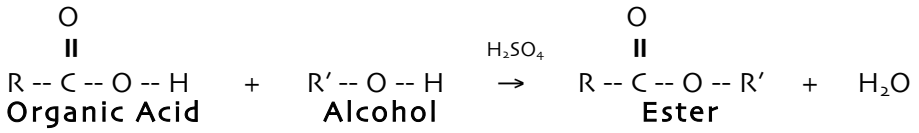
PREPARING ESTERS

AP Chemistry Lab/A. Collins 163 points

Introduction: An ester is a chemical compound that is formed when an organic acid reacts with an alcohol. Esters frequently have distinctive odors and are found in the flavorings of many fruits and plants. The reaction between an organic acid and an alcohol is shown below:



In the diagram, R and R′ represent organic groups such as hydrocarbons. The -OH group from the acid combines with the -H from the alcohol producing a water molecule. [Note: this is the opposite that you would expect. Weak organic acids typically dissociate an H^+ ion.] The R′--O - group from the alcohol attaches to the carbon on the acid - forming the ester.

Purpose:
What you will do and *how* you will do it. (5 points)

Pre-lab Questions: (17 points)
1. Adding some concentrated sulfuric acid, H_2SO_4, catalyzes the reaction. Do a little research and determine *why* and *how* H_2SO_4 acts as a catalyst. Remember to cite your source. (6 points)

2. Draw out a complete lewis structure sequence for the reaction between acetic acid and methanol. What are two names for this ester? (6 points)

3. Ester formation is known to take place between 60 and 110°C. Why is it important for us to carry out our reactions with methanol at temperatures closer to 60°C? (5 points)

Procedure: 10 points

1. Prepare a hot water bath. Fill a 400 mL beaker about half filled with water. Heat the water to boiling, and then turn off the hot plate.

2. Prepare the esters. Use the data table on the backside as your guide. For each ester, place 10 drops of the organic acid in a dry test tube. If using salicylic acid, use a small spatula amount, about 0.080 g. If using butanoic acid (butyric acid), perform the entire experiment under one of the fume hoods. Then, add 10 drops of the appropriate alcohol and 2 drops of concentrated sulfuric acid. Put the test tube into the beaker of hot water and let stand for ten minutes. You may want to prepare several esters at once to save time.

*** SAFETY:*

- The concentrated sulfuric acid used is very hazardous. It will most certainly dissolve your eyeballs if you are not wearing safety goggles! Wash spills off of your skin immediately with large amounts of water. Neutralize spills on the lab bench with baking soda.

- The alcohols are all poisonous. Methyl alcohol is absorbed through the skin. Wash with soap and water if you spill some on your skin.

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3. The odor of the ester is more easily detected when the ester is mixed in some water. Never try to directly smell the ester while it is still hot. Put about 100 mL of water in a 250 mL beaker. Pour the contents of the test tube into the beaker and swirl it or stir with a stirring rod to mix the contents. Carefully smell the ester after it is mixed with water by waving some of the vapors toward your nose. This is referred to as wafting. Can you identify the odor? Record your observations in your data table. You will need to thoroughly scrub out your 250 mL beaker, stirring rod, and test tube with soap before reusing it. The esters are very strong smelling and they tend to contaminate each other from trial to trial.

4. Repeat steps 2 - 4 to prepare 8 esters in total.

5. When you are done, all waste solutions can be poured down the drain with running water.

Safety Data Table/Physical Properties of Solution and Data Table *All In One*: (72 points)
In the following table, all structures should be represented as Lewis structures. All fields should be complete before lab begins (except for the observed odors)

Trial	Acid Name & Formula	Boiling Point	Alcohol Name & Formula	Boiling Point	Ester Name & Formula	Accept-ed Odor	Observed Qualitative Odor
1	Acetic Acid (ethanoic acid) CH_3COOH		Ethanol CH_3CH_2OH		Ethyl Acetate $CH_3COOCH_2CH_3$		
2	Acetic Acid (ethanoic acid) CH_3COOH		n-butanol (1-butanol) $CH_3(CH_2)_3OH$				
3	Salicylic Acid $C_6H_4(OH)COOH$		Methanol CH_3OH				
4	Butyric Acid (butanoic acid) $CH_3(CH_2)_2COOH$		Ethanol CH_3CH_2OH				
5	Butyric Acid (butanoic acid) $CH_3(CH_2)_2COOH$		1-pentanol (n-amyl alcohol) $CH_3(CH_2)_3COH$				
6	Propanoic Acid (propionic acid) CH_3CH_2COOH		1-hexanol (n-hexanol) $CH_3(CH_2)_5OH$				
7	Propanoic Acid (propionic acid) CH_3CH_2COOH		1-octanol (caproic acid) $CH_3(CH_2)_7OH$				
8	Acetic Acid (ethanoic acid) CH_3COOH		3-pentanol (isopentyl alcohol or isoamyl alcohol) $CH_3CH_2CH(OH)CH_2CH_3$				

Observations: 5 points

Calculations (none):

Conclusion: 2 points

Error Analysis: (10 points)

Post Lab Questions: 42 points

You will need to refer to the "Naming Organic Compounds" sheet and the lab's introduction for these questions!

1. DRAW OUT the Lewis structure and then, write the formulas for the following compounds (3 points each)

   a. propane
   b. 3-hexyne
   c. n-pentanol
   d. propene (propylene)
   e. pentanoic acid
   f. methanoic acid (formic acid)
   g. 2-butene
   h. 2,5 dimethylheptane

2. The structure of salicylic acid is illustrated below** (2 points each)
3.
   a. Indicate the hybridization at the lettered atoms.

   b. Indicate the approximate bond angles at the numbered locations.

   c. How many pi bonds exist in this molecule?

   d. Draw out the reaction of salicylic acid with methanol.

   (Be sure to show the removal of the water molecule)

3. Based on the convention that "like dissolves like," do you think salicylic acid or the ester produced in the reaction from #2d would be MORE soluble in water?
   Explain your reasoning!
   (5 points)

4. Rank the following compounds in order of INCREASING solubility in water: (5 points)
   butanol, butane, propanol, ethanol, octane.
   Explain your reasoning!