Pre-lab assignment/ Aspirin synthesis
Name _____ Date _____ Lab section _____

1. Complete the following:

   Formula for salicylic acid: _____

   Molar mass for salicylic acid: _____

   Formula for aspirin: _____

   Molar mass for aspirin: _____

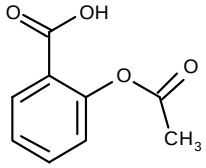
   Balanced reaction for the synthesis of aspirin:

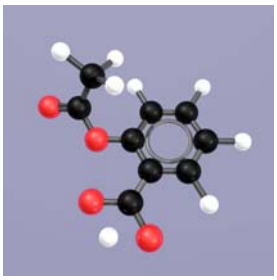
2. 2.50 g of salicylic acid and 2.50 moles of acetic anhydride are combined in a beaker with 3 drops of phosphoric acid. What is the theoretical yield (maximum amount) of aspirin that can be made?

3. If 1.55 g of aspirin is synthesized using the amounts question 2, what is the percent yield?

Synthesis and Analysis of Aspirin

The common pain reliever aspirin is known chemically as acetylsalicylic acid:





It is a member of a group of organic compounds known as esters. The particular reaction for the formation of aspirin is one in which an alcohol on the salicylic acid reacts with an acid anhydride (acetic anhydride):

$$C_6H_4OHCO_2H + O(COCH_3)_2 \rightarrow C_6H_4(COOH)OCOCH_3 + CH_3COOH$$

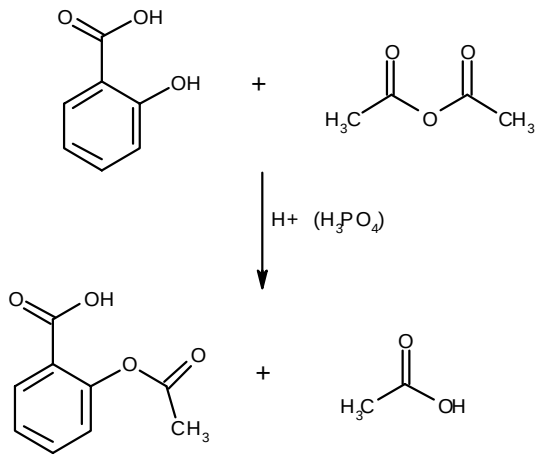
Acetic acid (CH_3COOH) is a by-product of the reaction.

This reaction may go only partially to completion, it may form undesirable side products, or it may not go at all. In this experiment we will utilize several techniques to try and increase the amount of aspirin produced while decreasing the amount of impurities in our product. The addition of a catalyst greatly speeds the formation of the ester. Unfortunately, although the catalyst helps in increasing the rate of reaction, it cannot make a reaction go to completion. The process of ***recrystallization*** can be used to purify our product. Acetylsalicylic acid is not very soluble in cold water, and salicylic acid and acetic anhydride are quite soluble in cold water. We will recrystallize our product to try and wash away some of the excess starting materials

Finally, we will use several analytical techniques to determine the purity of our final product. We will test the melting point of the product and compare it to that of aspirin, take an Infrared spectrum of the product and compare it to those of the starting products, analyze the purity using a gas chromatograph/ mass spectrometer, and use ultraviolet-visible spectroscopy to determine the weight percent of acetylsalicylic acid that is present in the product. These techniques taken together will give us an estimate of the purity of our sample.

Key Concepts	**Techniques**
catalyst	recrystallization
solubility	vacuum filtration
synthesis	quantitative transfer
molecular formulas	sample rinsing
molecular structures	
percent yield	

Key Reaction: $C_6H_4OHCO_2H + O(COCH_3)_2 \rightarrow C_6H_4(COOH)OCOCH_3 + CH_3COOH$



Calculations:

Percent Yield = $\frac{\text{observed yield}}{\text{theoretical yield}} \times 100$

Experimental Procedure:

Synthesis of Aspirin

1. Place approximately 4 g salicylic acid (known to 0.01g) into a 25 or 50 mL beaker.
2. Add 8 mL of acetic anhydride to the beaker.
3. Gently swirl the beaker then add three drops of phosphoric acid (H_3PO_4) as the catalyst.
4. Heat this mixture in a water bath on a hot plate for 20 minutes, occasionally stirring with a glass rod. Note any changes in your mixture, the temperature of the bath and the length of time in the bath.
5. Remove the beaker from the water bath and cool for five minutes. SLOWLY add 15mL of *chilled* water. Swirl the beaker to insure mixing and place into an ice bath. Crystals of acetylsalicylic acid should begin to form.
6. When crystal formation is complete (about 15 - 20 minutes), vacuum filter your product. Rinse out the beaker with a small amount of *chilled* water and then wash your crystals in the funnel with 15mL of *chilled* water.

Purification and Recrystallization

1. Transfer your crystals to a 150 - 250 mL beaker. While warming on a hot plate, add warm ethanol, 5 mL at a time, to your crystals until they are completely dissolved (use no more than 20 mL !!).
2. Add about twice as much ice water as you added ethanol and cool the mixture in an ice bath (about 20 minutes). Large quantities of crystals should for if you stir the solution vigorously with a stirring rod.

3. **Warning!** Instead of crystals, you may get an oil that makes the solution cloudy, but will pass through the filter paper. **Do not proceed** to the filtration until you are sure you have a crystalline product and not an oil!
4. Vacuum filter the products, again rinsing with ***chilled*** water. Allow to dry while aspirating for 5 minutes. You may want to weigh the filter paper first.
5. Weigh a small beaker (known to 0.01g). Transfer the crystals to the beaker and save them inside your lab drawer for the next lab period.
6. During the next lab period, weigh the beaker and crystals (known to 0.01g) to determine the amount of product. Use this value to calculate the percent yield for your reaction.

Characterization and Analysis: (Keep this procedure for next week)
Calculating Yield
Weigh your dry aspirin sample on the analytical balance before you remove any for analysis. Assume the mass is all aspirin. Calculate your percent yield.

Infrared Spectroscopy
Your instructor will assist you in taking an infrared spectrum of your product. Compare your spectrum to the spectra for salicylic acid and acetic anhydride and observe any similarities which would indicate the presence of any starting materials in your product.

Melting Point
Pure acetylsalicylic acid melts at about 135 °C. Impure product will melt at lower temperatures. Place a small amount of your product into a melting point capillary and use the melting point apparatus to determine the range of temperatures at which your compound melts.

UV/Vis concentration analysis
You will be provided with a Beer's Law curve (an A vs. c plot) which you can use to determine the weight percent of acetylsalicylic acid in your product. For your sample, weigh out approximately 0.0200 g (known to four decimal places) of your sample and dissolve that in 100 mL of distilled water with gentle warming. After the sample dissolves, cool to room temperature. Take this solution to the instructor or lab assistant who will show you how to use a diode array UV/Vis spectrophotometer to measure the absorbance of your solution. Using a cuvette, measure the absorbance of your sample at 274 nm. Use the Beer's Law curve provided to determine the concentration of your sample solution. Compare this concentration to the one based on the mass of sample weighed and use this ratio to determine the true weight percent of acetylsalicylic acid in your product.

Gas Chromatography/Mass Spectrometry (GC/MS) analysis:
GC/MS is a tool used by chemists to determine the components of a chemical mixture and the quantity of each component. You will analyze your aspirin sample using this technique to determine its composition. Chromatography is used to separate the individual components in the mixture. After these components have been separated, they enter the mass spectrometer and are analyzed as a function of their molecular mass. A more detailed explanation of mass spectrometry can be found in your text (Silberberg) on page 52. Prepare your aspirin sample for analysis by placing about 0.002 g into a GC/MS sample vial. Wearing gloves, fill the vial with 1.5 mL methylene chloride at the hood. Cap the vial, and mix until the sample is dissolved.