# Synthesis of aspirin essay

The Synthesis of Aspirin Chemistry Standard Level Lab Report Data Collection and Processing and Conclusion and Evaluation Date: December 8th, 2011 Purpose: The purpose of this lab was to synthesize aspirin, determine the theoretical yield, compare the percent yield to the theoretical yield and test the purity of aspirin by adding Iron (III) chloride to the product. Hypothesis: I hypothesize that salicylic acid will react with acetic anhydride to produce acetylsalicylic acid (aspirin) and acetic acid (vinegar).

Variables: Independent and controlled variables: The amount of sulfuric acid used for catalysis and the amount of salicylic acid and acetic anhydride. Dependent variables: Theoretical and actual yield of aspirin. Constant variables: Two beakers filled with 200 mL of water for the boiling water bath, the cold water bath and the temperature of the boiling water bath and cold water bath. Materials:

Safety goggles, Lab coat, protective rubber gloves, notebook for observations, pen or pencil, four trays, 3 grams of salicylic acid, 125 mL Erlenmeyer flask, 8 mL of acetic anhydride, 8 drops of concentrated (85%) phosphoric or sulfuric acid, five 10 mL graduated cylinders, 50 mL graduated cylinder, hot plate, stirring rod, two 400 mL beakers, one 250 mL beaker, ring stand, utility clamp, filter paper, funnel, stopwatch, balance, two pipettes, scoopula, 6 test tubes, test tube stand, 0. 1 grams of salicylic acid, 0. grams of commercial aspirin, 0. 1 of handmade aspirin, 2. 0 mL of Iron (III) chloride and cold water bath. Procedure: All the materials needed to begin were collected and the goggles, gloves and lab coat were worn for safety purposes. All the observations of synthesis of aspirin were recorded in tables in a notebook. Preliminary steps: The hot plate was set up first. A 400 mL

beaker was filled with 200 mL of water and placed on the hot plate to boil. 3 mL of cold water and 60 mL of water were measured and prepared with a graduated cylinder.

A 400 mL beaker was filled with 200 mL of cold ice water to prepare a cold water bath. A gravity filtration system was set up using filter paper, ring stand, utility clamp and a 250 mL beaker. The filter paper was weighed and subsequently placed in the funnel. Procedure of the synthesis of aspirin: 3. 00 grams of salicylic acid were weighed and placed in a 125 mL Erlenmeyer flask. Initial observations of salicylic acid were recorded. 8 cm3 (cm3 = mL) of acetic anhydride was carefully measured in a 10 mL graduated cylinder. Initial observations of acetic anhydride were recorded. drops of concentrated (85%) sulfuric acid was directly added to the acetic anhydride, using a pipette, which was then immediately added to the Erlenmeyer flask containing salicylic acid. Observations of the two solutions mixed together were recorded. The aqueous solution of salicylic acid and acetic anhydride was stirred thoroughly and then heated, using a hot plate, in a boiling water bath for 5 minutes. Initial observations of the solution were recorded before the solution was heated in the boiling water bath. The solution in the flask was stirred frequently.

The solution was removed from the boiling water bath and 3 mL of cold water was added immediately to the solution while stirring. Observations of the solution were recorded after the solution was heated in the boiling water bath. Observations were also recorded after adding the 3 mL of cold water to the solution. The solution was stirred for a couple minutes after being removed from the boiling water bath in order to destroy any excess acetic

anhydride. The solution was then stirred while adding 60 mL of water. Observations were recorded after adding 60 mL of water to the solution.

A precipitate began to form in the solution, and the solution in the Erlenmeyer flask was placed in a cold water bath for 5 minutes to complete the formation of aspirin crystals. Observations were recorded before, and after, the solution was placed in the cold water bath. Using a gravity filtration system, the crystals of aspirin were isolated by pouring the solution into the funnel with filter paper. The aspirin crystals were washed by pouring 10 mL of water over them through the funnel. The filter paper, holding the aspirin crystals, was removed from the funnel and was left to dry before being weighed.

Once the aspirin crystals were weighed, the theoretical yield and the percent yield of the experiment were calculated. The procedure was repeated once more using the same steps. Procedure for the test of purity of aspirin: 0. 1 gram of salicylic acid was weighed in a tray and was then added to a test tube containing 2. 0 mL of Iron (III) chloride, which was measured using a 10 mL graduated cylinder, to test for phenols. 0. 1 gram of commercial aspirin was weighed in a tray and was then added to a second test tube containing 2. mL of Iron (III) chloride, which was measured using a 10 mL graduated cylinder, to test for phenols. This was repeated once more to validate results. 0. 1 gram of my product from the first trial was weighed in a tray and was then added to a third test tube containing 2. 0 mL of Iron (III) chloride, which was measured using a 10 mL graduated cylinder, to test for phenols. This was repeated once more to validate results. 0. 1 gram of my product from the second trial was weighed in a tray and was then added to a fourth test

tube containing 2. mL of Iron (III) chloride, which was measured using a 10 mL graduated cylinder, to test for phenols. The observations of each test were recorded and the results of each test were compared for similarities and differences in the colours of the solutions. Diagram for the gravity filtration system: [pic] Observations and Data Collection: Observations Tables: Observations of salicylic acid – Table 1 | | Trial 1 | Trial 2 | | Initial observations of salicylic acid | Powdery, white crystals. Powdery, white crystals. | In trial 1, the appearance and state of salicylic acid was noted at the beginning of the experiment; salicylic acid is a white, granulated powder. The same observation was made in trial 2. Observations of acetic anhydride – Table 2 | | Trial 1 | Trial 2 | | Initial observations of acetic anhydride | Transparent, aqueous solution. | Transparent, aqueous solution. |

In trial 1, the appearance and state of acetic anhydride was noted at the beginning of the experiment; acetic anhydride is a transparent aqueous solution. The same observation was made in trial 2. Observations of sulfuric acid – Table 3 | | Trial 1 | Trial 2 | | Initial observations of sulfuric acid | Transparent, aqueous solution. | Transparent, aqueous solution. | In trial 1, the appearance and state of sulfuric acid was noted at the beginning of the experiment; sulfuric acid is a transparent aqueous solution.

The same observation was made in trial 2. Observations of sulfuric acid, a catalyst, mixed with the solution – Table 4 | | Trial 1 | Trial 2 | | Observation when sulfuric acid, a catalyst, is added | A light brown aqueous solution begins| The solution remains transparent and clear; no | | to the mixture | to form with a little yellow | change in colour.

The solution is transparent | | | precipitate on top of the solution. | with a little bit of yellow precipitate on top | | | | of the solution. | In trial 1, a light brown aqueous solution was formed when 9 drops of sulfuric acid was added to the mixed solution of salicylic acid and acetic anhydride. A small amount of yellow precipitate on top of the aqueous solution was observed.

In trial 2, a transparent and clear aqueous solution was observed when 8 drops of sulfuric acid was added to the mixed solution of salicylic acid and acetic anhydride. Observations of the solution before after the boiling water bath – Table 5 | | Trial 1 | Trial 2 | | Observation of mixture in boiling water | The solution is dark brown and almost completely opaque; | The solution is transparent; the | | bath at the beginning of 5 minutes | the yellow precipitate disappeared. yellow precipitate disappeared. | | Observation of mixture in boiling water | The solution is black and very opaque | The solution has a slight, pale yellow| | bath at the end of 5 minutes | | colour; the solution is transparent | In trial 1, before the boiling water bath, the solution turned dark brown and became very opaque. The yellow precipitate was no longer present. In trial 2, before the boiling water bath, the solution remained transparent and clear.

The yellow precipitate was no longer present. Both solutions were stirred with a stir stick before and throughout the boiling water bath; no changes occurred while stirring. In trial 1, after the boiling water bath, the solution turned black and continued to be very opaque. In trial 2, the solution had a pale yellow colour, after the boiling water bath, and remained transparent. The solution was stirred for a couple minutes to remove any remaining acetic anhydride; no changes occurred while stirring.

Observations after adding 3. 0±0. 1 mL of water and 60. 0±0. 5 mL of water to the solution – Table 6 | | Trial 1 | Trial 2 | | Observation of solution when 3. 0±0. 1 mL | Lots of fumes are created and a strong pungent smell is | Lots of fumes are created and a | | of water is added | present. The solution remains very dark and opaque | strong pungent smell is present. | | | The solution is transparent. | | Observation after adding 60. 0±0. 5 mL of | The colour of the solution has lightened up; the solution is | The solution remains transparent. | | water to the solution | brown, but is more transparent. | | In trial 1, after adding 3. 0 mL of water to the solution, using a 10 mL graduated cylinder with an uncertainty of ±0. mL, lots of fumes came off the solution creating a strong odour. The solution remained very dark and opaque. In trial 2, after adding 3. 0 mL of water with the same graduated cylinder, lots of fumes came off the solution creating a strong and pungent odour. The solution remained transparent. In trial 1, after adding 60. 0 mL of water to the solution, using a 60 mL graduated cylinder with an uncertainty of ±0. 5 mL, the solution became more transparent, but remained brown.

In trial 2, after adding 60 mL of water to the solution with the same graduated cylinder, the solution remained transparent with a slight, yellow tinge. Observations of the solution before and after the cold water bath – Table 7 | | Trial 1 | Trial 2 | | Observations of the solution before the cold water bath | The solution has settled and is still | The solution remains transparent. | | brown. | | | Observations of the solution after the cold water bath | A precipitate has formed at the bottom of | A precipitate of white crystals has| | | the flask. | formed at the bottom of the flask. | In trial 1,

before adding the solution in the flask to the cold water bath, the solution remained brown and settled.

In trial 2, before adding the solution in the flask to the cold water bath, the solution remained transparent and clear. In trial 1, after adding the solution in the flask to the cold water bath, the solution remained brown with a precipitate formed at the bottom of the flask. In trial 2, after adding the solution in the flask to the cold water bath, the solution remained clear and transparent with white crystals formed at the bottom of the flask.

Observations of the residue in the filter paper after filtration – Table 8 | | Trial 1 | Trial 2 | | Observations of the residue after | The residue in the filter paper has light brown | The residue in the filter paper has white | | filtration | crystals | crystals. In trial 1, after the filtration process, a light brown residue was collected in the filter paper. In trial 2, after the filtration process, a white residue of crystals was collected in the filter paper. Observation Tables, Purity Test:

Initial Observations of the substances used in the Purity Test – Table 9 | | Iron (III) chloride, FeCl3| salicylic acid | commercial aspirin | Trial 1 experimental | Trial 2 experimental| | | | | synthesized aspirin | synthesized aspirin | | Initial | Iron (III) chloride has a | Granulated and | Granulated and | Light brown crystals; | White, granulated | | observations of the| deep orange colour and is | powdery, white | powdery, white | the crystals are very | crystals. | substances | an aqueous solution. | crystals. | crystals. | flaky. | | An observation was recorded for each substance used in the purity test at the beginning, before Iron (III) chloride was added to test the purity of aspirin in

each substance. The initial observation of Iron (III) chloride, FeCl3 is that it has a dark orange colour and it is a transparent aqueous solution. The initial observation of salicylic acid is that it is a granulated and powdery substance. The initial observation of commercial aspirin is that it is a granulated and powdery substance.

The initial observation of the experimental synthesized aspirin from trial 1 is that it has light brown crystals that are flaky. The initial observation of the experimental synthesized aspirin from trial 2 is that it has white, granulated crystals. Observations of the purity test reaction between Iron (III) chloride and salicylic acid, commercial aspirin and both trials of synthesized aspirin – Table 10 | Uncertainty of ±0. 01 g, using a balance | 2. 0±0. 1 mL of Iron (III) chloride, FeCl3 | | 0. grams of salicylic acid | When both substances are mixed together a very dark purple aqueous | | | solution is produced. | | Purity test 1 – 0. 1 grams of commercial aspirin | When both substances are mixed together a brown aqueous solution is | | | produced. Some of the commercial aspirin settled on the bottom of the | | | test tube and had purple specks. | | Purity test 2 – 0. grams of commercial aspirin | When both substances are mixed together a light brown aqueous solution | | | is produced. There is no sign of purple specks at the bottom of the | | | test tube in the solution. The substance then turned a darker brown. | | Purity test 1, trial 1 – 0. 1 grams of experimental | When both substances are mixed together a light brown aqueous solution | | synthesized aspirin | is initially produced; the solution becomes slightly darker. | Purity test 2, trial 1 – 0. 1 grams of experimental | When both substances are mixed together a brown aqueous solution is | | synthesized aspirin | produced; the solution becomes

slightly darker. | | Trial 2 – 0. 1 grams of experimental synthesized aspirin| When both substances are mixed together a very dark purple aqueous | | | solution is produced. | Observations of the purity test reaction between Iron (III) chloride and salicylic acid, Iron (III) chloride and commercial aspirin, and Iron (III) chloride and synthesized aspirin were recorded. When 0. ±0. 01 g of salicylic acid is mixed with 2. 0±0. 1 mL of Iron (III) chloride, it is observed that they produce a very dark purple aqueous solution. For both purity tests, of 0. 1±0. 01 g of commercial aspirin mixed with 2. 0±0. 1 mL of Iron (III) chloride, it is observed that both tests yielded a brown aqueous solution. The first purity test of commercial aspirin differed slightly with the second, in that purple specks were observed at the bottom of the test tube in the first purity test, but none were observed in the second purity test of commercial aspirin. For both purity tests, of 0. 1±0. 1 g of trial 1 synthesized aspirin mixed with 2. 0±0. 1 mL of Iron (III) chloride, it is observed that both tests yielded a brown aqueous solution. The colour of the aqueous solution, in both purity tests of the trial 1 synthesized aspirin, was almost exactly the same; the first purity test of trial 1 synthesized aspirin was a slight shade darker than the second purity test. When 0. 1±0. 01 g of the trial 2 synthesized aspirin is mixed with 2. 0±0. 1 mL of Iron (III) chloride, it is observed that they produce a very dark purple aqueous solution, similar to the reaction of salicylic acid with Iron (III) chloride stated above.

The same balance was used for the salicylic acid, commercial aspirin and both trials of synthesized aspirin. The same graduated cylinder was used to measure Iron (III) chloride. Data Tables: Mass of salicylic acid used in the reaction with acetic anhydride – Table 11 | | Trial 1 (±0. 01g) | Trial 2 (±0.

01g) | | Mass of the salicylic acid used | 3. 13 grams | 3. 00 grams | In trial 1, 3. 13 grams of salicylic acid was measured on a balance with an uncertainty of ±0. 01g. Exactly 3. 00 grams of salicylic acid was measured on the same balance. Molar mass of salicylic acid – Table 12 | Trial 1 | Trial 2 | | Molar mass of salicylic acid | 138. 13 g mol-1 | 138. 13 g mol-1 | The compound salicylic acid has the equation, C7H6O3. Adding the atomic weight of seven carbon atoms, six hydrogen atoms and three oxygen atoms, the molar mass of salicylic acid is determined to be 138. 13 g mol-1, and is the same for both trial 1 and 2. Volume of acetic anhydride used in the reaction with salicylic acid – Table 13 | | Trial 1 | Trial 2 | | Volume of the acetic anhydride | 8. ±0. 1 mL | 8. 0±0. 1 mL | | Density of the acetic anhydride at 25°C | 1. 082g mL-1 | 1. 082g mL-1 | | Mass of the acetic anhydride | 8. 7±0. 1 grams | 8. 7±0. 1 grams | In both trial 1 and 2, 8 mL of acetic anhydride was measured with a 10 mL graduated cylinder with an uncertainty of ±0. 1mL. As the volume and density of acetic anhydride is known, the mass of acetic anhydride can be calculated by rearranging the equation Density = mass/volume, i. e. 1. 082 g mL-1 = (mass)*(8. 0±0. 1 mL). (1. 082 g mL-1)*(8. 0±0. 1 mL) equals the mass. Mass = 8. ±0. 1 grams. As both trial 1 and trial 2 have the same values for the volume and density, they will both have the same mass. To find the uncertainty of the mass from both trials, the uncertainty of the volume must be divided by the volume, i. e. 0. 1/8. 0 = 0. 0125. This answer is subsequently multiplied by the density, giving the uncertainty of the mass for acetic anhydride, i. e. (0. 0125)*(1. 082) = ±0. 13525g. Using the rules of significant digits, the uncertainty of the mass of acetic anhydride is ±0. 1 g. Molar mass of acetic anhydride – Table 14 | Trial 1 | Trial 2 | | Molar mass of acetic anhydride | 102. 10 g mol-1 | 102. 10 g mol-1 | The compound acetic

anhydride has the equation, C4H6O3. The atomic weight of four carbon atoms, six hydrogen atoms and three oxygen atoms equals the molar mass of acetic anhydride, which is 102. 10 g mol-1, and is the same for both trial 1 and 2. Theoretical yield of aspirin – Table 15 | | Trial 1 | Trial 2 | | Theoretical yield of aspirin | 4. 1±0. 2g | 3. 9±0. 2g |

The theoretical yield of aspirin in trial 1 was found by finding the limiting reagent, salicylic acid, and then multiplying the number of moles of aspirin that can be produced by the molar mass of aspirin, as there is a 1: 1 stoichiometric ratio between salicylic acid and aspirin. In trial 2, the theoretical yield of aspirin was found using the same method. The first step to finding the theoretical yield in Trial 1 is to convert the mass of salicylic acid into moles by dividing the mass used by its molar mass: | 3. 13±0. 01 grams | 1 mol |= 0. 02266±0. 0002 mol | | | 138. 13 grams | | To find the uncertainty of the moles of salicylic acid, the uncertainty of the mass of salicylic acid is divided by the mass used, and then divided by its molar mass: (0. 01/3. 13)*(1/138. 13). Uncertainty equals ±0. 00002 mol, according to significant digits. The next step is to find the mass of acetic anhydride in grams. This can be done by rearranging the equation Density = mass/volume to find mass. As the density of acetic anhydride at room temperature is 1. 82 g mL-1and the volume of acetic anhydride is 8 mL, the mass of acetic anhydride equals 8. 7±0. 1 grams: 1. 082 g mL-1= (mass)*(8. 0±0. 1 mL) (1. 082 g mL-1)*(8. 0±0. 1 mL) = mass Mass = 8. 7±0. 1 grams To find the uncertainty of the mass of acetic anhydride, the uncertainty of the volume must be divided by the volume, i. e. 0. 1/8. 0 = 0. 0125. This answer is subsequently multiplied by the density, giving the uncertainty of

the mass for acetic anhydride, i. e. (0. 0125)*(1. 082) = ±0. 13525 g. Using the rules of significant digits, the uncertainty of the mass of acetic anhydride is ±0. g. The mass of acetic anhydride is then divided by its molar mass to determine the number of moles of the solution we have: | 8. 7±0. 1 grams | 1 mol |= 0. 0848±0. 0001 mol | | | 102. 10 grams | | To find the uncertainty of the moles of acetic anhydride, the uncertainty of the mass of acetic anhydride is divided by the mass used, and then divided by its molar mass: (0. 1/8. 7)*(1/102. 10). Uncertainty equals ±0. 0001 mol, according to significant digits.

By comparing the number of moles of salicylic acid and acetic anhydride, we find that salicylic is the limiting reagent. Therefore 0. 02266±0. 00002 mol of salicylic acid reacts with 0. 02266±0. 00002 mol of acetic anhydride to produce 0. 02266±0. 00002 mol of acetylsalicylic acid (aspirin). The mass of aspirin can be calculated by multiplying the number of moles of aspirin by its molar mass: | 0. 02266±0. 00002 mol | 180. 17 grams |= 4. 1±0. 2 grams | | | 1 mol | |

To find the uncertainty of the mass of the aspirin from trial 1, the uncertainty of the moles of salicylic acid is divided by the number of moles, and then multiplied by the molar mass of aspirin: (0. 00002/0. 02266)*(180. 70). Uncertainty equals ±0. 2 grams, according to significant digits. The theoretical yield for trial 2 was found using the same method. The mass of salicylic acid used at the beginning of the experiment in trial 2 is the only measurement that contrasts with the recorded measurements of the first trial; all other measurements are the same.

Percent yield of aspirin – Table 16 | | Trial 1 | Trial 2 | | Actual yield of aspirin | 1. 29±0. 02 g | 1. 04±0. 02 g | | Percent yield of aspirin | 31. 46±6% | 26. 58±7% | The first step, to find the percent yield in trial 1, is to subtract the mass of the filter paper from the mass of aspirin that is collected from the experiment after drying. 2. 14±0. 01 g – 0. 85±0. 01 g = 1. 29±0. 02 g.

The uncertainty of the actual yield of aspirin is the sum of the uncertainties, 0. 01 g + 0. 01 g = ±0. 02 g. The percent yield of aspirin for trial 1 was found by dividing the actual yield of aspirin by the theoretical yield of aspirin and then multiplied by 100%. (1. 29±0. 02 g/4. 1±0. 2 g)*100% = 31. 46%. The uncertainty in percent yield is found by adding the division of 0. 02 by 1. 29 and 0. 2 and 4. 9, and multiplying by 100% to give an uncertainty of ±6% using significant digits. The percent yield of aspirin for trial 2 was found using the same method.

Data Processing: Calculations: Theoretical yield of the reaction of salicylic acid and acetic anhydride to form acetylsalicylic acid and acetic acid: [pic] Acknowledging that there is a 1: 1 stoichiometric ratio for both reactants and products, shown in the diagram above, the first step to finding the theoretical yield in Trial 1 is to convert the mass of salicylic acid into moles by dividing the mass used by its molar mass: | 3. 13±0. 01 grams | 1 mol |= 0. 02266±0. 00002 mol | | 138. 13 grams | | To find the uncertainty of the moles of salicylic acid, the uncertainty of the mass of salicylic acid is divided by the mass used, and then divided by its molar mass: (0. 01/3. 13)*(1/138. 13). Uncertainty equals ±0. 00002 mol, according to significant digits. The next step is to find the mass of acetic anhydride in grams. This can be done by rearranging the equation Density = mass/volume to find mass. As the

density of acetic anhydride at room temperature is 1. 82 g mL-1and the volume of acetic anhydride is 8 mL, the mass of acetic anhydride equals 8. 7±0. 1 grams: 1. 082 g mL-1= (mass)*(8. 0±0. 1 mL) (1. 082 g mL-1)*(8. 0±0. 1 mL) = mass Mass = 8. 7±0. 1 grams To find the uncertainty of the mass of acetic anhydride, the uncertainty of the volume must be divided by the volume, i. e. 0. 1/8. 0 = 0. 0125. This answer is subsequently multiplied by the density, giving the uncertainty of the mass for acetic anhydride, i. e. (0. 0125)*(1. 082) = ±0. 13525 g. Using the rules of significant digits, the uncertainty of the mass of acetic anhydride is ±0. g. The mass of acetic anhydride is then divided by its molar mass to determine the number of moles of the solution we have: | 8. 7±0. 1 grams | 1 mol |= 0. 0848±0. 0001 mol | | | 102. 10 grams | | To find the uncertainty of the moles of acetic anhydride, the uncertainty of the mass of acetic anhydride is divided by the mass used, and then divided by its molar mass: (0. 1/8. 7)*(1/102. 10). Uncertainty equals ±0. 0001 mol, according to significant digits.

By comparing the number of moles of salicylic acid and acetic anhydride, we find that salicylic is the limiting reagent. Therefore 0. 02266±0. 00002 mol of salicylic acid reacts with 0. 02266±0. 00002 mol of acetic anhydride to produce 0. 02266±0. 00002 mol of acetylsalicylic acid (aspirin). The mass of aspirin can be calculated by multiplying the number of moles of aspirin by its molar mass: | 0. 02266±0. 00002 mol | 180. 17 grams |= 4. 1±0. 2 grams | | | 1 mol | |

To find the uncertainty of the mass of the aspirin from trial 1, the uncertainty of the moles of salicylic acid is divided by the number of moles, and then multiplied by the molar mass of aspirin: (0. 00002/0. 02266)*(180. 70).

Uncertainty equals ±0. 2 grams, according to significant digits. The first step, to find the percent yield in trial 1, is to subtract the mass of the filter paper from the mass of aspirin that is collected from the experiment after drying. 2. 14±0. 01 g – 0. 85±0. 01 g = 1. 29±0. 02 g. The uncertainty of the actual yield of aspirin is the sum of the uncertainties, 0. 01 g + 0. 01 g = ±0. 02 g.

The percent yield of aspirin for trial 1 was found by dividing the actual yield of aspirin by the theoretical yield of aspirin and then multiplied by 100%. (1. 29±0. 02 g/4. 1±0. 2 g)*100% = 31. 46%. The uncertainty in percent yield is found by adding the division of 0. 02 by 1. 29 and 0. 2 and 4. 9, and then multiplying by 100% to give an uncertainty of ±6% using significant digits. The percent yield of aspirin for trial 2 was found using the same method. Conclusion and Evaluation: My hypothesis, that salicylic acid will react with acetic anhydride to produce acetylsalicylic acid (aspirin) and acetic acid (vinegar), proved to e true. The procedure, observations and data collection all supported my hypothesis and the purpose of the lab, which was to synthesize aspirin, determine the theoretical yield, compare the percent yield to the theoretical yield and test the purity of aspirin by adding Iron (III) chloride to the product. From the data collection and processing, it can be concluded that there was a reduced amount of product that was collected and observed, due to limitations in the experimental procedure, such as the excessive amounts of water added to the aqueous solution at different stages throughout the experiment.

Limitations to conclusion and experimental procedure: The limitations to the experimental procedure include: the use of excessive amounts of water added to the aqueous solution, placing the Erlenmeyer flask containing the

aqueous solution into a boiling water bath, stirring the solution after removing it from the boiling water bath, the lack of a thermometer to maintain controlled variables and the use of a gravitational filtration system.

Reasons for why the conclusion is limited, based on the experimental procedure, include: the use of water to purify the aspirin led to the water diluting the concentration of aspirin and, perhaps, dissolving and removing crystals, the use of a boiling water bath, instead of heating the solution in a water bath at 70°C, could have led to the solution evaporating, the lack of proper equipment to regulate the temperature and keep the temperature a controlled variable, the stirring of the solution after the boiling water bath may have interrupted the formation of aspirin, the step in the procedure where 63 mL of water is added before being placed in the cold water bath may have hindered the crystallization process of aspirin, and the use of a gravitation filtration system may have caused some of the aspirin to end up as filtrate. Weaknesses and realistic suggestion to improve experiment: One weakness in the experimental procedure and method is the amount of water used to purify the aspirin.

The addition of too much water to the solution throughout different stages may have hindered the crystallization of aspirin; therefore reducing the amount of water added to the solution would improve the yield of aspirin. Another weakness was the use of a boiling water bath. To improve the formation of aspirin, it would be ideal to heat the water bath to about 70°C, so that the solution does not reach the level of heat at which it begins to change into its gaseous state. Temperature, although a controlled variable, was poorly recorded. The use of a mercury thermometer may have improved

the yield of aspirin, by keeping the controlled variable of temperature consistent.

Another way to improve the yield of aspirin would be to place the solution into the cold water bath, immediately after the boiling water bath and the addition of 3 mL of water, so that the crystallization process will be effective, rather than adding 60 mL of water and waiting so long before placing the solution in the cold water bath. Finally, the use of the gravitation filtration system combined with the addition of 10 mL of water to wash and purify the solid aspirin crystals could have caused abundant amounts of aspirin crystals to go through the filter, thereby reducing the yield. Therefore, one way to improve the yield of aspirin would be to maximise the yield of aspirin crystals with a Buchner funnel. The use of a suction filtration would leave a greater amount of residue in the filter paper, remove the filtrate effectively without removing large amounts of residue and would dry the product more effectively.