Experimental No. (9) **Identification of hydrocarbons**

Identification of hydrocarbons

Purpose of experimental

1. To investigate the physical properties, solubility and density, of some hydrocarbons.
2. To compare the chemical reactivity of an alkane, an alkene, and an aromatic compound.
3. To use physical and chemical properties to identify an unknown.

Theory part of experimental

Hydrocarbons are organic compounds that contain only carbon and hydrogen. **Hydrocarbons** can be classified into two main types which are: 1) aliphatic hydrocarbons and, 2) aromatic hydrocarbons. **Aliphatic hydrocarbons** are further divided into three major groups which are: 1) alkanes, 2) alkenes and 3) alkynes. **Aromatic hydrocarbons** are hydrocarbons that have at least one aromatic ring. They are known as **arenes**. Some examples of aromatic hydrocarbonsinclude benzene (C_6H_6) and methylbenzene ($C_6H_5CH_3$).These **hydrocarbons** can also be classified into: 1) saturated and, 2) unsaturated hydrocarbons. If ahydrocarbon contains only carbon-carbon single bonds (C-C) and has no multiple bonds(double or triple bonds), it is said to be **saturated** because it has the maximum number of bonded hydrogen atoms. If a hydrocarbon contains multiple bonds, it is said to be **unsaturated**. That means that alkanes and cycloalkanes are classified as saturated hydrocarbons while alkenes, alkynes and aromatic hydrocarbons are known as unsaturated hydrocarbons. **Alkanes** are the simplest family of hydrocarbons that contain carbon – hydrogen bonds and carbon – carbon single bonds. The general formula for alkane is **C_nH_{2n+1}** where **n** can be either 1, 2, 3 and so on.

Experimental No. (9) Identification of hydrocarbons

The Alkanes are only very slightly polar. Alkanes have a fairly restricted set of reactions that in which are combustion, halogenations and cracking process. Alkanes are not very reactive and have little biological activity. **Cycloalkanes** or cyclic alkanes are a type of hydrocarbon just like alkanes but contain one or more rings such as cyclopropane, cyclobutane, cyclopentane, cyclohexane and so on. The larger cycloalkanes with greater than 20 carbon atoms are typically called paraffins. Cycloalkanes have the same general formula as alkenes (**C_nH_{2n}**). Cycloalkanes are similar to alkanes in their general physical properties, but they have higher boiling points, melting points, and densities than alkanes.

Some of the observed **physical properties of hydrocarbons** result from the nonpolar character of the compounds. A-In general, hydrocarbons do not mix with polar solvents such as water or ethyl alcohol. B-On the other hand, hydrocarbons mix with relatively nonpolar solvents such as carbon tetrachloride, or dichloromethane. C-Since the density of most hydrocarbons is less than that of water. Crude oil and crude oil products (home heating oil and gasoline) are mixtures of hydrocarbons; these substances, when spilled on water, spread quickly along the surface because they are insoluble in water. The chemical reactivity of hydrocarbons is determined by the type of bond in the compound. Although saturated hydrocarbons (alkanes) will burn (undergo *combustion*), they are generally unreactive to most reagents.

Alkanes do undergo a substitution reaction with halogens but require ultraviolet light.) Unsaturated hydrocarbons, **alkenes and alkynes**, not only burn, but also react by *addition* of reagents to the double or triple bonds. The addition products become saturated, with fragments of the reagent becoming attached to the carbons of the multiple bond.

Experimental No. (9) Identification of hydrocarbons

Aromatic compounds burn with a sooty flame as a result of unburned carbon particles being present. These compounds undergo *substitution* in the presence of catalysts rather than an addition reaction.

Chemical and Apparatus

1% aqueous KMnO4, 1% Br_2, Concentrated H_2SO_4, Cyclohexene, Hexane, Test tubes, Toluene, Watch glasses, Ice, distilled water

Procedure of Experimental

A- Physical Properties of Hydrocarbons

1- melting and boiling points

2. *Water solubility and density of hydrocarbons*.

Solubility: Add about 2 ml. of water in a small test tube and add 2 or 3 drops of the hydrocarbon (hexane, cyclohexene, toluene) to be tested. Shake the mixture to determine whether the hydrocarbon is soluble (a colorless second layer may be hard to see). Is there any separation of components? Which component is on the bottom; which component is on the top. Record your results.?

Relative Density: Mix the contents as described above. What do you conclude about the density of the hydrocarbon? Is the hydrocarbon *more* dense than water or *less* dense than water? Record your observations.

B- Chemical Properties of Hydrocarbons

1. *Combustion*. Place 5 drops of each hydrocarbon on separate watch glasses. Carefully ignite each sample with a match. Observe the flame and color of the smoke for each of the samples.

Record your observations on the Report Sheet.

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

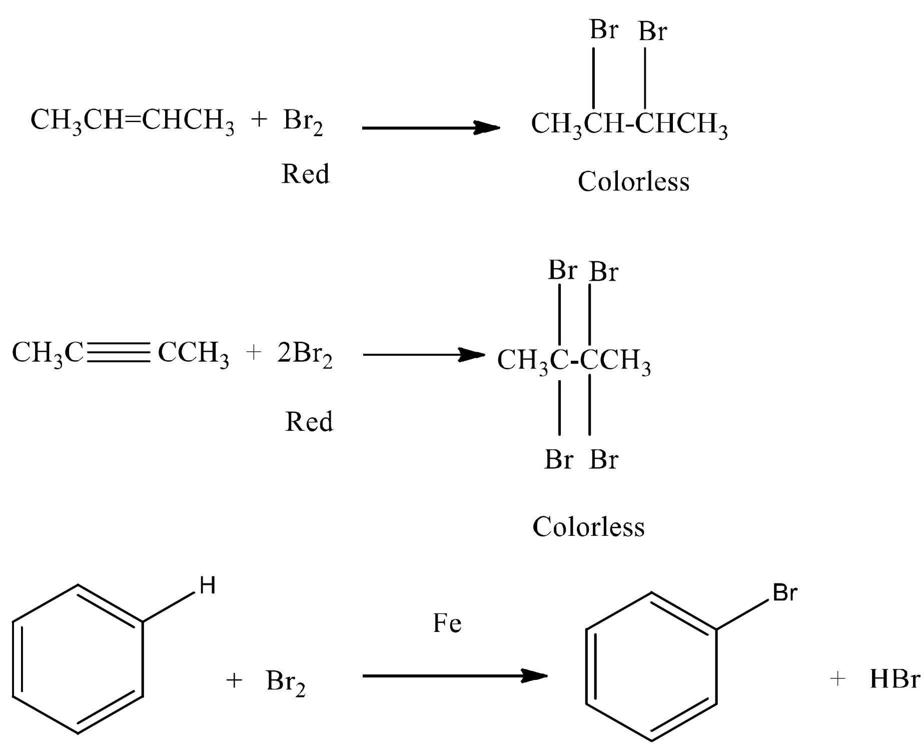
$$CH_3CH_2CH_3 + 5O_3 \longrightarrow 3CO_2 + 4H_2O$$

Experimental No. (9) Identification of hydrocarbons

The major component in "natural gas" is the hydrocarbon methane. Other hydrocarbons used for heating or cooking purposes are propane and butane. The products from combustion are carbon dioxide and water (heat is evolved, also).

2. *Reaction with bromine*.

In a small test tube, add (1 ml) of hydrocarbon (hexane, cyclohexene, toluene) to (3-4 ml) of 2% bromine in carbon tetrachloride (Br_2/CCl_4). Shake well and observe after two or three minutes. If the bromine is not decolorized prepare a second similar tube and place on tube in your laboratory locker and the other in bright sunlight. Allow both tubes to stand for ten to fifteen minutes and compare them. Observe the color of each tube, and whether or not hydrogen bromide was evolved and record the results. Record your observations.



Unsaturated hydrocarbons react rapidly with bromine in a solution of carbon tetrachloride. The reaction is the addition of the elements of bromine to the carbons of the multiple bonds.

The bromine solution is red; the product that has the bromine atoms attached to carbon is colorless. Thus a reaction has taken place when there is a loss of color from the bromine solution and a colorless solution remains. Since **alkanes**, no reaction with bromine is observed; the red color of the reagent would persist when added. **Aromatic compounds** resist addition reactions because of their "aromaticity": *the possession of a closed loop (sextet) of electrons*. These compounds react with bromine in the presence of a catalyst such as iron filings or aluminum chloride. Note that a substitution reaction has taken place and the gas HBr is produced.

4. ***Reaction with concentrated sulfuric acid***.

In a small test tube add 1 ml. of hydrocarbon (hexane, cyclohexene, toluene), cautiously and with gentle shaking, to about 3 ml. of concentrated sulfuric acid. Shake the tubes well and note the results. Observe whether heat evolved and whether the hydrocarbon dissolves. Discard the contents by pouring them into a beaker containing at least 50 mL of water. Although alkanes are inert to cold, concentrated sulfuric acid, alkenes react by addition. The product, alkyl hydrogen sulfate, is soluble in concentrated sulfuric acid. Record your observations.

$$\underset{}{CH_3CH{=}CHCH_3} + \underset{(H_2SO_4)}{HOSO_2OH} \longrightarrow CH_3\underset{\displaystyle H}{\underset{|}{CH}}-\underset{\displaystyle OSO_2OH}{\underset{|}{CH}}CH_3$$

Alkenes react with cold concentrated sulfuric acid by addition. Alkyl sulfonic acids form as products and are soluble in H_2SO_4. Saturated hydrocarbons are unreactive (additions are not possible); alkynes react slowly and require a catalyst ($HgSO_4$); aromatic compounds also are unreactive since addition reactions are difficult.

4. ***Reaction with potassium permanganate (Baeyer's Test)***

In a small test tube, add (1 ml) of hydrocarbon (hexane, cyclohexene, toluene) to a mixture of (3 ml) of dilute potassium permanganate solution (0.5 % $KMnO_4$ solution) and (3 ml) of dilute sodium carbonate solution (10% Na_2CO_3 solution) and shake the tube for 1-2 minutes, and note the results. (Note -Dilute sulfuric acid may be substituted for sodium carbonate. This substitution gives a better test reagent for certain purpose since manganese dioxide is not precipitated in the acid solution)

$$CH_3CH{=}CHCH_3 + KMnO_4 + 4H_2O \longrightarrow 3CH_3\underset{OH}{\underset{|}{C}}H\text{-}\underset{OH}{\underset{|}{C}}HCH_3 + \underset{\text{Brown}}{2MnO_2} + 2KOH$$

Dilute or alkaline solutions of $KMnO_4$ oxidize unsaturated compounds. Alkanes and aromatic compounds are generally unreactive. Evidence that a reaction has occurred is observed by the loss of the purple color of $KMnO_4$ and the formation of the brown precipitate manganese dioxide, MnO_2.

5. ***Unknowns***. By comparing the observations you made for your unknowns with that of the known hydrocarbons, you can identify unknowns A, B, and C. Record their identities on your Report Sheet.

Experimental No. (9)   Identification of hydrocarbons

Table of tests

No.	Name of hydrocarbone	*Combustion*	Test with water		Test with $KMnO_4$	Test with H_2SO_4
			solubility	*Density		
1-						
2-						
3-						
4-						

*Relative densities (L = low, H = high)

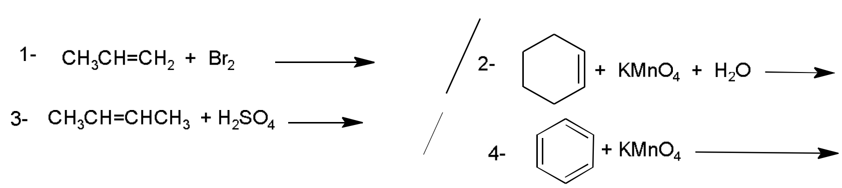
Questions for discussion

1- Distinguish between *saturated* and *unsaturated* hydrocarbons.

2- Show the structural feature that distinguishes whether a hydrocarbon is an alkane, alkene, alkyne, aromatic

3- Hydrocarbons do not mix with water, and they float. Explain these characteristics.

4- Write the structure of the major organic product for the following reactions; if no reaction, write NR.



5- Octane isunbranched alkane of formula C_8H_{18}. Based on your observations in this experiment, predict the following:

a. Solubility in water, b. Combustion characteristics, c. Density versus water.

6- 1-Hexene is alkene. Based on your observations in this experiment, what should you expect to see for this compound in the following tests:

a. Bromine test, b. $KMnO_4$ test, c. Combustion.