Experiment 2

Properties of Alkanes, Alkenes, Aromatic Compounds and an Alcohol

In the reactions we will perform in this experiment, hexane will be used to represent the saturated hydrocarbons, cyclohexene will be used as an unsaturated hydrocarbon, and toluene, the aromatic hydrocarbon. Methanol will also be examined. You will use combustion, reactions with halogens and potassium permanganate, as well as solubility to characterize these organic compounds.

> *As a precaution during these experiments, you should be extremely careful since hydrocarbons are extremely flammable. The Bunsen burner, or other sources of flames, will not be used in the laboratory, unless expressly directed by the instructor.*

The Bunsen burner, or other sources of flames, will not be used in the laboratory, unless expressly directed by the instructor (for the combustion part of this experiment, you will ignite your hydrocarbons using a match). All waste chemicals, both liquids or solids, will be disposed of in the appropriate waste containers.

Methyl alcohol is not a hydrocarbon, since it contains the element oxygen, in addition to its carbon and hydrogen atoms. However, alcohols are used during many chemical processes, and like the hydrocarbons, can be used as a fuel. In fact Indy-type race cars (for the Indianapolis 500 race) often use methanol (a 1-carbon alcohol) as a fuel because it burns clean and is saver than conventional fuels because it does not burn as hot.

After you do each part of this experiment, write conclusions that you can draw about each of the chemicals used. For the unknown samples, try to determine which of the four known organic chemicals it most resembles. Include these conclusions at the end of each experimental section in you lab notebook.

A. Combustion

One of the most important uses of organic compounds, especially hydrocarbons, is combustion. This is the basis of the internal combustion engine and other heat generating sources such as using methane as the fuel for a gas furnace or water heater and propane for your home barbecue. In fact, most alkanes are so unreactive (you will observe this in today's experiment) that the only reaction that they undergo is combustion, combining with molecular oxygen to produce carbon dioxide and water.

Typical combustion reaction: $2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_20$ + heat energy

> ***Caution:*** *All these combution experiments should be performed in the hood, or by placing the evaporating dish on the stainless steel lip of the hood.*

Place about 1 mL (*no more*) of each of the chemicals, in the order shown, in an evaporating dish, one chemical at a time. Start the chemical burning by carefully bringing a lighted match, or burning splint, next to the liquid surface. Repeat this process with an equally small volume of hexane, cyclohexene, and toluene. (Set up your notebook similar to the table below.)

Chemical	Formula	Observations
Methanol	CH_4O	
Hexane	C_6H_{14}	
Cyclohexene	C_6H_{10}	
Toluene	C_7H_8	

For each of the known chemicals used in this experiment, write complete balanced combustion reactions. Include these reactions in your notebook.

After you characterize each these compounds, repeat this analysis with kerosene and each of the two unknown liquids, and make observations.

Chemical	Observations
Kerosene-like	
Unknown A	
Unknown B	

Based on your observations above, what types of hydrocarbons do you think that Kerosene, Unknown A, and Unknown B compounds belong?

B. Reaction with Bromine

> ***CAUTION:*** *Carefully dispense the bromine solution under the hood (you will need about 1 mL total for your experiments) into a small test tube. Be especially careful not to spill any of the bromine on your hands, as bromine is an extremely strong oxidizing agent.*

Add about 1 mL of the hexane, cyclohexene and toluene to three clean test tubes. Add about 3 drops of a 5% bromine solution to each tube. Note any initial observations and any changes, including a change in temperature. Carefully mix the contents of the tubes, and observe what happens.

Did a reaction take place? A reaction occurs when any of the following takes place:

- you have a change in color
- evolution of heat
- formation of a solid
- appearance of a gas

Note: For this reaction, pay attention to the color of the Br_2 that you are adding. If the Br_2 that you are adding just appears to get fainter in color, then no reaction occurred. If the color of the Br_2 that you add disappears, then that is a color change for the Br_2, and a reaction took place between the Br_2 and the organic chemical.

C. Reaction with Potassium Permanganate

The Baeyer test for unsaturated hydrocarbons involves reaction with a hydrocarbon with alkene (or alkyne) like double bonds. Even though you can draw double bonds for aromatic hydrocarbons (benzene or toluene), these double bonds do not react like alkene double bonds. Evidence that an alkene-like double bound is present is the rapid dissappearance of the permanganate purple color. Potassium permanganate is a very strong oxidizing agent and can also oxidize other organic compounds, such as alcohols.

Add 2-3 drops of 0.5% potassium permanganate solution to about 1 mL of hexane, cyclohexene, and toluene added to separate test tubes. Mix the solutions and note the results, including color changes, whether the liquide mixture remains clear, is there change in temperature, etc. Based on your experiments, what types of bonds in hydrocarbons react with potassium permanganate?

D. Kerosene

Using the chemical tests described above, determine whether kerosene belongs to the alkane, alkene or aromatic hydrocarbon groups. Use Tests B and C, reaction with bromine and with potassium permanganate. What did you observe? Can you positively exclude, or include, any of the hydrocarbon families with these tests using kerosene?

E. Acetylene (optional, at the discretion of the instructor, or a class demo)

In this part of the experiment, you will prepare acetylene (ethyne) and test its combustibility.

Fill a 400-mL beaker nearly full of tap water. Fill three test tubes (18x150 mm) with water as follows: Tube #1 completely full; Tube #2 with15 mL water; and Tube #3 with 6 mL water.

Obtain a small lump of calcium carbide from the reagent bottle and drop it into the beaker of water. Place your thumb over the full test tube, invert it, and place the opening of the tube below the water level in the beaker. Remove your thumb, after the tube is in the water, and collect the acetylene glass, holding the tube over the bubbling sample. When the tube is full of gas, and before removing the tube from the water, place a stopper into the tube. Repeat the collection of acetylene gas for the other two tubes, keeping the air in the tube before you collect more acetylene gas. Stopper these tubes as well.

Test the contents of each tube as follows:

- Tube #1: Bring the mouth of the tube to the burner flame as you remove the stopper. After the acetylene ignites, tilt the mouth of the tube up and down.
- Tube #2: Bring the mouth of the tube to the burner flame as you remove the stopper.
- Tube #3: Wrap the tube in a towel and bring the mouth of the tube to the burner flame as you remove the stopper.

What are your observations? Why do these different tubes appear to react differently? What other chemical is required for these reactions to proceed besides the acetylene in the tubes? Why is the tube with the least amount of acetylene (Tube #3) the most explosive of the three?

F. Solubility Tests

Water is usually always used as a solvent for most experiments in chemistry. However, water, which is a polar molecule, and many organic compounds, which are often not polar, at not miscible. Organic compounds which are soluble in water usually also contain polar bonds due to the presence of oxygen, such as the alcohols and acids. Do you expect hydrocarbons, which contain only hydrogen and carbon to be polar?

To test the solubility of hexane, cyclohexene and toluene in water, add 1 mL (no more) of each hydrocarbon to three clean test tubes containing about 5 mL water. Shake each mixture for a few seconds, and note whether the organic chemical dissolves in water. If the chemical does not dissolve, is it more or less dense than water?

Test the miscibility of each hydrocarbon in the other two hydrocarbons. To do this experiment, add about 1 mL of hexane to two clean and dry test tubes. Then, add about 1 mL of the cyclohexene and toluene to each tube. Shake as before, and determine if the chemicals are miscible. If they are not miscible, which chemical is less dense? How could you determine this?

Reagents required for this experiment:

Hydrocarbons:

- hexane (C_6H_{14})
- cyclohexene (C_6H_{10})
- toluene (C_7H_8)
- kerosene (large hydrocarbon consisting mostly of alkanes)

Other Reagents or chemicals:

- 5% bromine (Br_2 dissolved in either trichloroethane or in methylene chloride; either solvent is fine)
- 0.5% potassium permanganate ($KMnO_4$) dissolved in water
- Calcium carbide (CaC_2)

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