color change occurred. When the solution remained a red color, the titration was completed and the solution reached the end point. This process was repeated a second time except a larger volume of FAS was used.

1. **RESULTS AND DISCUSSION**

The difference between a stock solution and a standard solution is the accuracy of each solution. A standard solution is more accurate in concentration than that of a stock solution. A solution with a highly precise molarity allows better results to be obtained from experiments. If 0.1 M barium hydroxide was used instead of sodium hydroxide, the volume of the base would change because one mole of barium hydroxide reacts with two moles of KHP. However, one mole of sodium hydroxide reacts with one mole of KHP so the volumes are different.

The average concentration of the sodium hydroxide solution is 0.163 M. Some potential sources of error that could have caused variation in the concentration are the volumetric measurement of the acid using the burette, overshooting in the titration process causing the solution to pass the equivalence point and inaccurate measurements which lead to calculations that are generally false. If a solution of iron (III) was titrated with potassium permanganate, nothing would happen unless the iron solution was reduced to iron (II) first.

The average concentration of potassium permanganate is 0.131 M. The potential sources of error that could have caused variation in the concentration are the same as the sources of error with the sodium hydroxide titration: volumetric measurement of the acid using the burette, overshooting in the titration process causing the solution to pass the equivalence point and inaccurate measurements which lead to calculations that are generally false.

1. **CONCLUSION**

Standard solutions and the process of standardization are important concepts in chemistry. They allow us to create and maintain accurate results from experiments and force us to recognize that excellent results can only be obtained through trial and error. By learning how to use standardization techniques, we also learn about other science concepts such as titration, equivalence point, and acid/base and oxidation/reduction reactions. Chemistry is an interconnected field of study where concepts are related and contribute to one another.

Table I. The molar mass of KHP, mass of KHP used, volume of H2O used and molarity of KHP calculated for the titration and standardization of KHP.

|  |  |
| --- | --- |
| Molar mass of KHP | 204.22 g/mol |
| Mass of KHP | 2.021 g |
| Volume of H2O | 100 mL |
| Molarity of KHP | 0.0989 M |

Table II. The molar mass of FAS, mass of FAS used, volume of H2O used and molarity of FAS calculated for the titration and standardization of FAS.

|  |  |
| --- | --- |
| Molar mass of FAS | 284.05 g/mol |
| Mass of FAS | 4.069 g |
| Volume of H2O | 100 mL |
| Molarity of FAS | 0.143 M |

Table III. The readings of KHP (acid) and NaOH (base) for two trials and the calculated concentrations for the acid and base.

|  |  |  |
| --- | --- | --- |
|  | Trial #1 | Trial #2 |
| Initial acid burette reading | 50 mL | 50 mL |
| Final acid burette reading | 24 mL | 21.5 mL |
| Volume of acid in flask | 26 mL | 28.5 mL |
| Concentration of acid | 0.0989 M | 0.0989 M |
| Initial base burette reading | 50 mL | 50 mL |
| Final base burette reading | 30.6 mL | 35.5 mL |
| Volume of base required for endpoint | 19.4 mL | 14.5 mL |
| Concentration of base | 0.1325 M | 0.1943 M |

Table IV. The readings of FAS and potassium permanganate for two trials and the calculated concentrations for FAS and potassium permanganate.

|  |  |  |
| --- | --- | --- |
|  | Trial #1 | Trial #2 |
| Initial FAS burette reading | 50 mL | 28.3 mL |
| Final FAS burette reading | 25.8 mL | 1.2 mL |
| Volume of FAS in flask | 24.2 mL | 27.1 mL |
| Concentration of FAS | 0.143 M | 0.143 M |
| Initial permanganate burette reading | 50 mL | 47.5 mL |
| Final permanganate burette reading | 22.8 mL | 18.9 mL |
| Volume of permanganate required for endpoint | 27.2 mL | 28.6 mL |
| Concentration of permanganate | 0.127 M | 0.135 M |