Some Reactions of Hydrocarbons

Experiment #2

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

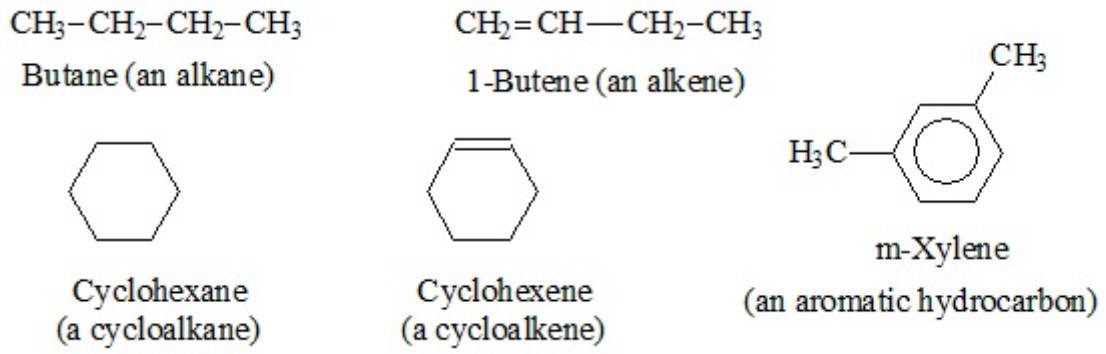
Introduction

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.



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.

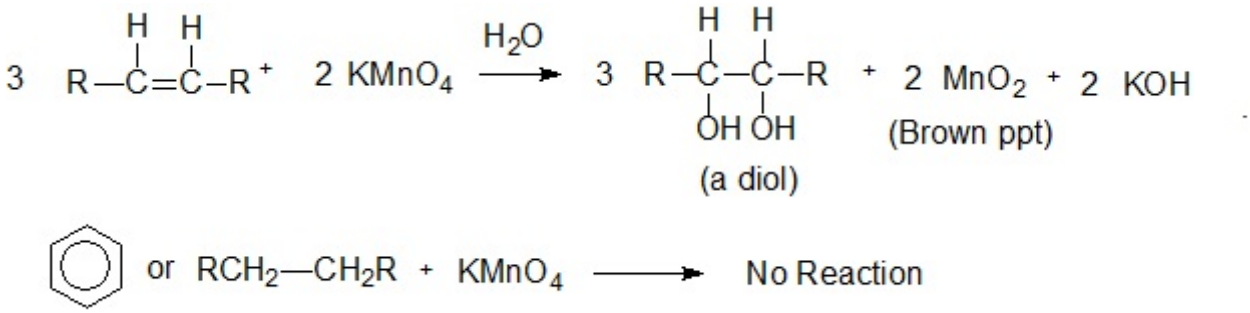
*** * Dispose of all reagents and products in the specially marked organic waste container located in the fume hood. * ***

WEAR SAFETY GLASSES AT ALL TIMES IN LAB

<u>Notice:</u> Each student must have his/her own unknown and be sure to record the number of your unknown on the report sheet. If you work in pairs, each pair must have 2 unknowns. Keep the unknown tubes at your bench until you finish all parts of the lab.

<u>Part A. Baeyers Test: Reaction of Alkenes with Aqueous Potassium Permanganate</u>

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.



Procedure

1. Place 5 drops of each of the following hydrocarbons in clean separate test tubes: hexane, cyclohexane, hexene, cyclohexene, m-xylene and your unknown.

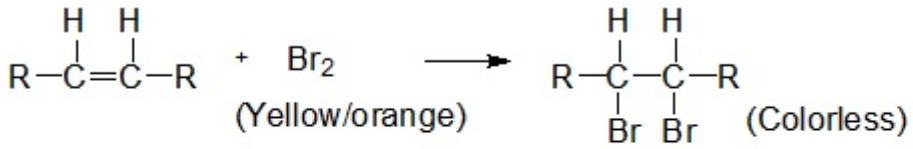
2. Add 2 drops of dilute potassium permanganate ($KMnO_4$) solution to each test tube and shake.

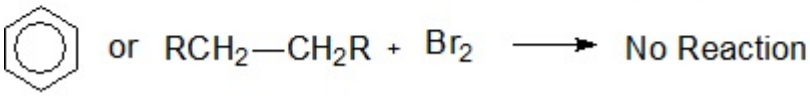
3. Record your observations on the Report Sheet.

****Dispose of these reagents in the Organic Liquid Waste container in the fume hood ****

<u>Part B. Reaction of Alkenes with Bromine (Br_2)</u>

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.





Procedure

1. Place 5 drops of each of the following hydrocarbons in clean separate test tubes: hexane, cyclohexane, hexene, cyclohexene, m-xylene and your unknown.

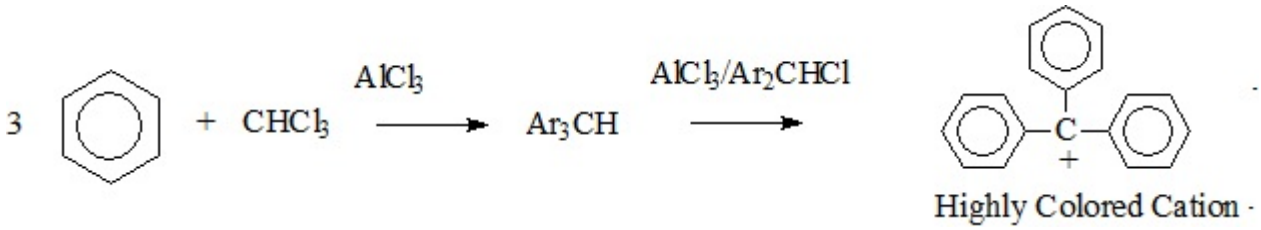
2. Add 2 drops of bromine solution to each test tube and observe whether there is any change in color of the bromine solution indicating a reaction with the hydrocarbon.

3. Record your observations on the Report Sheet.

****Dispose of these reagents in the "Halogentated" Organic Liquid Waste container in the fume hood ****

<u>Part C. Reaction of Aromatic Hydrocarbons with Chloroform</u>

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 <u>dry</u> before performing this test.

Procedure

1. Add 1 mL of chloroform to each of 4 (or 5 if you work in pairs) clean, **<u>dry</u>** (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.

****Dispose of these reagents in the "Halogentated" Organic Liquid Waste container in the fume hood ****

You should now be able to determine to which class of hydrocarbon your unknown belongs: alkanes, alkenes, or aromatic hydrocarbons.

Name _____ Chemistry 4X, Sec _____

Reactions of Hydrocarbons

Experiment #2 **Pre-Lab Exercise**

1. How would you describe the difference between saturated and unsaturated hydrocarbons and what is a distinguishing feature of aromatic hydrocarbons.

2. Describe the relative reactivity of alkanes, alkenes and aromatic hydrocarbons with respect to their chemical reactions. You may want to give some examples in your answer.

3. Alkanes find many commercial uses. Give at least 3 commercial uses for alkanes and name one alkane that is used as you describe. You may want to give the names of 3 specific alkanes and describe how each is used.

4. Safety in the Laboratory should be read before beginning experiments for the semester. It mentions that glassware should be cleaned at the end of each experiment and gives one particular reason for doing this. What is that reason?

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Name _____ Section _____

Reactions of Hydrocarbons

Experiment #2 Data & Report Sheet

Table 1. Observations for reactions with $KmnO_4$, bromine and test for aromatic hydrocarbons.

		Part A. Baeyers Test with $KMnO_4$	Part B. Reaction with Bromine	Part C. Reaction with Chloroform/$AlCl_3$
#1	Hexane			*****
#2	Cyclo-hexane			
#3	Hexene			*****
#4	Cyclo-hexene			
#5	m-Xylene			
#6	Unknown			

Unknown Number _____

Type of Hydrocarbon for Unknown _____

Answer questions on back of page

Questions

1. Did you observe any differences between the reactivity of cycloalkanes or cylcoalkenes relative to the straight chain hydrocarbons in any of the tests where they were compared? Describe any differences you did observe.

2. Should the cyclic compounds behave differently in these tests compared to the straight chain compounds? Explain why or why not.

3. Do you expect the aromatic hydrocarbons to react in a similar way to the cyclic alkenes, since they are both cyclic compounds and have at least one double bond? Explain.