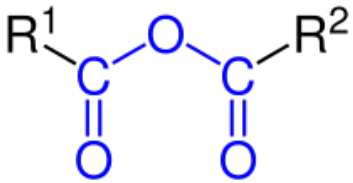
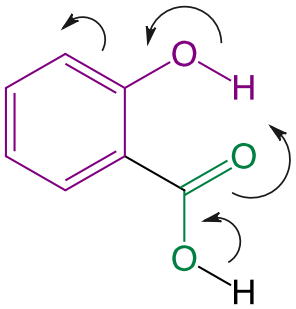
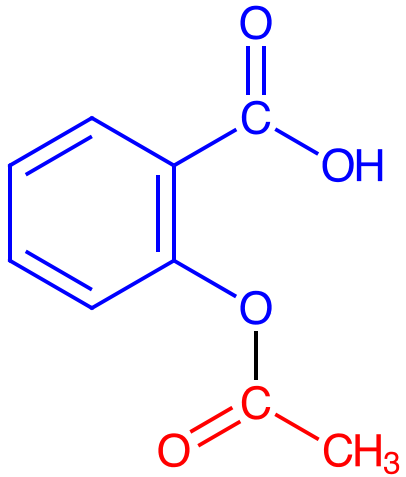
Ex09

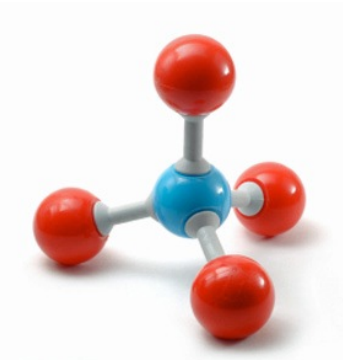
Aspirin

- Esterification
  - Fisher Esterification
  - Anhydride Esterification
- Aspirin Synthesis
- Phenol Test
- The Experiment
  - Setup
  - Reaction
  - Isolation & Drying
  - Analysis
- For Next Week





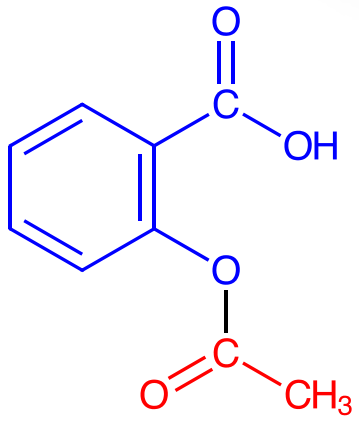




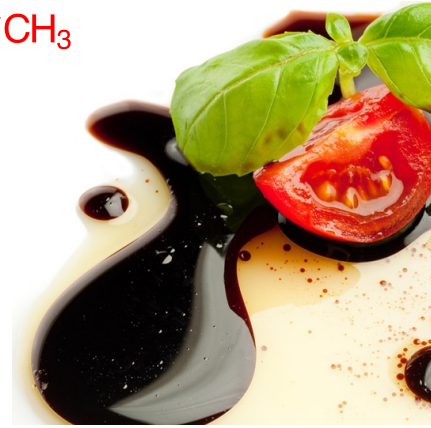
Aspirin

- We're going to synthesize aspirin today.
- Aspirin an useful pharmaceutical that relieves pain, reduces swelling and reduces fever.
- Aspirin is an ester.

- Esters are substances derived from a carboxylic acid in which they hydroxyl group is replaced by an -O-alkyl or -O-aryl group.

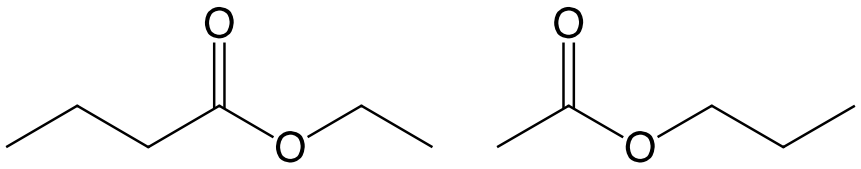


- Most naturally occurring fats and oils are esters.
- Many of the food additives that provide our favorite flavors are esters or acids.



Esters

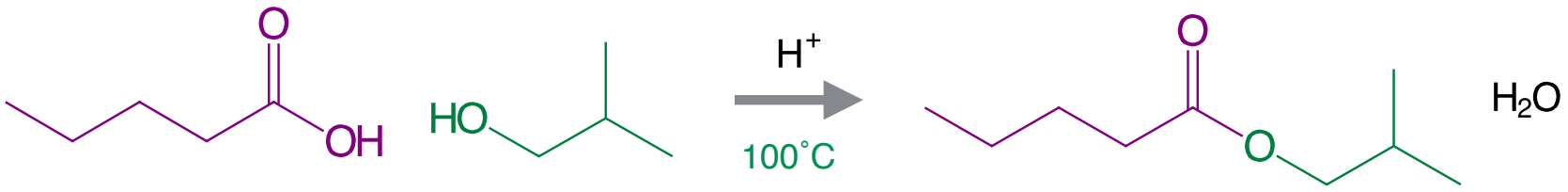
- Many of the fragrances of perfumes and flowers and the flavors of fruits are due to esters.
- Simple esters are volatile, so we can smell them, and they are soluble in water, so we can taste them.
  - Being a hydrogen bond accepter esters are reasonably water soluble.
  - Having no hydroxy group, they cannot be a hydrogen bond donator, so they have a lower boiling point (more volatile).



Condensed Structural Formula and Name	Flavor/Odor
$CH_3-\overset{\overset{O}{\|}}{C}-O-CH_2-CH_2-CH_3$ Propyl ethanoate (propyl acetate)	Pears
$CH_3-\overset{\overset{O}{\|}}{C}-O-CH_2-CH_2-CH_2-CH_2-CH_3$ Pentyl ethanoate (pentyl acetate)	Bananas
$CH_3-\overset{\overset{O}{\|}}{C}-O-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$ Octyl ethanoate (octyl acetate)	Oranges
$CH_3-CH_2-CH_2-\overset{\overset{O}{\|}}{C}-O-CH_2-CH_3$ Ethyl butanoate (ethyl butyrate)	Pineapples
$CH_3-CH_2-CH_2-\overset{\overset{O}{\|}}{C}-O-CH_2-CH_2-CH_2-CH_2-CH_3$ Pentyl butanoate (pentyl butyrate)	Apricots

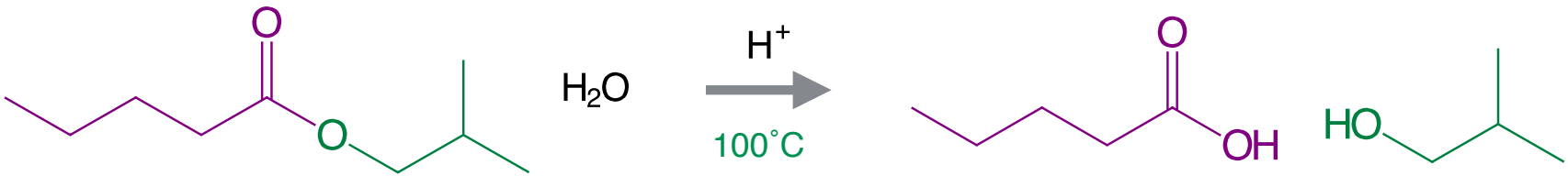
Esters

- Esters are formed by condensing an alcohol and a carboyxlic acid.
- The reaction is also called an esterification of a carboxylic acid.
- It's an equilibrium reaction, but driven forward by using a large excess of the alcohol.



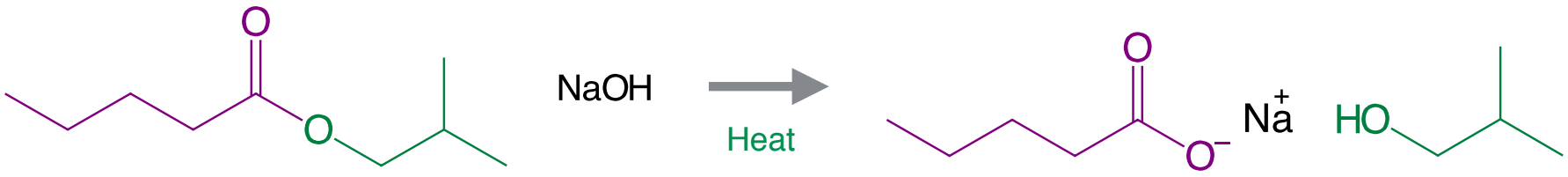
Esters

- Hydrolysis of esters is breaking them into alcohols and carboxylic acids.
- It can be accomplished with acid and heat.
  - It's an equilibrium reaction, but driven forward by using a large excess water.
  - It's the reserve of esterification.



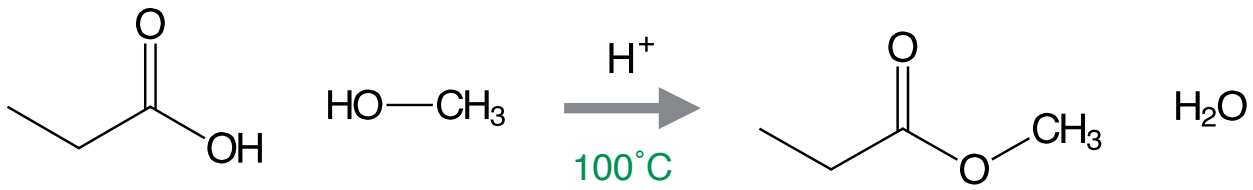
Esters

- Hydrolysis of esters is breaking them into alcohols and carboxylic acids.
- Hydrolysis can also be accomplished with strong base.
- This type of hydrolysis is called saponification (soap making).
- It produces carboxylic acid salts instead of acids.

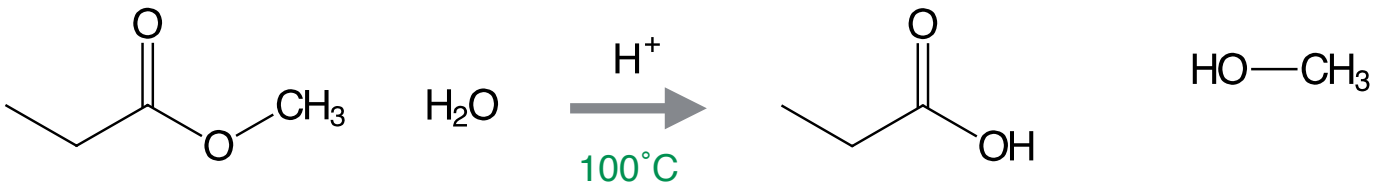


Esters

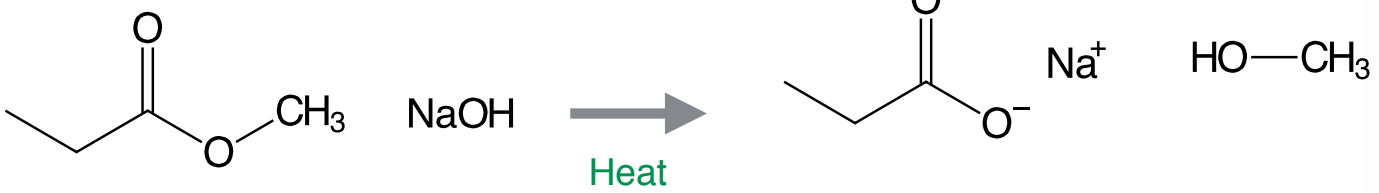
- Esterification:

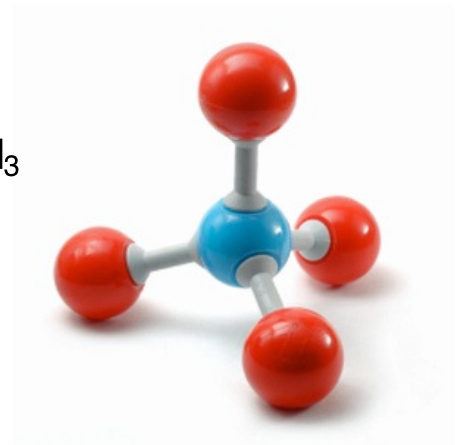


- Hydrolysis:



- Saponification:





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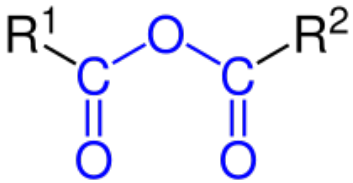

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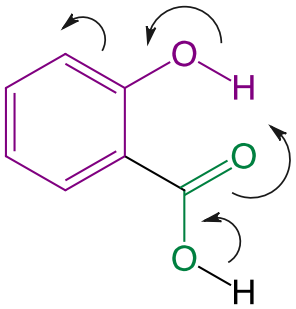
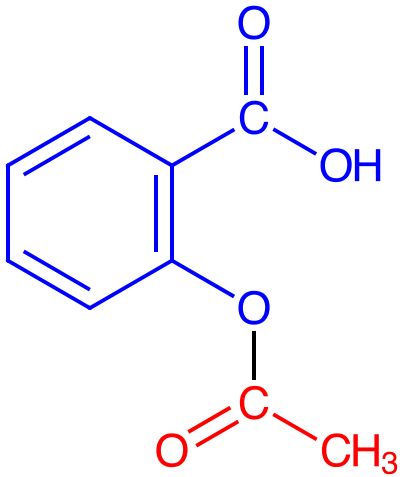
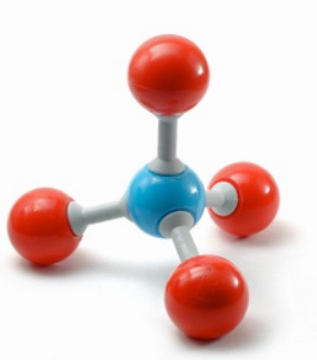
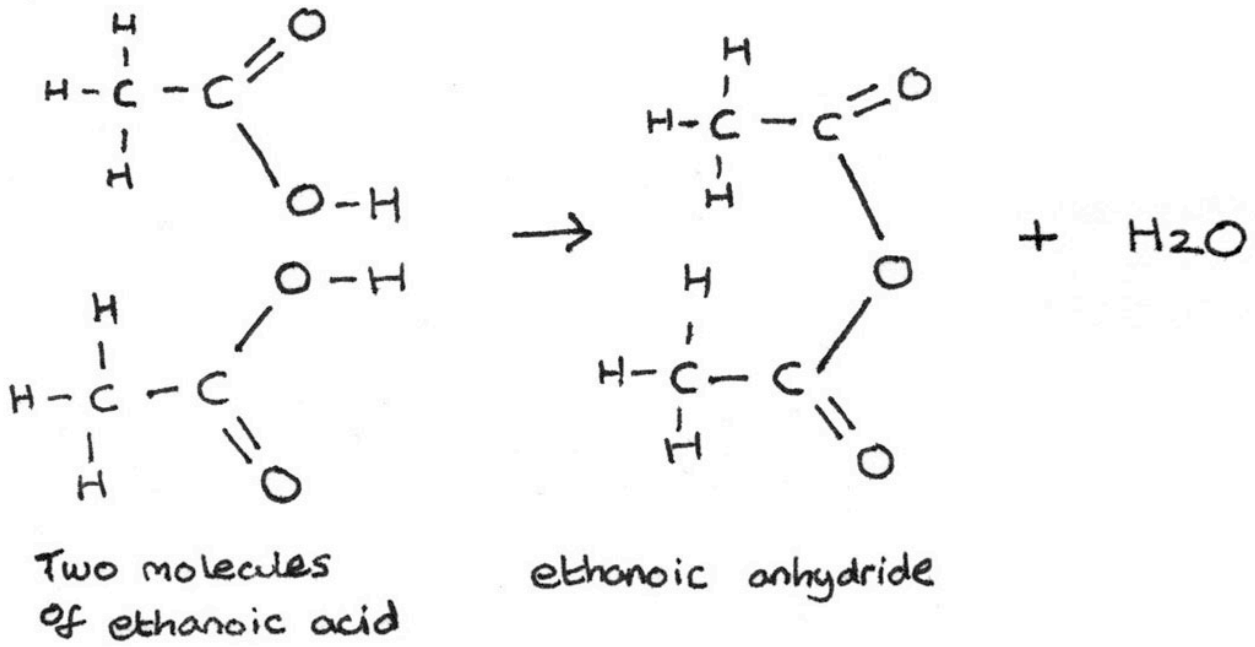


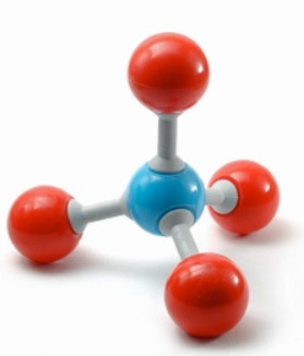




Esters

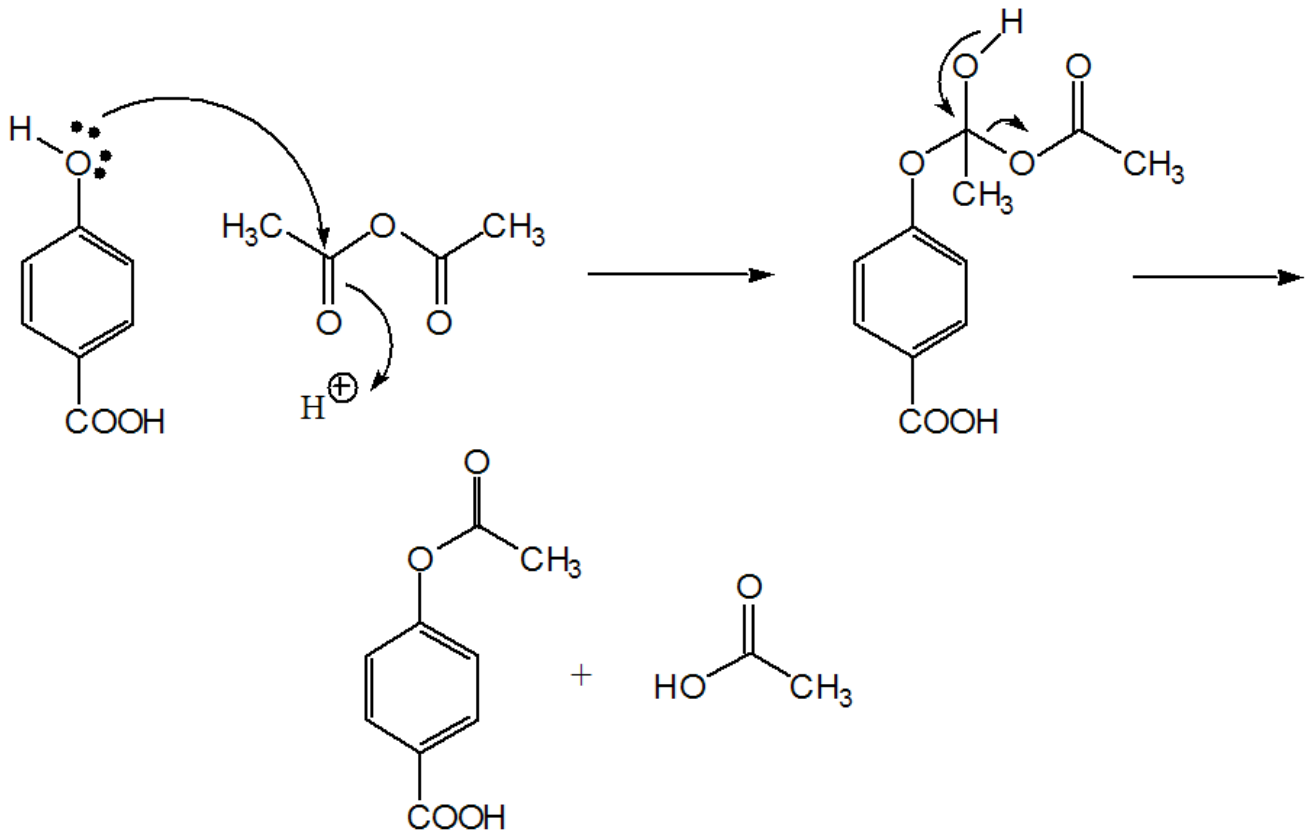
- Many starting materials cannot be heated to 100˚ without decomposing.
- It is possible to accomplish esterification at lower temperatures by dehydrating the acid before reacting it with the alcohol.
- Acids heated to 100˚C will dehydrate to form acid anhydrides.

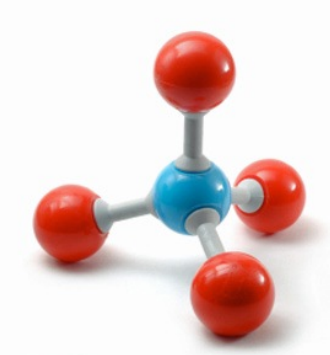




Esters

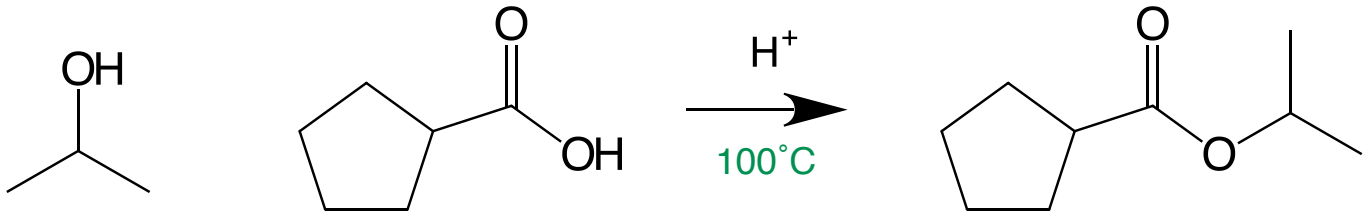
- Alcohols will react with the acid anhydride as they would with acids, but reaction can occur at much lower temperatures.
- You don't need the higher temperatures required to drive the reaction and eliminate water.

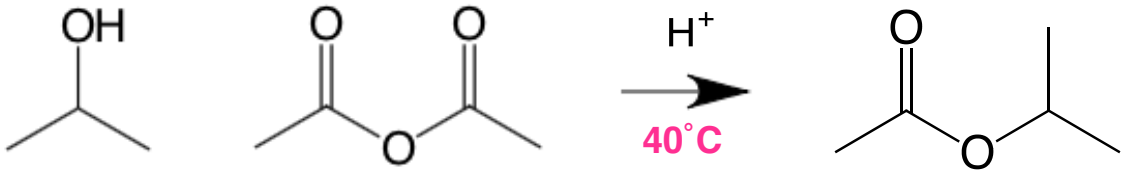


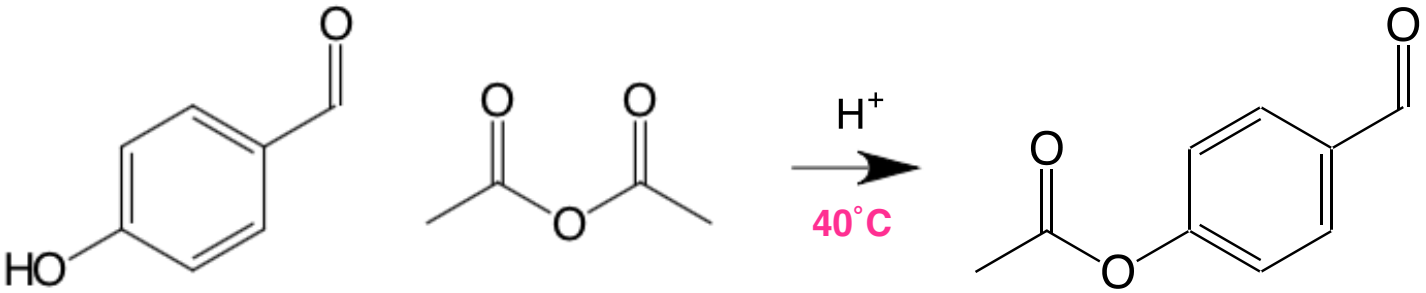


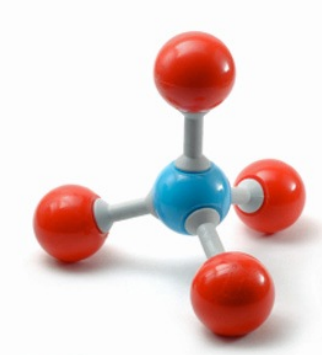
Esters

- Predict the product below:









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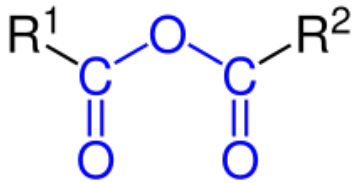
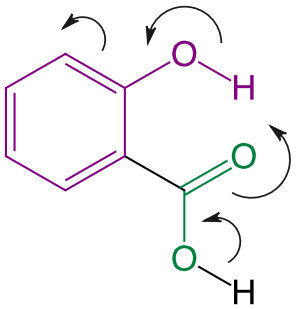
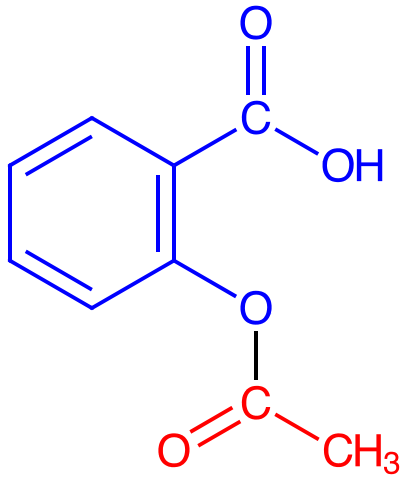
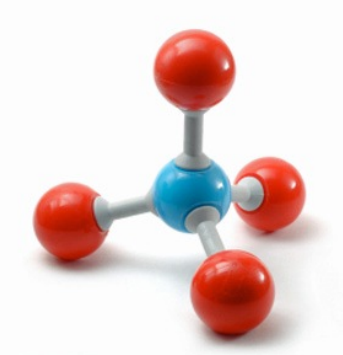


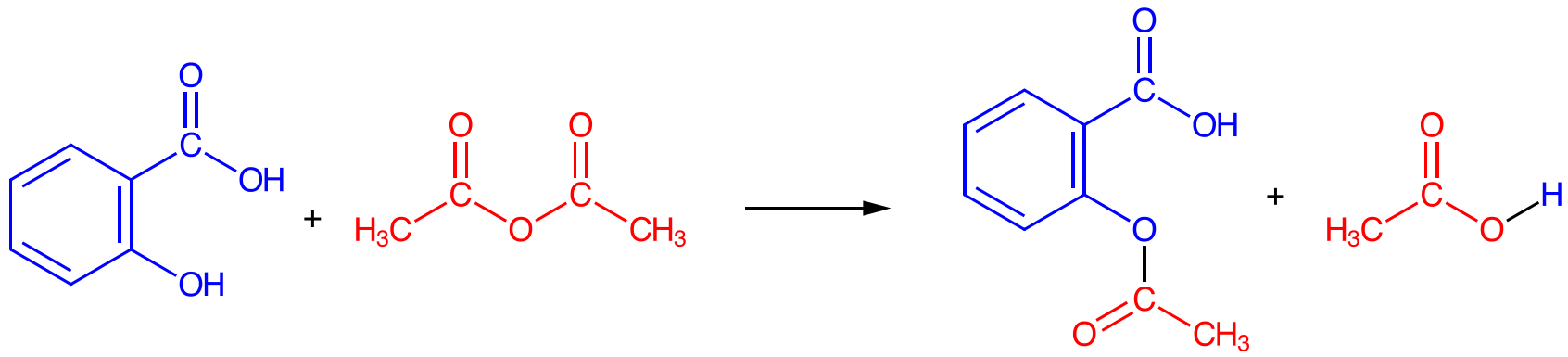


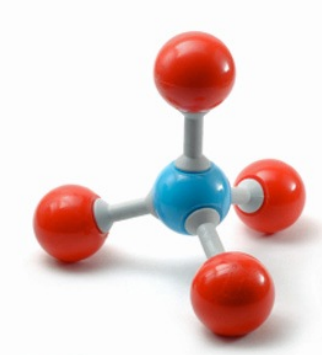




Aspirin

- Todays reaction will be an esterification using acetic anhydride.





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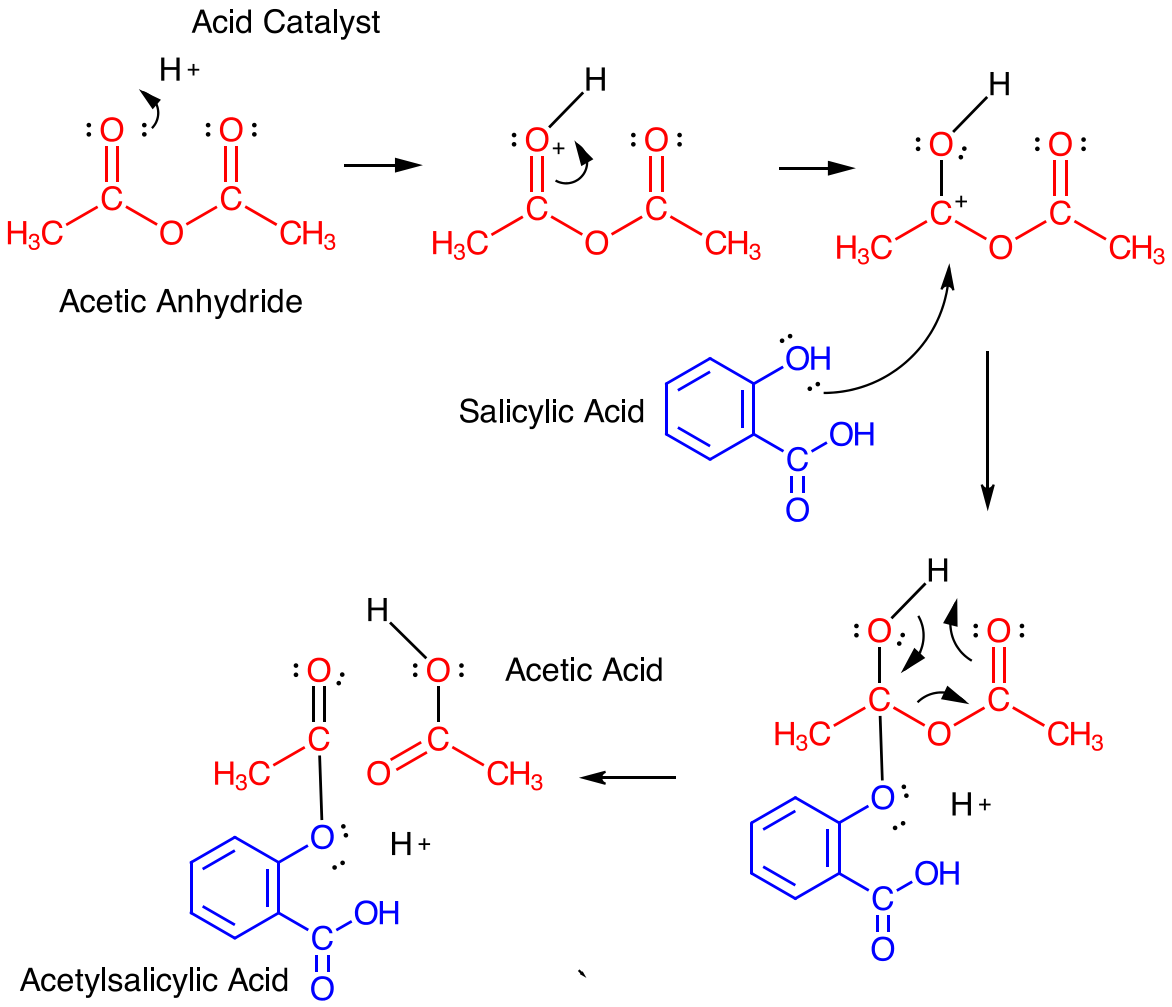

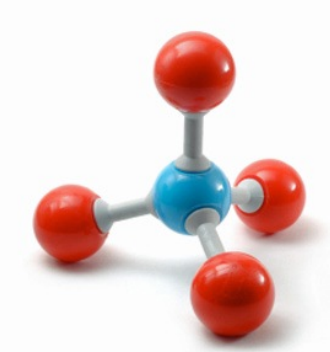

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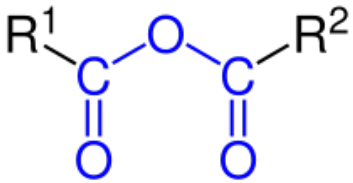
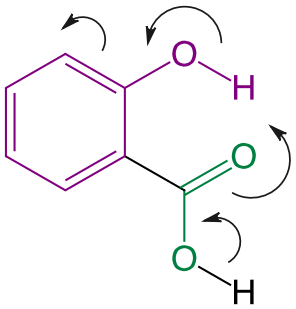
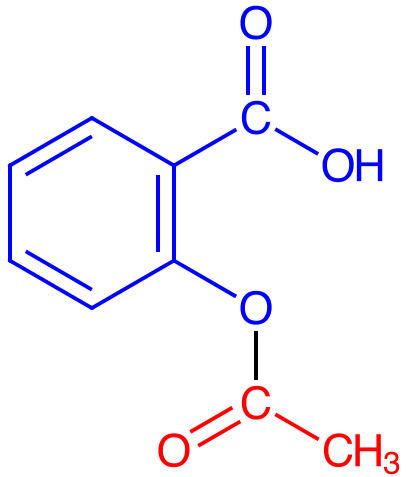
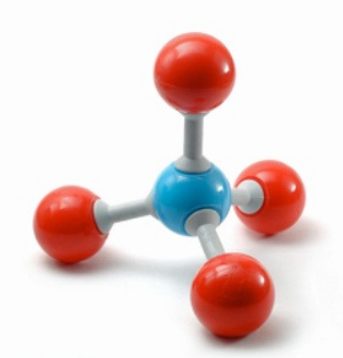


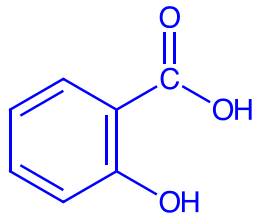


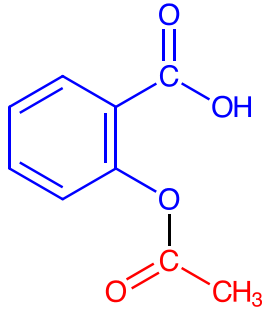


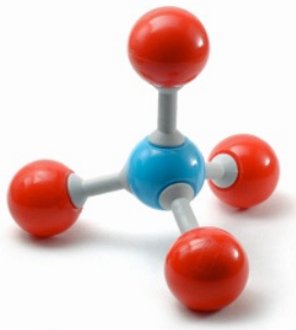


Aspirin

- To demonstrate the substance you prepare is the product you expect, you'll react it ferric chloride.
- Phenols (alcohols attached to an aromatic ring) create a violet solution when reacted with ferric chloride.







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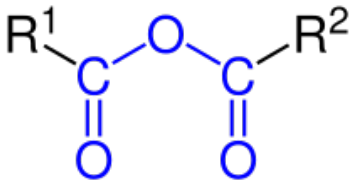

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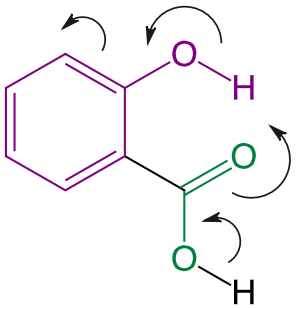
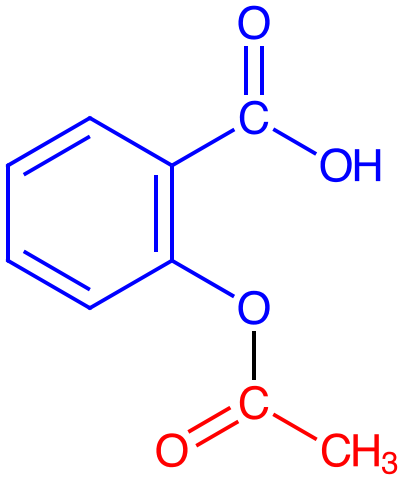
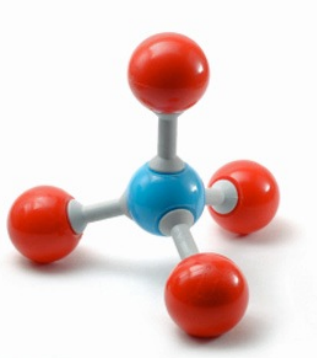
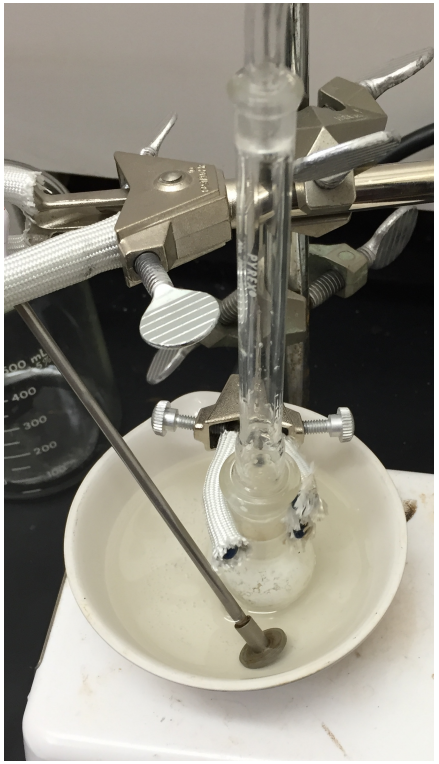


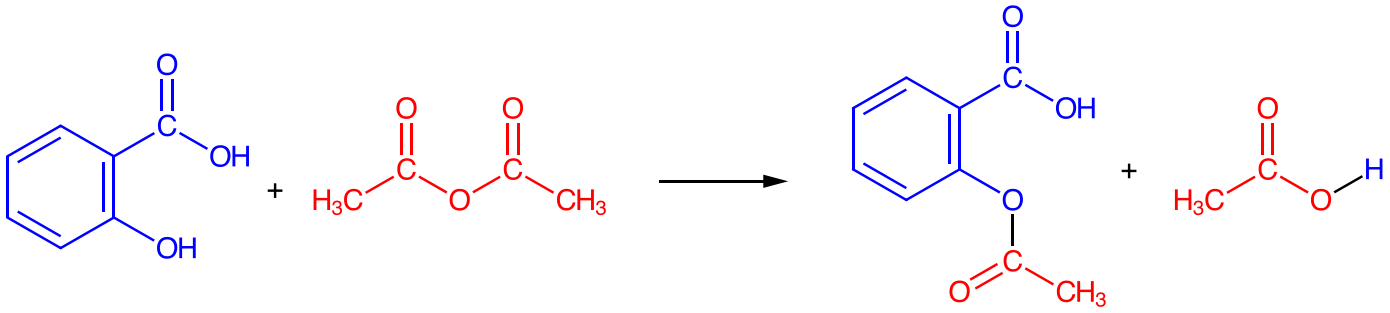




Aspirin

- OBJECTIVE: Synthesize aspirin by the esterification of salicylic acid.
- GOAL: To accomplish the preparation of useful organic substance applying the skills explored in this class for preparation, separation, isolation and testing of purity.

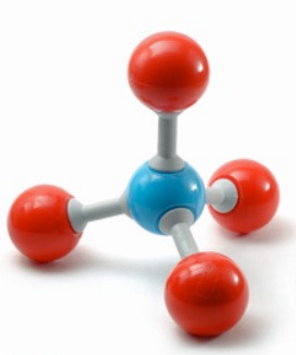


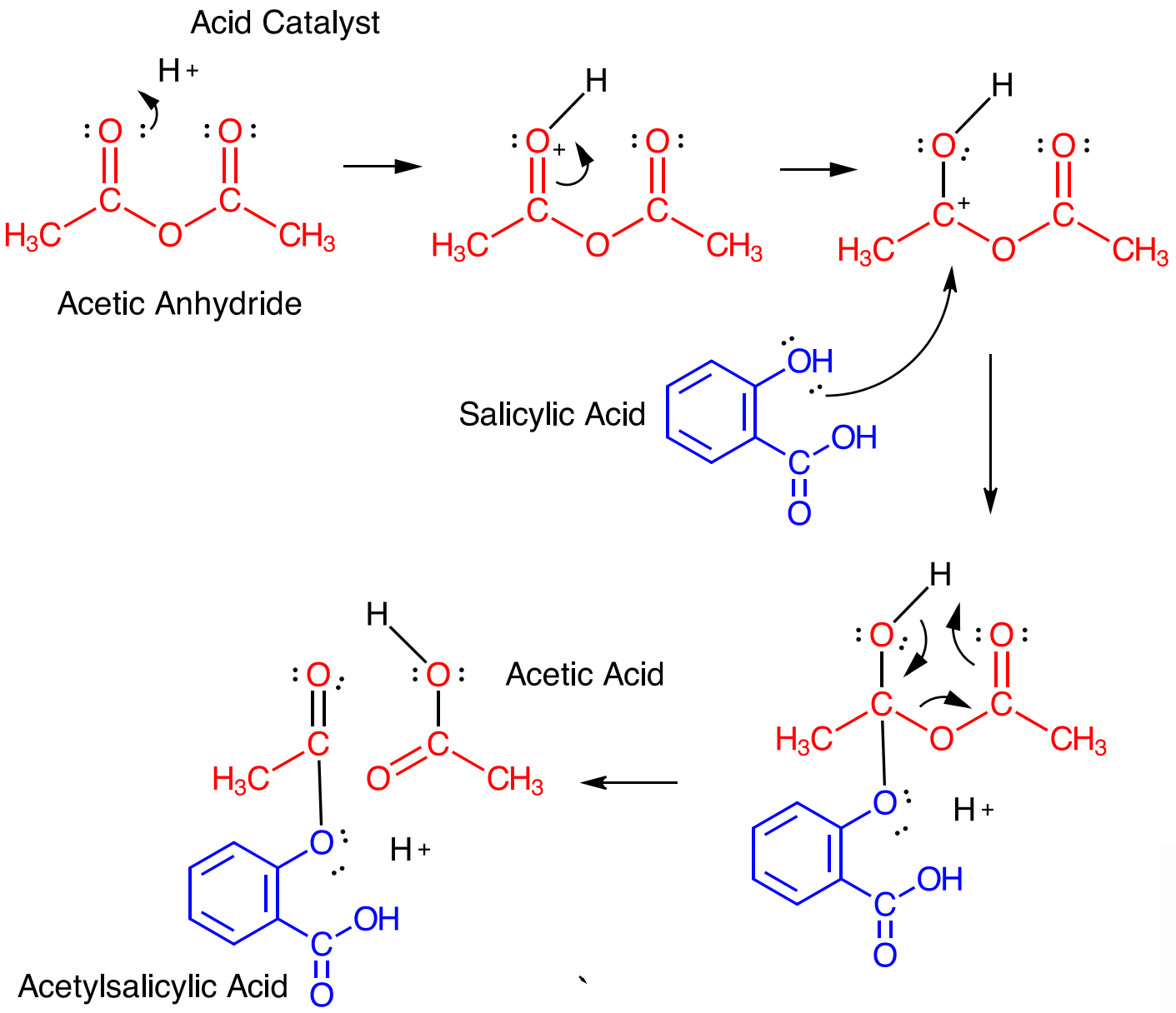


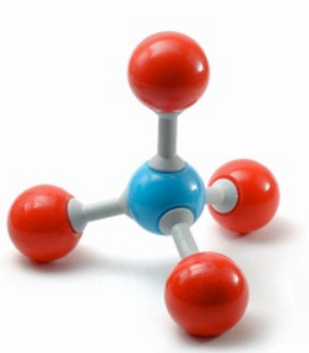
$C_7H_6O_3$ + $C_4H_6O_3$ ⟶ $C_9H_8O_4$ + $C_2H_4O_2$

Salicylic Acid — Acetic Anhydride — Acetylsalicylic Acid — Acetic Acid

bp 134-136˚C ˚C

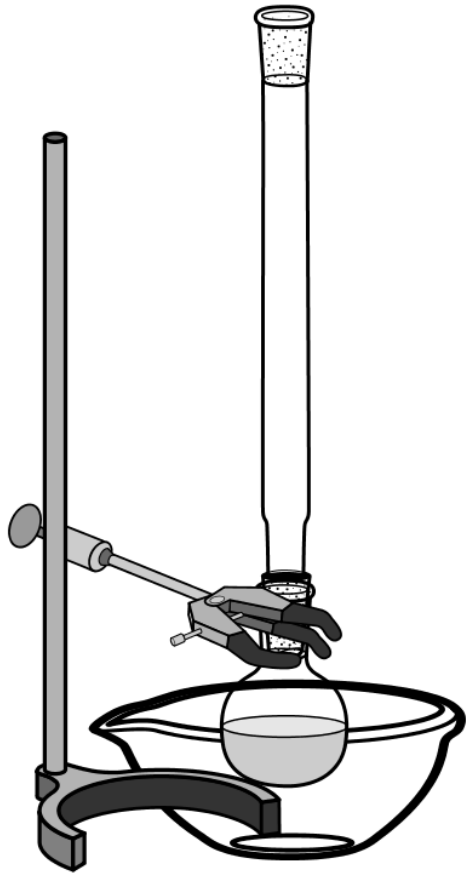


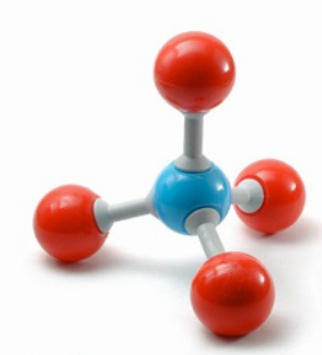

Acid Catalyst
H+
Acetic Anhydride
Salicylic Acid
Acetic Acid
Acetylsalicylic Acid



Aspirin

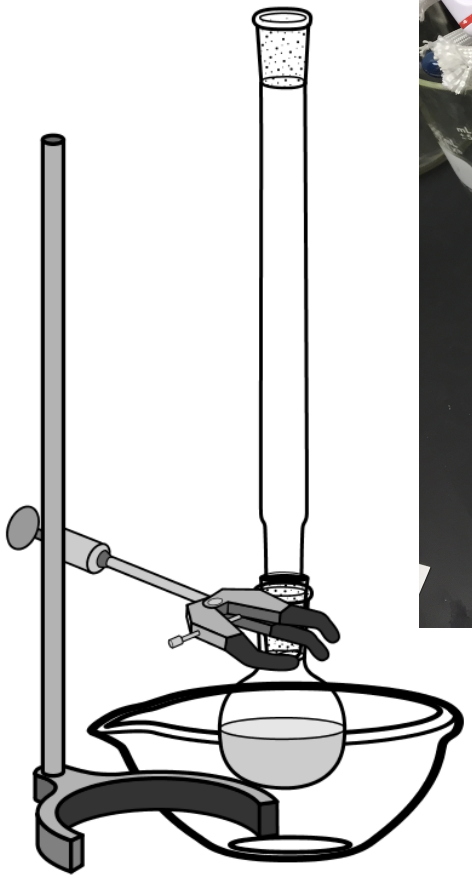
- Setup
  - Prepare a water bath with electronic thermometer in the hood.
    - Preheat the bath to 50˚C.
  - Prepare an air condenser.
  - Pre-weigh a 5 mL round bottom flask.

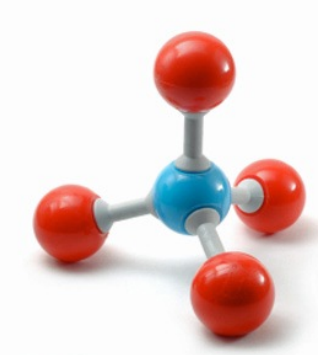




Aspirin

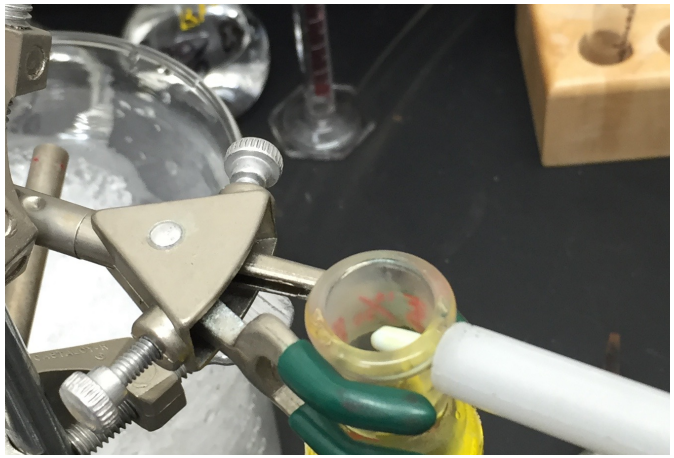
- Reaction
  - To reaction vessel
    - Add 520 mg of acetic anhydride
      - d = 1.08 g/mL mm 102.1 mg/mol
    - Add 210 mg of salicylic acid
      - mm 138.1 mg/mol
  - Add large mag stir bar (instructor will provide)
  - By pipet add:
    - 1 drop concentrated (85%) H_3PO_4
  - Attach condenser and apply heat until the solution becomes homogenous.
  - Heat an additional 10 minutes

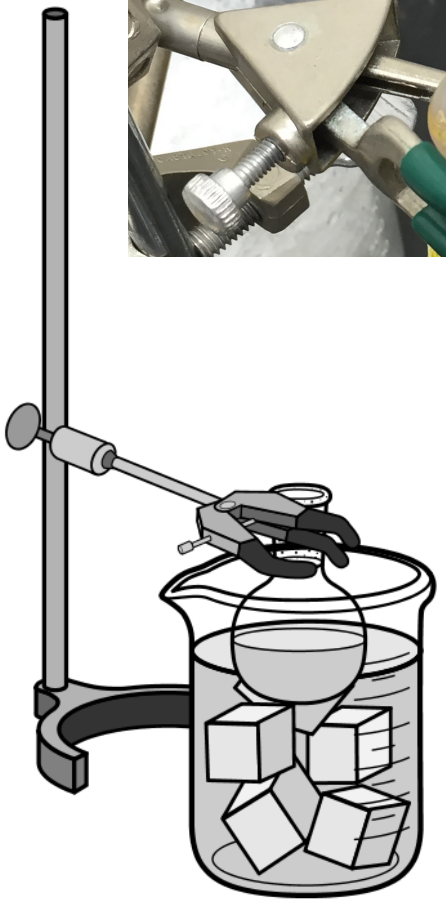


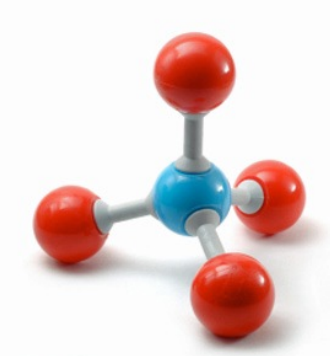


Aspirin

- Isolation & Purification
  - Remove the vessel from the bath and allow to cool.
  - Detach condenser.
  - Remove magnetic stir bar (use magnet)
  - Crystalize the product from reaction mixture by cooling reaction vessel in ice.
    - Scratch inside of vessel with glass rod if necessary.

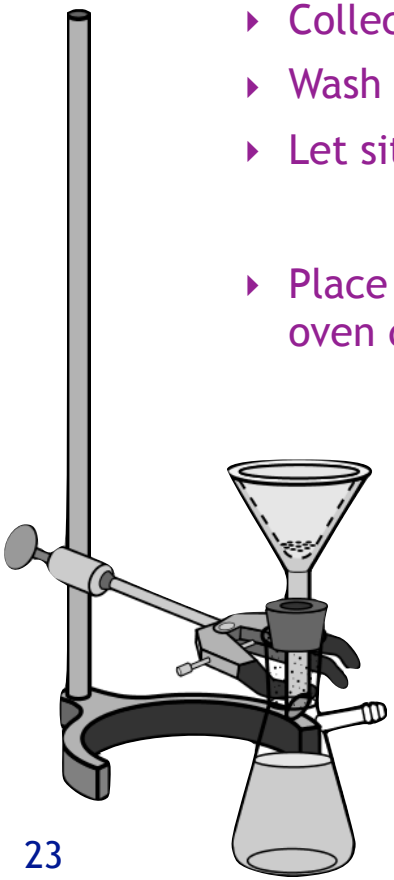


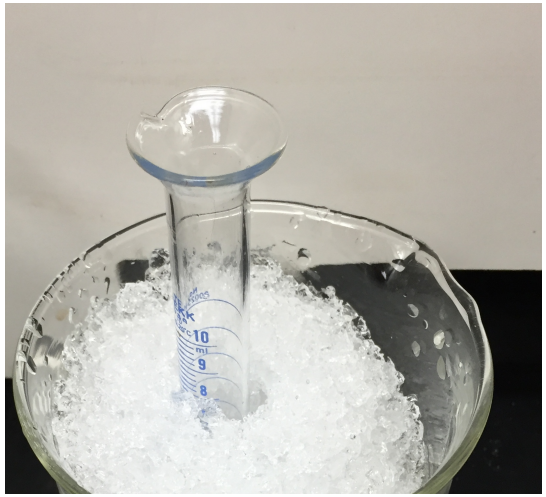


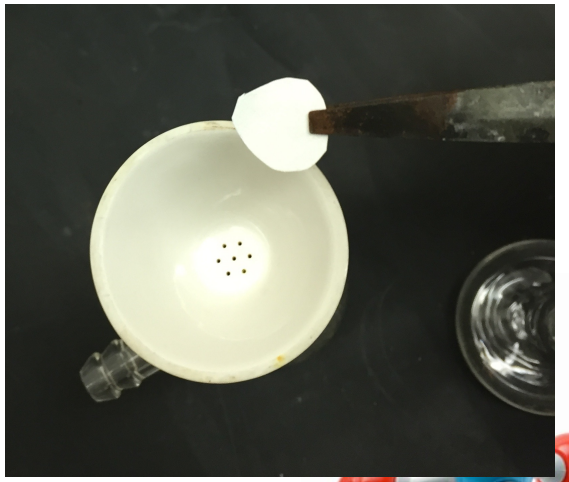


Aspirin

- Isolation & Purification
  - Chill 10 mL of deionized water.
  - After crystals form, add 3.0 mL of chilled water and stir with spatula.
  - Collect crystals by vacuum filtration.
  - Wash with 0.5 mL portion of cold water (3x)
  - Let sit on vacuum 5-10 minutes.
  - Place crystals on pre-weighed watch glass, oven dry 10 minutes.

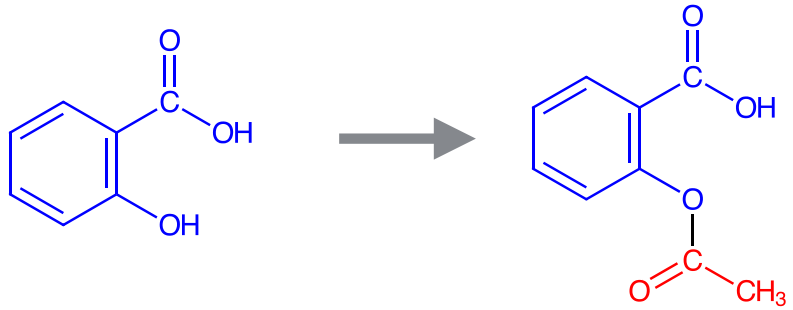


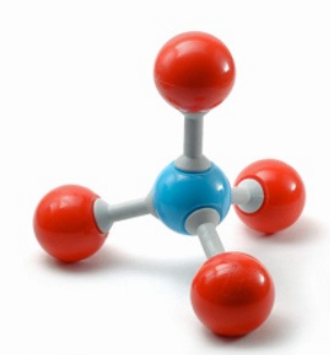




Aspirin

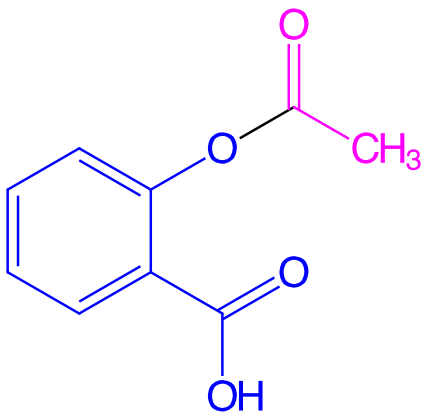
- Analysis
  - Determine absence of starting material with a ferric chloride test for phenols.
  - Add 0.5 mL deionized water to four small test tubes.
    - Add a small amount of your starting material to tube #1.
    - Add an equal amount of your product to tube #2.
    - Add an equal amount of aspirin to tube #3.
    - Tube #4 is your standard containing only water.
  - Add 1 drop of 1% Ferric Chloride to each tube, cap and shake.
  - Record your observations.





Aspirin

- Analysis
  - Determine and report the melting point for your product.
  - Compare your melting point to the melting point reported in literature.



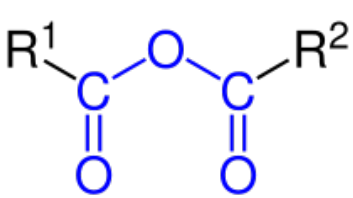
bp 134-136˚C ˚C

Ex09

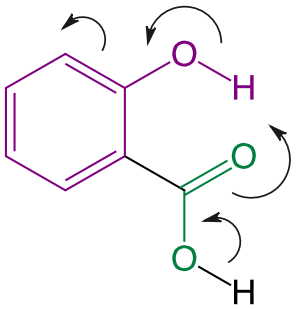
Aspirin

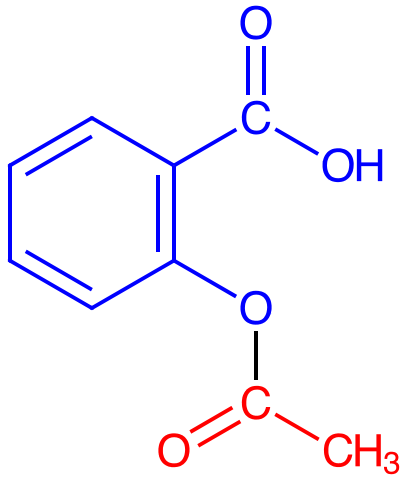
- Esterification
  - Fisher Esterification
  - Anhydride Esterification
- Aspirin Synthesis
- Phenol Test

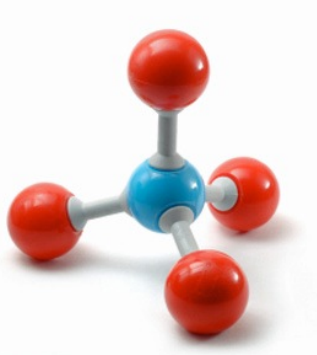
- The Experiment
  - Setup
  - Reaction
  - Isolation & Drying
  - Analysis



For Next Week

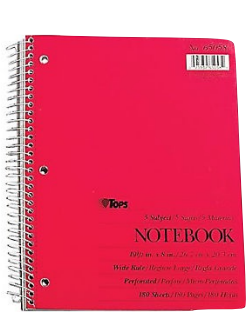


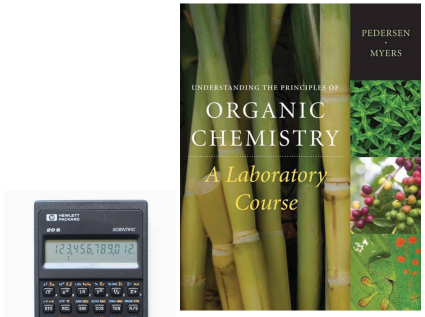


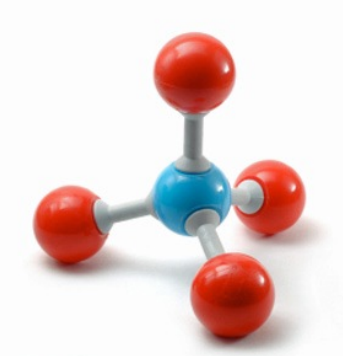


Next Meeting

- For next Meeting:
  - Final Exam
  - Bring to class your calculator, pencils, and eraser.







Questions?