Experiment 9: *Reaction of Functional Group - 1*
Some Reactions of Hydrocarbons

Objective:

- To distinguish alkanes, alkenes and aromatic hydrocarbons by their chemical reactions and reactivity.

Introduction

Hydrocarbons are organic compounds containing carbon and hydrogen. The *aliphatic* hydrocarbons include the alkanes, alkenes, alkynes and the alicyclic hydrocarbons (such as cyclohexane).

The *alkanes* are saturated hydrocarbons and tend to be unreactive. These compounds have a single bond between carbon atoms. The unsaturated hydrocarbons have one (or more) multiple bonds between carbon atoms and tend to be chemically reactive. The *alkenes* have a double bond and the *alkynes* have a triple bond.

The cyclic hydrocarbons form a ring of carbon atoms. The *cycloalkanes* have a single bond between all carbon atoms in the ring, whereas the *cycloalkenes* have a double bond between carbon atoms somewhere in the ring. In general, these alicyclic hydrocarbons react with reagents in a similar manner to their linear analogs, *i.e.*, alkanes and alkenes..

The *aromatic* hydrocarbons are compounds related to benzene. These compounds have six carbons in a ring with alternating single and double bonds around the ring. The reactions of the aromatic compounds are unique to this class of unsaturated compounds and are relatively unreactive compared to the aliphatic (linear) alkenes. In this experiment you will use *meta*-xylene (a dimethylbenzene) as a representative aromatic hydrocarbon.

Hydrocarbons

- Aliphatic HC
  - Saturated HC
    - alkane
  - Unsaturated HC
    - alkene
    - alkyne
- Aromatic HC
  - Benzene
  - toluene

Cycloalkanes

Cyclohexane

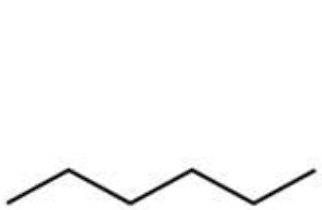
Cycloalkenes

Cyclohexene

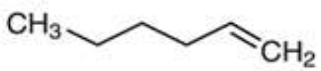
Materials: Test tubes, hexane, cyclohexane, hexene, cyclohexene, m-xylene, dilute $KMnO_4$, aluminum chloride, chloroform, bromine in carbon tetrachloride.

CAUTION!! Be extremely careful handling bromine solution, it can cause burns. If you get it on your skin or clothing wash it immediately with plenty of water.

WEAR SAFETY GLASSES AT ALL TIMES IN LAB

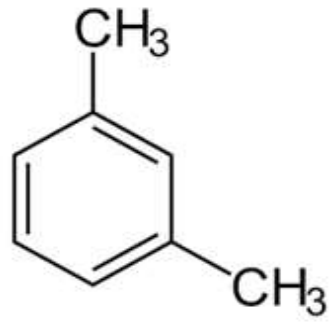


Hexane



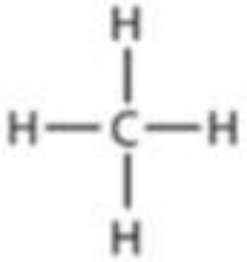
1-Hexene

cyclohexene

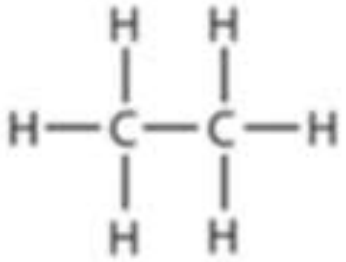


m-Xylene

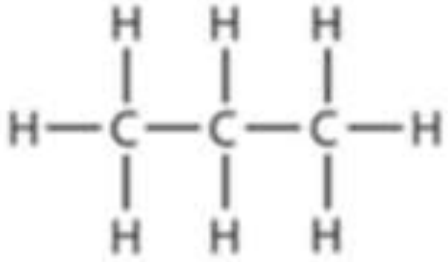
Alkanes and Cycloalkanes



Methane - CH_4

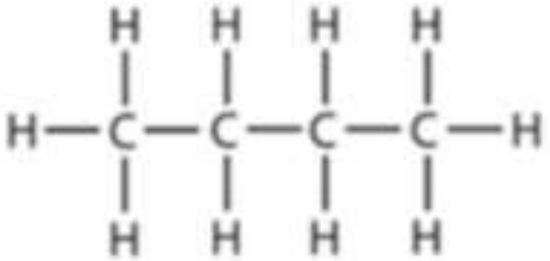


Ethane - C_2H_6

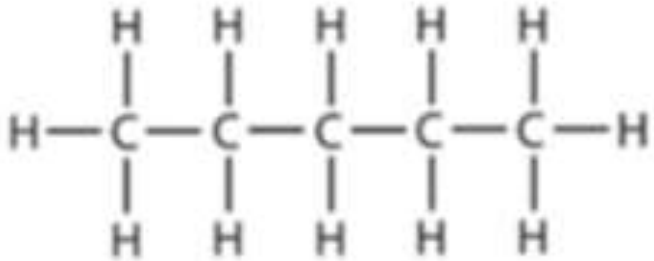


Propane - C_3H_8

Cyclopentane



Butane - C_4H_{10}

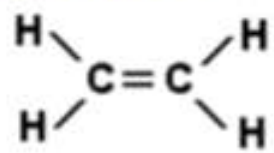


Pentane - C_5H_{12}

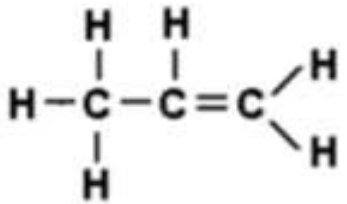
Cyclohexane

Alkenes and Cycloalkenes

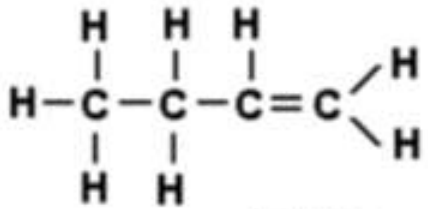
ALKENES



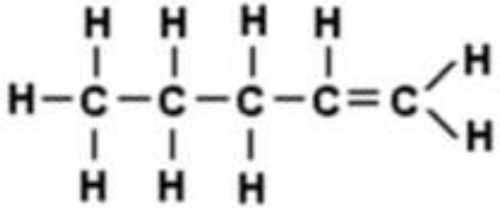
ethene



propene



butene

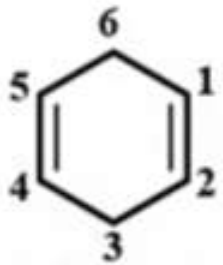


pentene

Cyclobutene

Cyclopentene

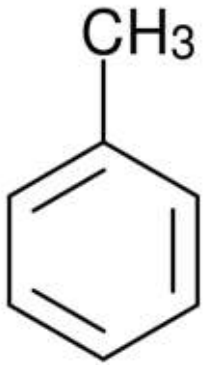
Cyclohexene



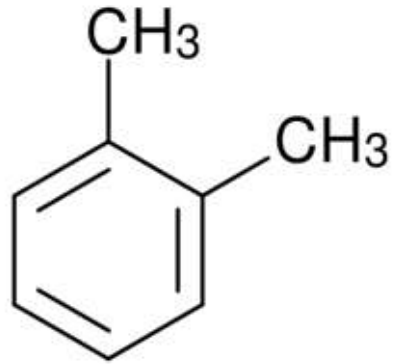
1, 4 - Cyclohexadiene

Aromatic Hydrocarbons

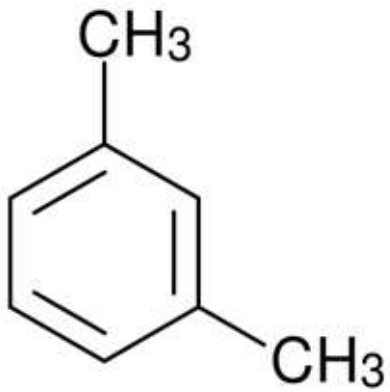
benzene



toluene



ortho-xylene



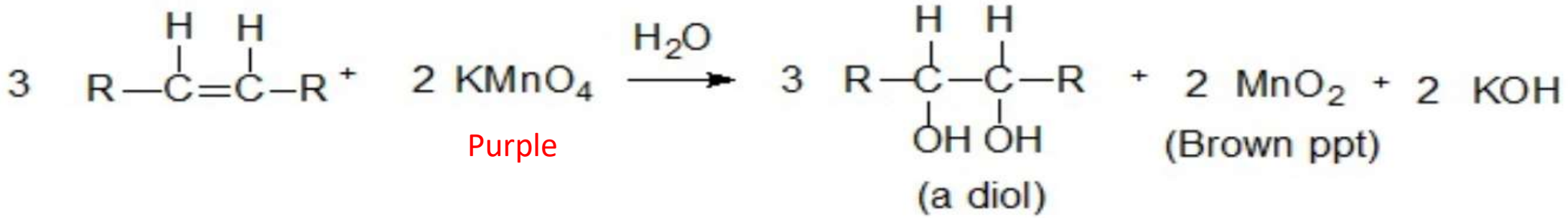
meta-xylene

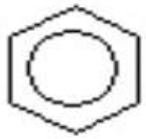
para-xylene

Naphthalene

Part A. Baeyers Test: Reaction of Alkenes with Aqueous Potassium Permanganate

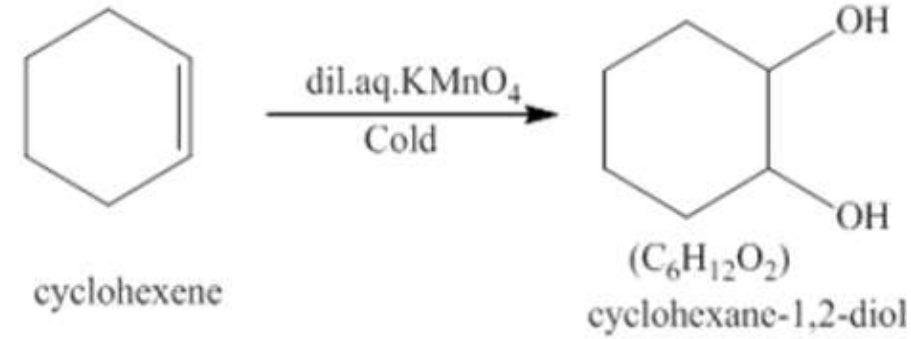
Potassium permanganate is an oxidizing agent that reacts with unsaturated aliphatic hydrocarbons, but does not react with alkanes or aromatic hydrocarbons. The dilute $KMnO_4$ solution has a deep purple color, if there is no reaction you should see no color change. When it reacts with unsaturated aliphatics it produces MnO_2, a brown precipitate. This reaction is useful as a test for the presence of a multiple bond, if there is no other easily oxidizable group, such as an alcohol or aldehyde.

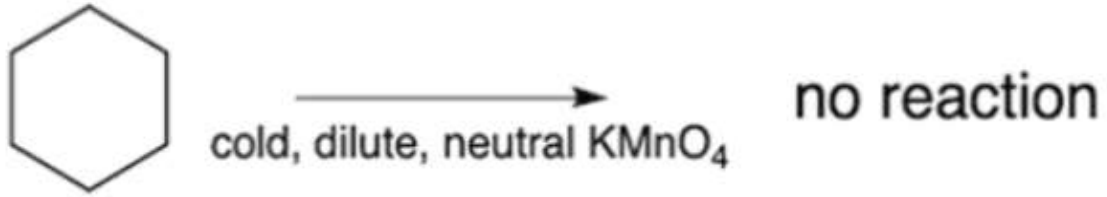


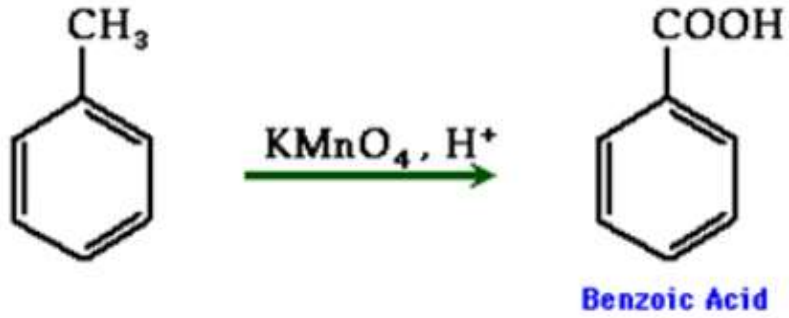
 or $RCH_2—CH_2R + KMnO_4 \longrightarrow$ No Reaction

Procedure:

1. *Place 5 drops of the following HC in clean separate test tubes: Cyclohexane, Cyclohexene, and Toluene.*
2. *Add 2 drops of dilute KMnO4 solution to each test tube and shake.*
3. *Record your observations.*







For Experimental Procedure; See the following YouTubes:

https://youtu.be/B1hqWTKXlQg

$KMnO_4$ test

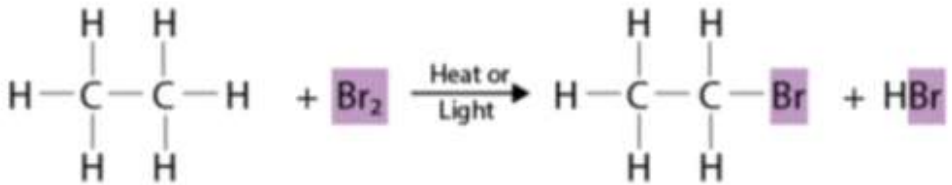
https://youtu.be/pv_-zMbf7Tc

Benzene and Toluene with $KMnO_4$

Part B. Reaction of Alkenes with Bromine (Br_2)

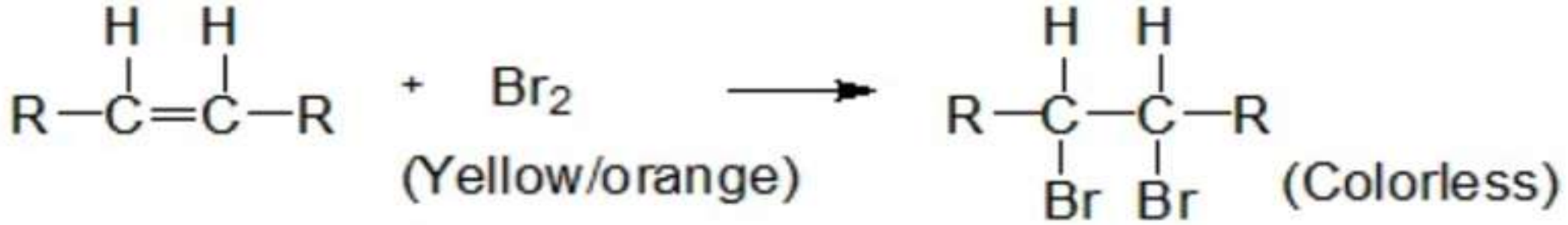
Alkenes, but not alkanes or aromatic hydrocarbons will react with Br_2 in solution to produce the corresponding alkyl bromide (or dibromoalkane). The yellow/orange color of Br_2 will disappear as it reacts with the alkenes; the bromoalkane products are usually colorless. Iodine (I_2) gives a similar reaction and is often used to determine the degree of unsaturation of fats and oils. The amount of unsaturation in fats and oils is often given as the iodine number, which is a related to the amount of iodine consumed by a given amount of fat or oil.

Alkanes react very slowly by substitution only in the presence of ultraviolet light



Alkenes decolorize Bromine rapidly and completely
With dilute solution of Br_2 in CCl_4, even in dark

Ethylene | Bromine (brownish-red) | 1,2-Dibromoethane (colorless)

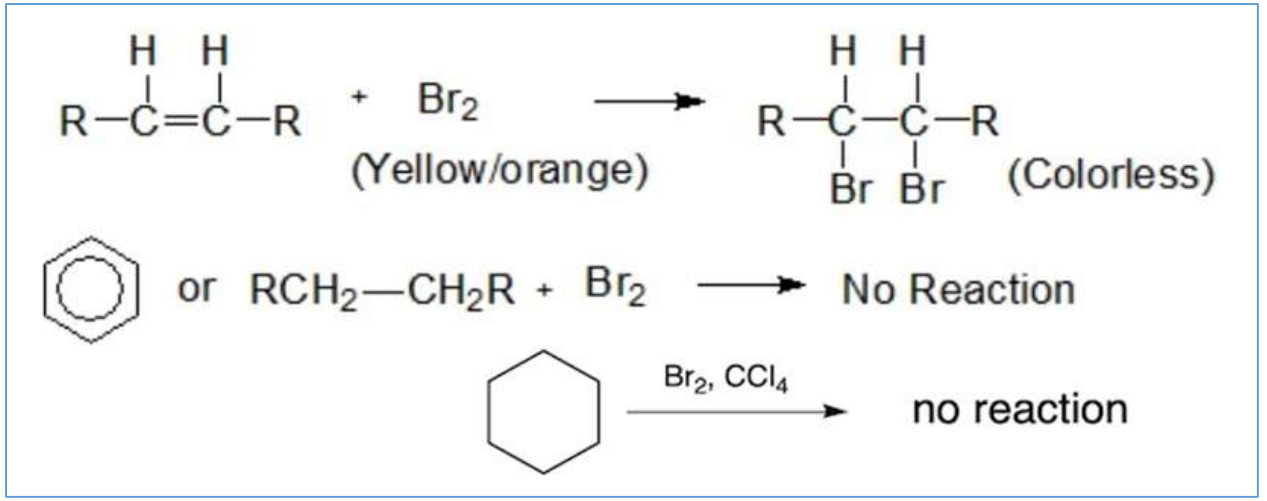


or $RCH_2—CH_2R + Br_2 \longrightarrow$ No Reaction

Br_2, CCl_4 ⟶ no reaction

Procedure:

1. ***Place 5 drops of the following HC in clean separate test tubes: Hexane, Hexene, and Toluene.***
2. ***Add 2 drops of bromine solution to each test tube and observe the disappearance of red color of Br_2.***
3. ***Record your observations.***



For Experimental Procedure; See the following YouTubes:

https://youtu.be/2C_6ax2TsV8

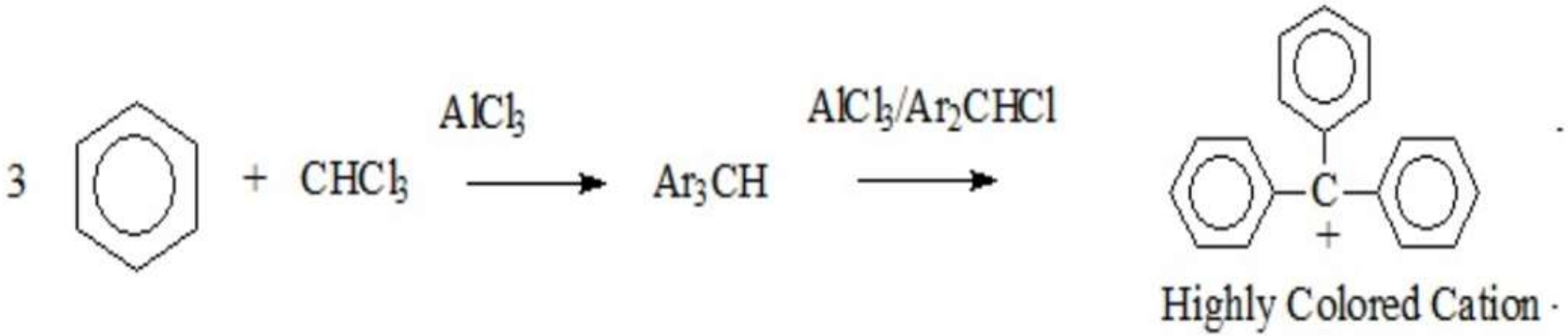
BROMINE TEST HEXANE & HEXENE

https://youtu.be/qEm-CaqhcOs

Br_2 test

Part C. Reaction of Aromatic Hydrocarbons with Chloroform

Aromatic compounds react serially with chloroform in the presence of anhydrous aluminum chloride to produce triarylmethanes (Ar_3CH, where Ar represents an aromatic radical). The product readily undergoes ionization in the presence of $AlCl_3$ and the reaction intermediates to yield a highly colored cation, Ar_3C^+. The color depends on the number of rings in the aromatic hydrocarbon. Benzene and its derivatives give an orange-red color; naphthalene and its derivatives give blue-purple colors.



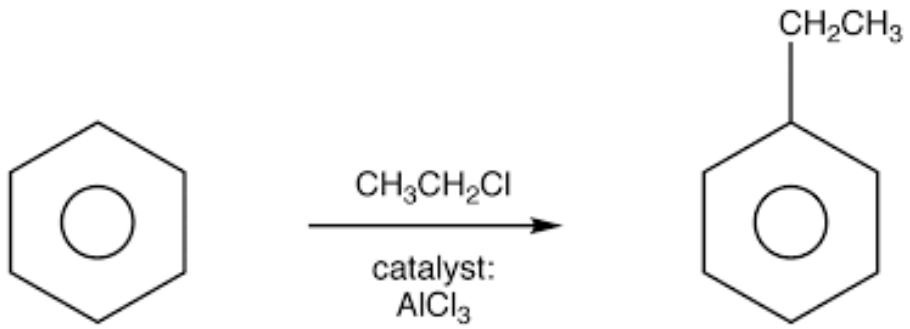
Note: It is essential that the aluminum chloride be anhydrous (water free). Be sure your test tubes and other materials are clean and dry before performing this test.

Procedure

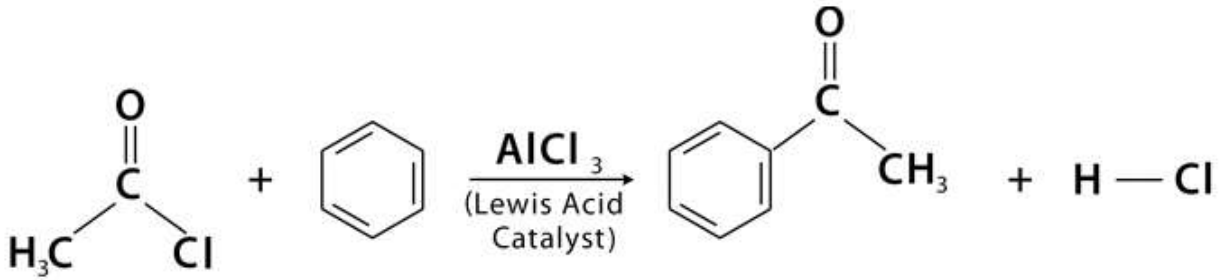
1. Add 1 mL of chloroform to each of 4 (or 5 if you work in pairs) clean, **dry** (no water drops) test tubes.
2. Add 5 drops of the following hydrocarbons to **separate** test tubes containing the chloroform: cyclohexane, cyclohexene, m-xylene, and your unknown. Mix each tube well to dissolve the hydrocarbon in the chloroform.
3. Tilt the first test tube to get some of the solution near the top of the tube, then using a spatula, add a pinch (very little) of $AlCl_3$ to the tilted tube so the powder sticks to the walls of the tube where the solution was (it is not necessary to put the solid $AlCl_3$ in the bottom of the tube).
4. Allow the mixture to stand for 1 or 2 minutes and record your observations on the Report Sheet. Do you observe any color change?
5. Tilt each of the other tubes containing the chloroform mixture with hydrocarbon, and add a pinch of $AlCl_3$ to the tilted test tube so it makes contact with the solution on the walls of the tube as you did for the first tube. Allow it to stand and record your observations on the Report Sheet for each tube.

C. Electrophilic Aromatic Substitution Reactions

1. Friedel – Crafts Alkylation Reaction



2. Friedel – Crafts Acylation Reaction

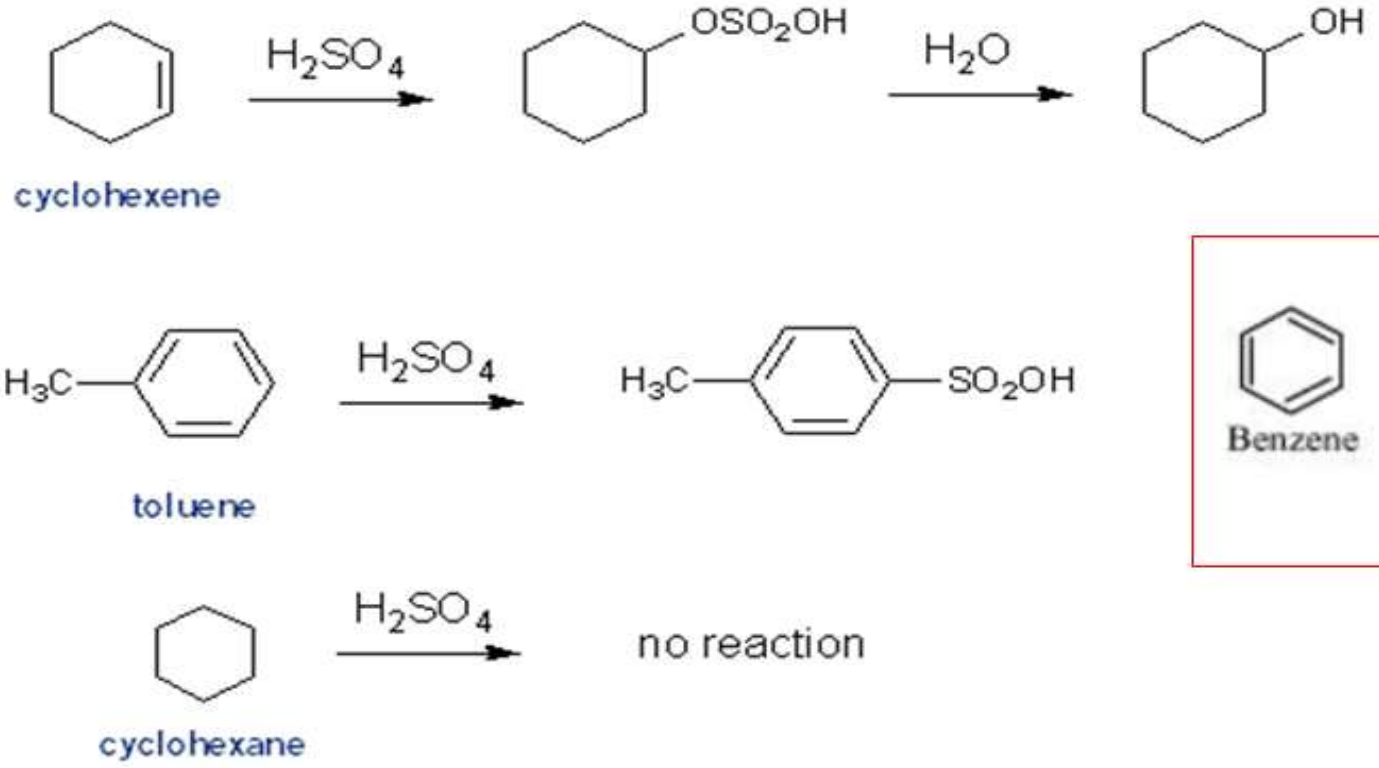


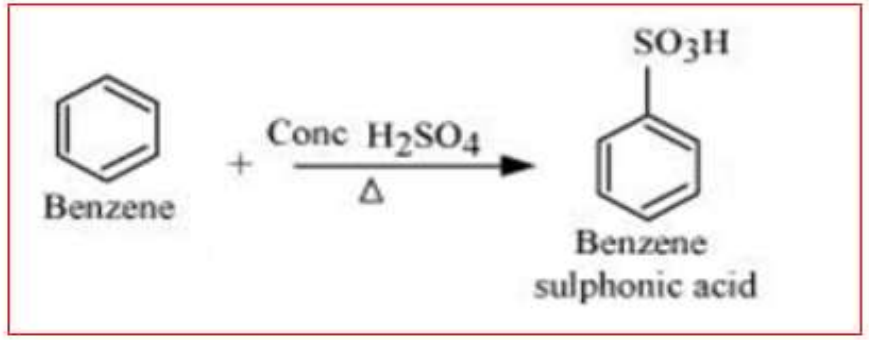
For Experimental Procedure; See the following YouTubes:

https://youtu.be/33D7IYfuEq8
Alkylation and aceylation of benzene

https://youtu.be/mCTHFpwrOKg
Alkylation of *m*-xylene

D. Reaction of Hydrocarbons with Sulfuric Acid





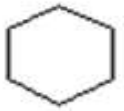
https://youtu.be/oNbwlfqNUD4

H_2SO_4 solubility test cyclohexene, cyclohexane, and benzene

E. Combustion of Hydrocarbon in Presence of O_2

Saturated compounds burn cleanly, while unsaturated ones tend to produce soot.

$$C_3H_8 + 5\,O_2 \longrightarrow 3\,CO_2 + 4\,H_2O$$

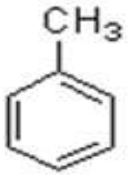


cyclohexane

$$C_6H_{12} + 9\,O_2 \longrightarrow 6\,CO_2 + 6\,H_2O + \text{energy}$$

cyclohexene

$$C_6H_{10} + 8.5\,O_2 \longrightarrow 6\,CO_2 + 5\,H_2O + \text{energy}$$



toluene

$$C_7H_8 + 9\,O_2 \longrightarrow 7\,CO_2 + 4\,H_2O + \text{energy}$$

For Experimental Procedure;
See the following YouTube:

https://youtu.be/EaGbYoZ-6W0

Rxns of Hexane & 1-Hexene:1. Combustion. 2. Br_2 3. $KMnO_4$