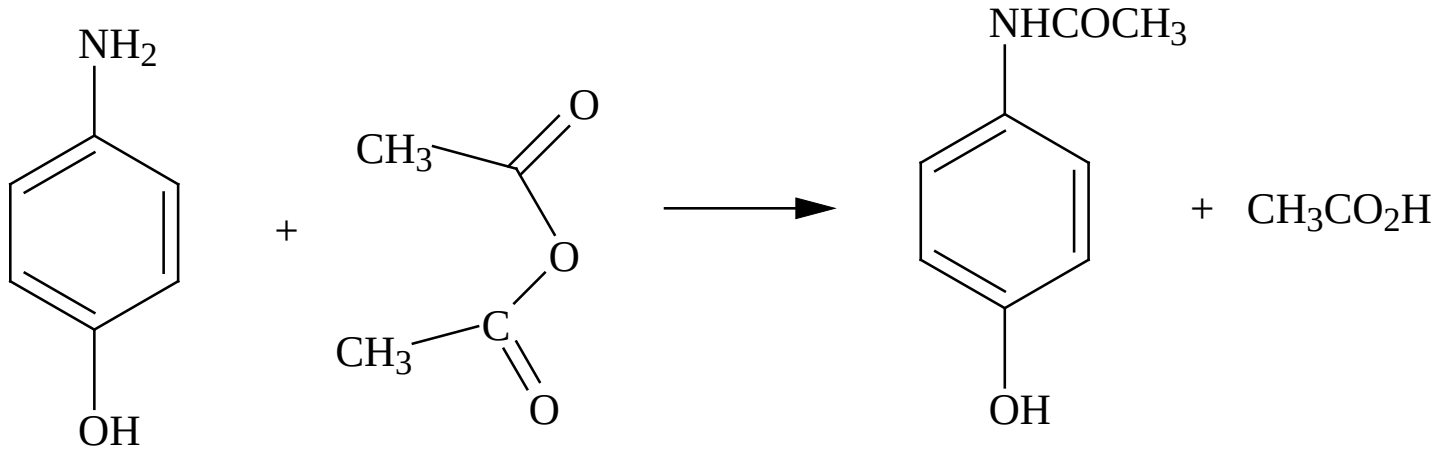
Experiment 2

Preparation of Acetaminophen

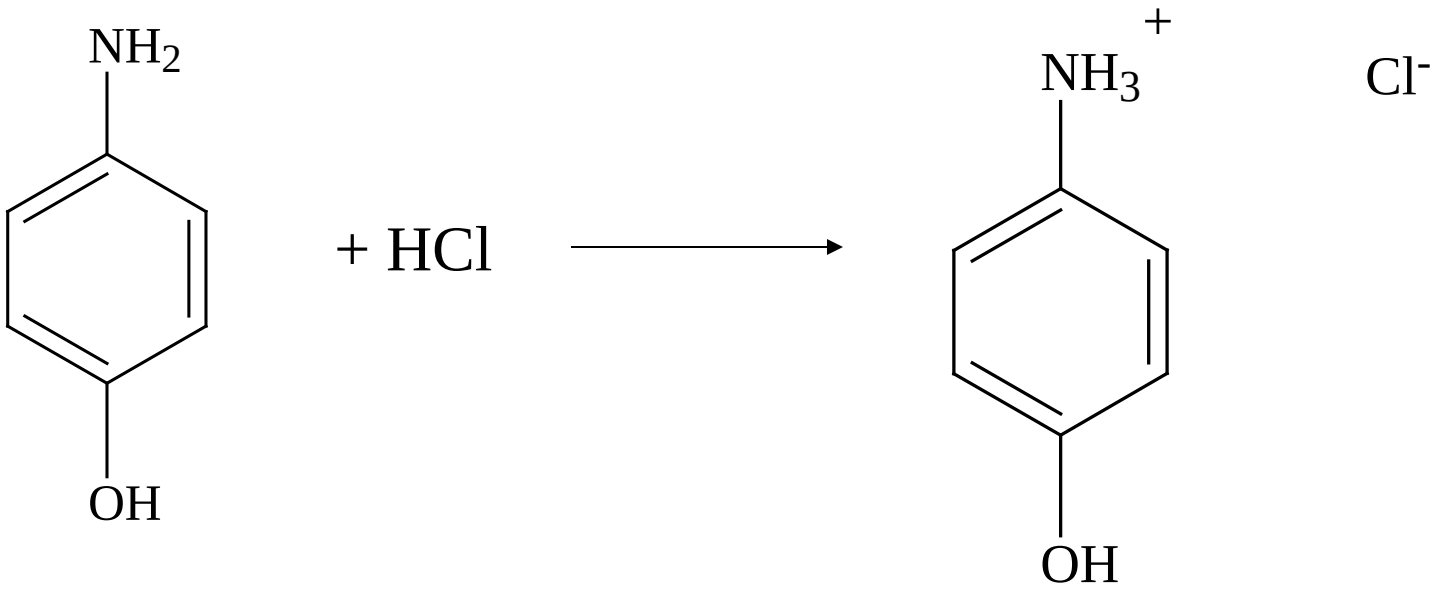


p-aminophenol
material used: 2.1 g

acetic anhydride: MW =102
material used: 2.0 mL
density: 1.10 g/mL

Note: The quality of p-aminophenol is sufficient that the Norit treatment should not be necessary.

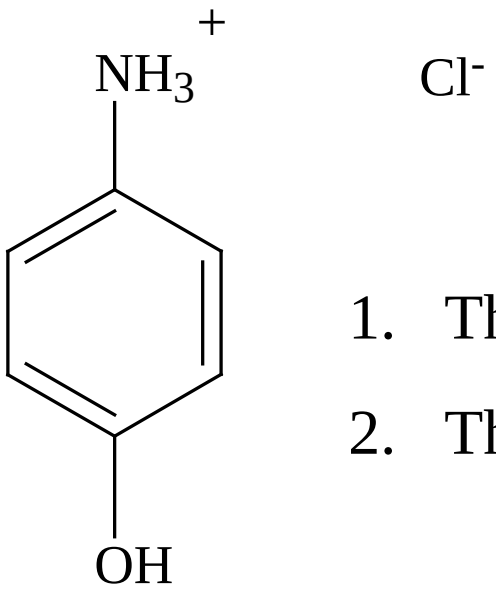
Norit: is activated charcoal with a very high surface area. Norit has the tendency to adsorb polar materials. It is used to remove trace impurities. Highly colored impurities are usually quite polar.



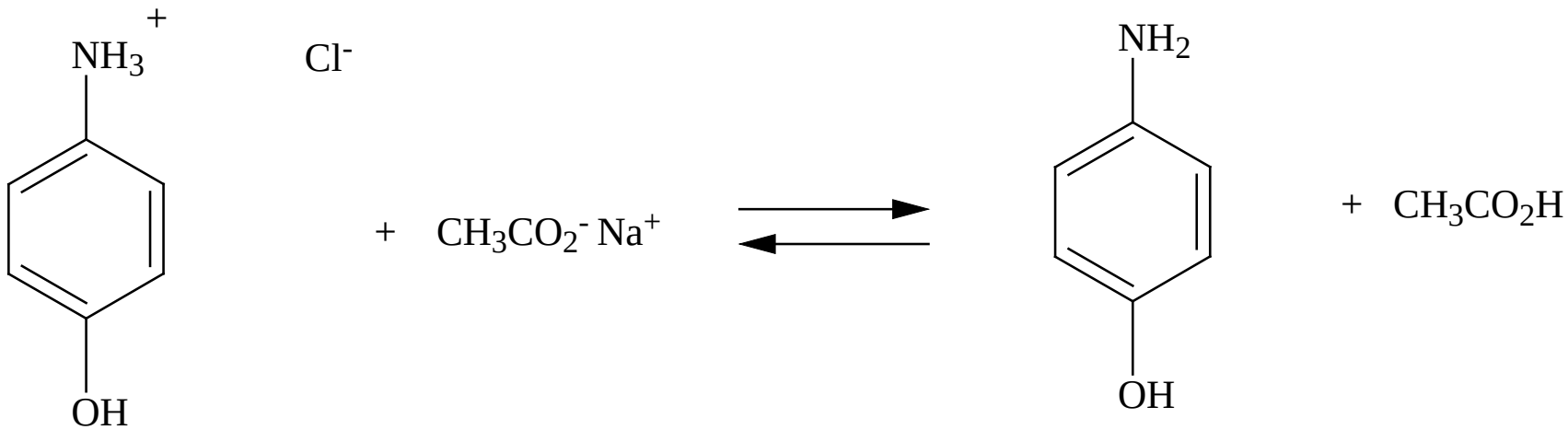
p-aminophenol: not very soluble in water

Soluble in HCl

However!

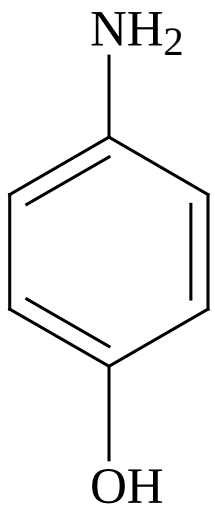


1. The NH_3^+ group in not reactive in this form
2. Therefore, $CH_3CO_2^-Na^+$ is added



The solubility is increased while maintaining a small amount of the free reactive amino group in equilibrium with the ammonium salt

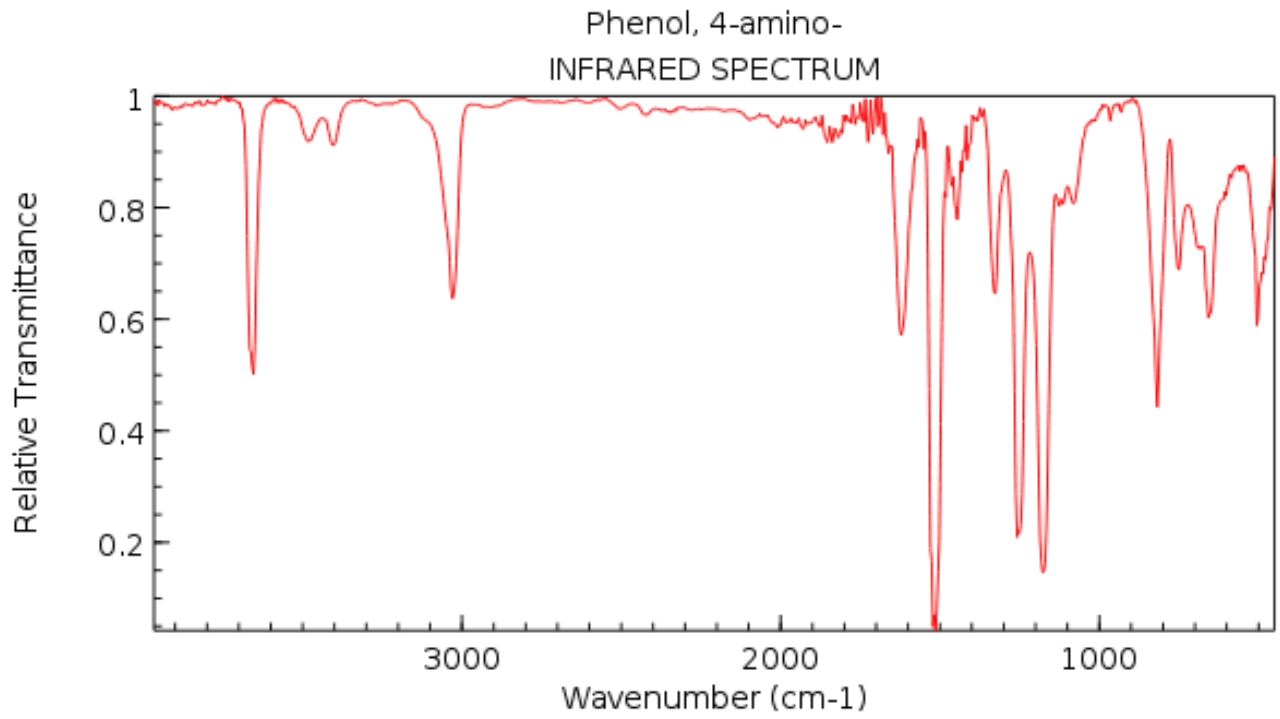
Why does the acetic anhydride react with the -NH_2 and not the -OH group as in salicyclic acid?



The –NH_2 group is more reactive

It is a matter of kinetics; the –OH of the phenol is about as reactive as the -OH in H_2O; therefore since water is present in a much higher concentration, some acetic anhydride reacts with water

1. Heat your reaction mixture on a hot water bath
2. Cool your reaction mixture and scratch with a glass rod, if necessary, to achieve crystallization (wait about 1 hr, use this time to work on the aspirin experiment)
3. Vacuum filter your crystals and recrystallize your acetaminophen from hot (boiling) water using a hot plate.
4. Identify the product by its melting point and determine the yield (next week).

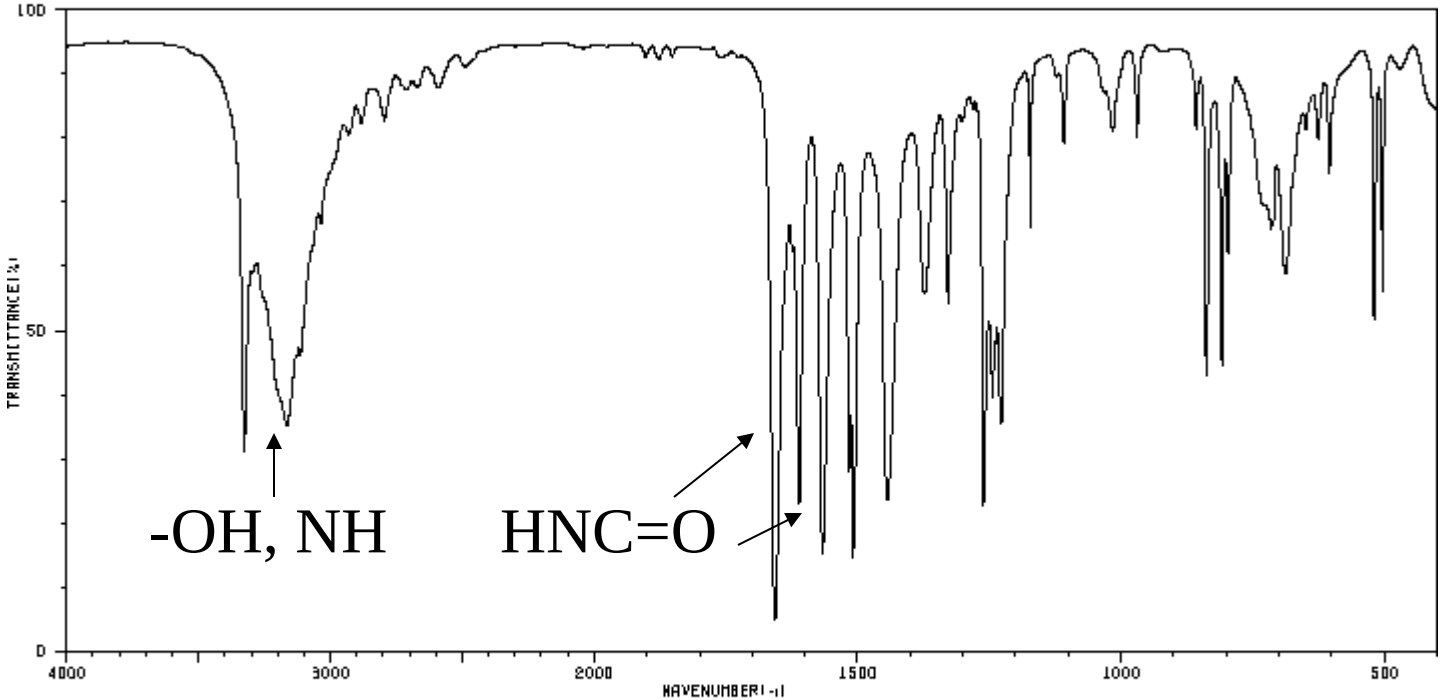


NIST Chemistry WebBook (http://webbook.nist.gov/chemistry)

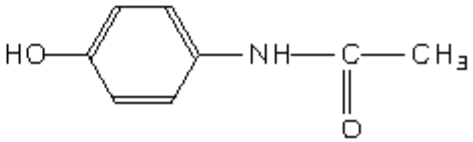
HIT-NO=2434	SCORE= ( )	SDBS-NO=3290	IR-NIDA-61329 : KBR DISC

4'-HYDROXYACETANILIDE

$C_8H_9NO_2$

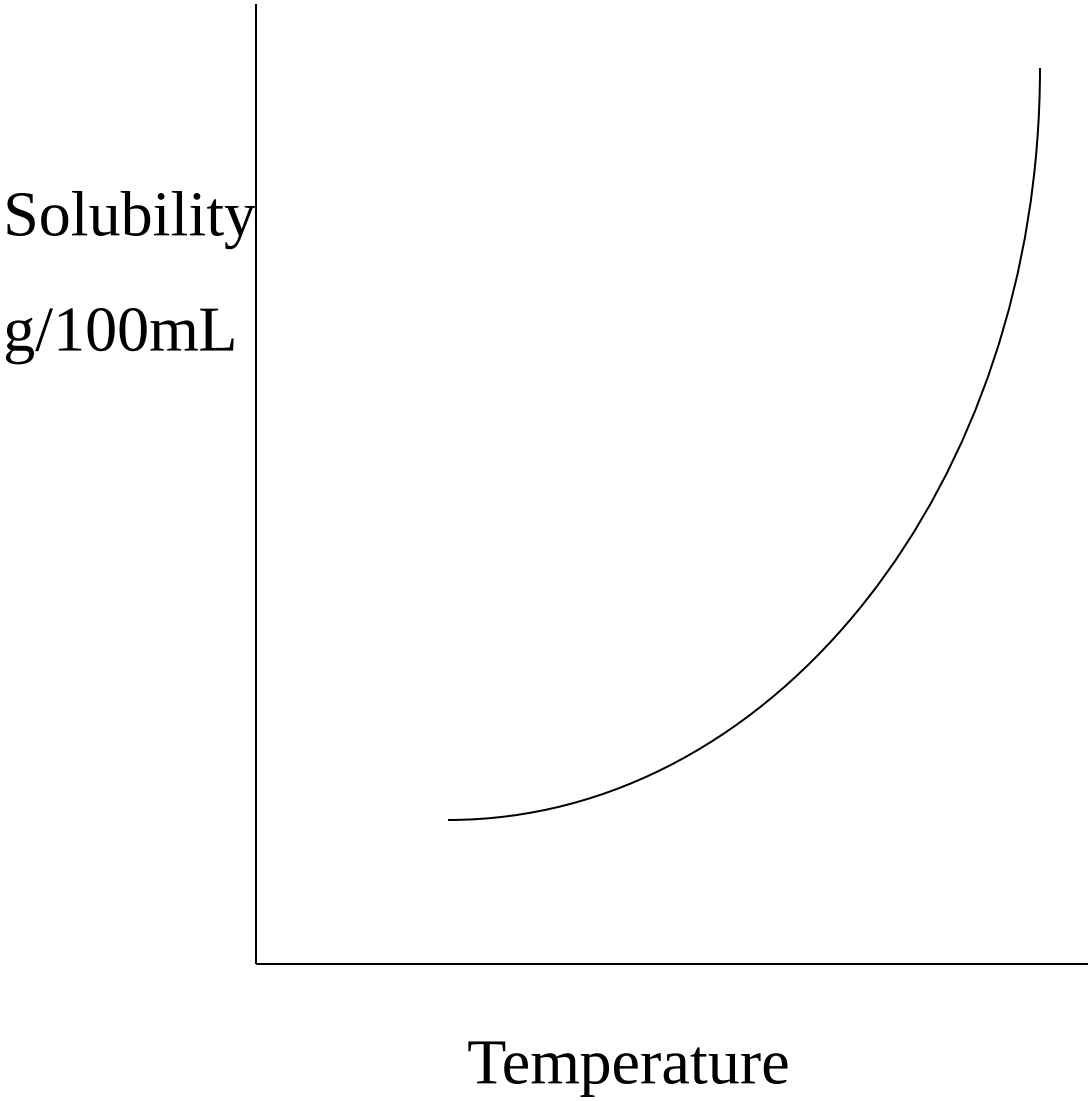


3326	30	1667	4
3165	33	1624	60
3149	37	1611	21
3114	44	1567	14
3036	64	1516	26
2930	77	1509	15
2795	79	1444	22



Recrystallization of Solids

1. Dissolve the solid in a <u>minimum</u> amount of hot solvent.
2. If necessary, filter the hot solution if everything doesn't dissolve, by keeping everything hot.
3. Allow the hot solution to remain undisturbed; cool in ice water **after** the solution has reached room temperature.
4. Vacuum filter the solid and wash with a small amount of cold solvent.
5. Vacuum filtration is used to quantitatively remove the mother liquor which contains soluble impurities.


Solubility
g/100mL
Temperature

Solvent selection

1. Polar solvents dissolve polar solutes
2. Non-polar solvents are usually best for non-polar solutes
3. Boiling temperature of solvent is a consideration

Aspirin (from last week)

1. Weigh you purified aspirin and determine the yield Save a small amount for a mp determination

2. Recrystallize from ethyl acetate

   Aspirin is quite soluble in ethyl acetate so it is important to use your smallest Erlenmeyer flask and a minimum of solvent. Usually, this means evaporating and concentrating the solution once all the solid has dissolved. Allow the solution to cool slowly!

3. Ferric chloride test: ferric chloride often forms colored complexes with enols and phenols. It is therefore used as a test for enols. You should test salicylic acid, your purified aspirin and your recrystallized aspirin for the presence of any enol. Only a few mg are needed for the test!

4. Take a melting point of your purified and recrystallized aspirin and run an IR spectrum of the recrystallized aspirin.

Melting point determinations:

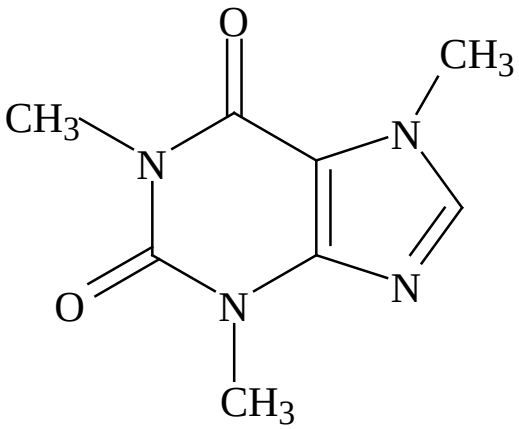
1. Only a mg or less is needed for a melting point determination.
2. The heating rate should be 2-3 ° C per min. For a compound with a known melting point, heat quickly to within 10-15 ° quickly, then lower the heating rate accordingly to obtain the desired heating rate.
3. If the melting point of the solid is not known, the following should be followed: Heat the sample 10-15 °/min until the sample melts. Using a new sample, cool the apparatus to about 10-15 ° below the observed melting point and use a fresh sample of solid. Raise the temperature at the correct heating rate, 2-3 ° C per min.

The Digimelt Apparatus

1. Press the START TEMP button and use ▲and ▼arrows to set the start temperature.
2. Repeat step 1 to set the ramp rate (° C/min) and STOP TEMP (end temperature).
3. Press START/STOP to preheat oven to desired temperature. {PREHEAT is lit}.
4. When the ready light is lit, insert filled capillary into oven. Press START/STOP to begin temperature ramp. {MELT} indicator is lit.
5. After the sample is melted press START/STOP to end the experiment. {COOLING} is lit.

Experiment 3

Isolation of caffeine from tea

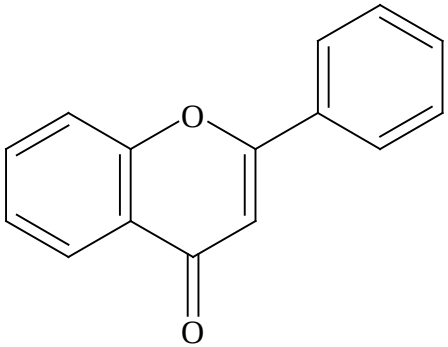


Caffeine is a natural product produced by a variety of botanicals that constitutes about 5% of the dry weight of tea leaves. It is a stimulant and used in a variety of over the counter drugs. In this experiment we will isolate caffeine from a host of other compounds present in tea by taking advantage of the solubility of caffeine in water.

In addition to the caffeine that is water soluble, some tannins, chlorophyll and various flavonoids and other compounds are also somewhat soluble in water giving the brewed tea its characteristic color and beneficial effects.

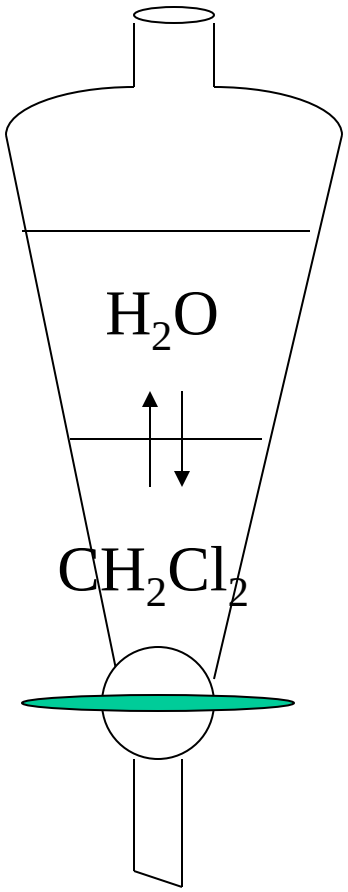
Calcium carbonate is added to help precipitate some of the tannins.

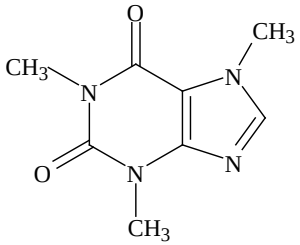
In this experiment you will be asked to determine the % caffeine in dry tea leaves. You will use 14 g of tea or 6 tea bags (13.6g) and 200 mL of water. After brewing and filtering, you will measure the amount of water recovered. You will use the fraction of liquid recovered in your final calculation to determine how much caffeine was originally present in the tea leaves.



Molecular structure of the flavone backbone (2-phenyl-1,4-benzopyrone)

Separatory funnel





Water: density 1.0 g/mL

CH_2Cl_2: density 1.34 g/ mL

Which layer will be on top?

The caffeine dissolved in water will still be warm by the time it is time to extract.

DO NOT use CH_2Cl_2 to extract until the aqueous layer is at **room temperature**. Methylene chloride has a low boiling point (~40 °C) and has a high vapor pressure even at room temperature. Stoppering the separatory funnel with warm water and CH_2Cl_2 generates a closed system in which pressure can build up and cause the contents of the separatory funnel to violently erupt. **Use an external ice bath to cool the tea solution to room temperature.**

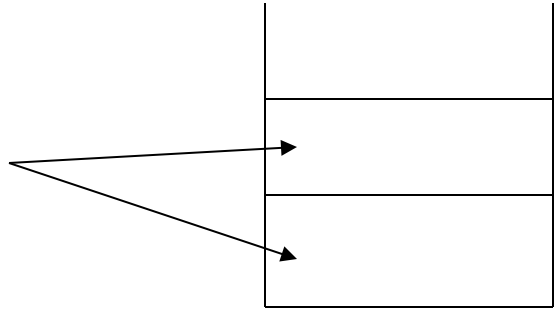
Do not shake the separatory funnel vigorously or you will form an emulsion!

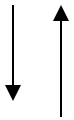
How is an organic compound soluble in water recovered from an aqueous solution?

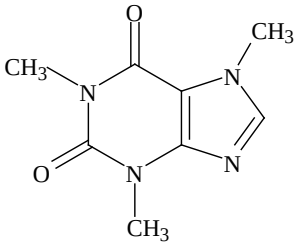
Extraction:

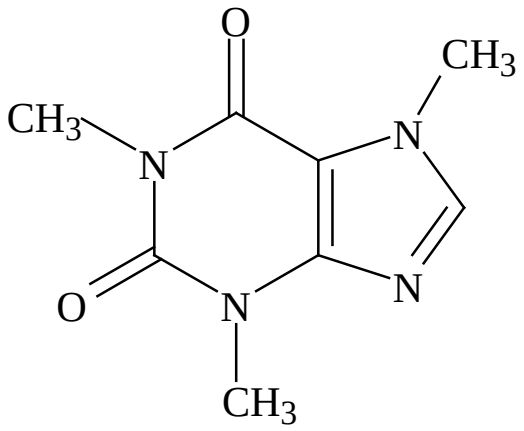
Suppose you allowed two immiscible liquids to come in contact with each other and and one of the liquids had a solute dissolved in it. What would happen to the solute?

solute









caffeine

Suppose caffeine has a solubility in water of 1 g /100 mL

and a solubility in CH_2Cl_2 of 10 g/100 mL.

How would the caffeine partition itself if we place 11 g of caffeine in contact with 100 mL of water and 100 mL of CH_2Cl_2 ?

solubility of caffeine in water/methylene chloride = 1/10

$1g/100mL_{H2O}]/[10g/100mL_{CH2Cl2}] = 1/10$

$1g/100mL_{H2O}]/[10g/100mL_{CH2Cl2}] = 1/10$

How would caffeine partition itself if we only dissolved 1g in the same quantity of water and CH_2Cl_2 ?

x = amount in H_2O;

1-x =amount in CH_2Cl_2

$x_{H2O}/[1-x]_{CH2Cl2} = 0.1$

x = 0.091 g in water

1- x = 0.909 in CH_2Cl_2

What is the most quantitative way to isolate caffeine from water?

Suppose we had 1 g of caffeine dissolved in 100 mL of water and

100 mL of CH_2Cl_2. Would it be more efficient to extract once with 100 mL of CH_2Cl_2 or twice with 50 mL portions?

One extraction: 0.909 in CH_2Cl_2

Two extractions:

$[g/100mL_{H2O}]/[g/50mL_{CH2Cl2}] = 1/10$

x = amount in H_2O;

1-x = amount in CH_2Cl_2

x/100/[1-x]/50 = 0.1

x/(2-2x) = 0.1

x = 0.166 g in water; 0.834g in CH_2Cl_2

2nd Extraction:

x/100/[0.166-x]/50 = 0.1

x/(0.333-2x) = 0.1

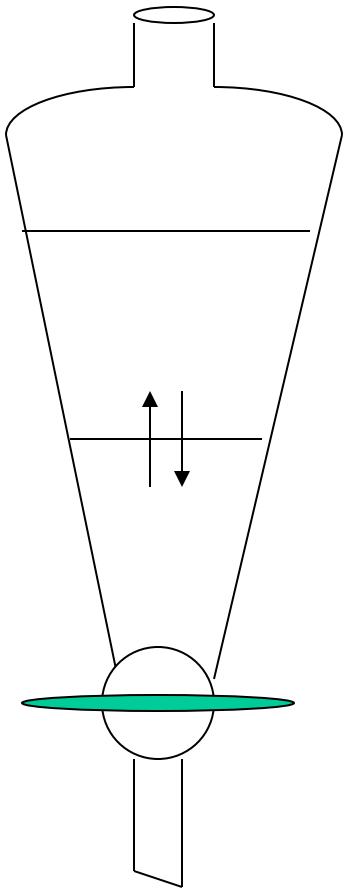
x = 0.028 in water; 0.138 g in CH_2Cl_2

Combining the CH_2Cl_2 layers, 0.834g +0.138g = 0.972g

One extraction with 100 mL CH_2Cl_2 yields 0.909 g caffeine

Two extractions with 50 mL CH_2Cl_2 yields 0.972 g caffeine

Separatory funnel



Proper Use of a separatory funnel

1. Use only cold or cool materials

2. If any gas is evolved, make sure it has completely evolved

3. Place stopper, invert and quickly vent via the stopcock any pressure generated

4. Shake carefully to avoid emulsions while venting periodically

Suppose for the sake of argument, you recover only 150 mL of tea from the 200 mL of water you started with from 14 g of tea leaves. Assume that you didn't lose any water to evaporation during the brewing process, this means you recovered 75 % of the original liquid. The remaining liquid was lost in the tea leaves and in the process of filtering. If you recovered 0.4 g of caffeine from the 150 mL of tea following extraction, this means that the total amount of caffeine in the 14 g of tea leaves is 0.4/0.75 or 0.53 g of caffeine in 14 g of tea leaves.

0.53/14 *100 = 3.8% by weight of caffeine in tea

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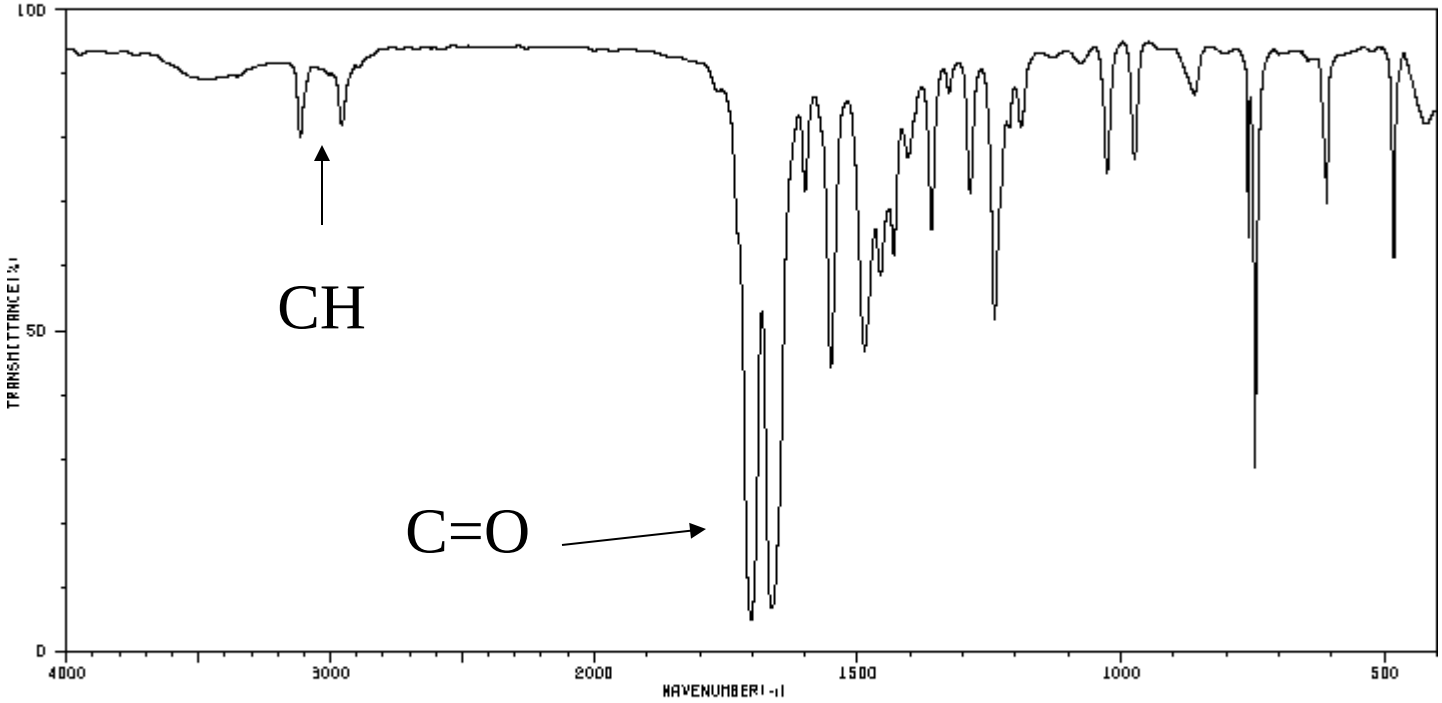
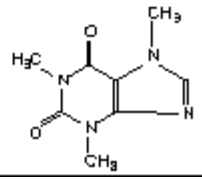
CAFFEINE

$C_8H_{10}N_4O_2$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