HYDROCARBONS

Hydrocarbons are organic compounds which contain only carbon and hydrogen. They are extremely important to our society because so many products are derived from them: fabrics, plastics, antifreeze, cosmetics, insecticides, to name a few.

The major sources of hydrocarbons is petroleum which is an extremely complex mixture of compounds, mainly aliphatic hydrocarbons. Each of us, on the average, directly or indirectly use several tons of petroleum each year, mostly for fuel. We need to consider this fact seriously since petroleum is a natural resource which is not being replenished.

In this experiment you will observe the physical property of solubility of three different groups of hydrocarbons: alkanes, alkenes and aromatic compounds. You will also study some of their chemical properties and reactions.

Types of Hydrocarbons:

<table>
<thead>
<tr>
<th>Types</th>
<th>Characteristic Functional Groups</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkanes</td>
<td>Contain carbon-carbon single bonds</td>
<td>Methane, CH(_4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ethane, C(_2)H(_6)</td>
</tr>
<tr>
<td>Alkenes</td>
<td>Contain carbon-carbon double bonds</td>
<td>Ethylene, C(_2)H(_4)</td>
</tr>
<tr>
<td>Aromatic</td>
<td>Contain a benzene ring</td>
<td>Benzene C(_6)H(_6)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Toluene C(_7)H(_8)</td>
</tr>
</tbody>
</table>

SOLUBILITY (Read pg 404, 365 & 367 of your text.)

The solubility of a substance (the solute) in a solvent is the most important chemical principle underlying three major techniques you will study in the organic chemistry laboratory: crystallization, extraction, and chromatography. In one part of this experiment, you will determine whether an organic compound is soluble or insoluble in a given solvent.

A generalization which is very useful in predicting solubility behavior is the widely used rule, "like dissolves like." This rule is most commonly applied to polar and nonpolar compounds. According to this rule, a polar solvent will dissolve a polar compound or a nonpolar solvent will dissolve a nonpolar substance. The reason why this rule works has to do with the nature of intermolecular forces of attraction (Review section 4.7 pg 136-39, section 4.10 pg 152 and section 5.5 pg 170). The force of attraction between polar molecules is called dipole-dipole interaction between nonpolar molecules it is called van der Waals forces (also called London or dispersion forces). In both cases these attractive forces can occur between molecules of the same
compound or different compounds. In organic chemistry, the solubility rule (like dissolves like) may also be applied to compounds which belong to the same family. For example, 1-octanol (an alcohol) is soluble in the solvent ethyl alcohol. Most compounds within the same family have similar polarity.

If the organic compound being dissolved in a solvent is a liquid, (as is the case in this experiment) then it is sometimes more appropriate to say that the compound and the solvent are miscible. Likewise, if the liquid organic compound is insoluble in the solvent, then they are immiscible.

**REACTIVITY**

**Reactions with Bromine** (See the halogenation reaction on pg 429 of your text.)

In today’s experiment you will use specific chemical reactions and other simple tests to distinguish between alkanes and aromatics. For example, bromine reacts differently with each of these hydrocarbons.

**Alkanes**

\[ R-CH_3 + Br_2 \rightarrow \text{no reaction} \]

**Alkenes**

\[ R-\overset{\text{C}}{\text{C}}-R + Br_2 \rightarrow R-\overset{\text{C}}{\text{C}}-R \quad \text{reddish-brown} \]

The reaction of alkanes with bromine no reaction will occur. The reaction of alkenes with bromine is virtually instantaneous. Whenever a reaction occurs, the reddish-brown color of bromine disappears and colorless products are formed.

**Aromatics** (see section 13.6, pg 437 of your text) are a class of compounds which consist of 3 conjugated double bonds arranged in a six membered ring. Aromatic compounds, however, do not react with bromine as do simple alkenes or polyenes. Aromatic compounds are greatly stabilized by resonance energy, which prevents them from undergoing addition reactions.

\[
\begin{align*}
\text{Toluene} & \quad \text{an aromatic compound} \\
\end{align*}
\]
Reactions with Potassium Permanganate

Potassium permanganate, KMnO₄, reacts with alkenes but not with alkanes. Evidence of this reaction is the disappearance of purple KMnO₄ and the formation of brown manganese dioxide, MnO₂.

\[
3 \text{Alkene} + 2 \text{KMnO}_4 + 2 \text{H}_2\text{O} \rightarrow 3 \text{Alcohol} + 2 \text{MnO}_2 + 2 \text{KOH}
\]

SPECIAL NOTES/SAFETY CONSIDERATIONS

When doing an experiment always wear your goggles. Cyclohexane, cyclohexene, toluene and ethanol are extremely flammable, do not use near a flame. Bromine vapors can be irritating, do all bromine additions in the hood. Dispose of waste in the appropriate containers. Potassium permanganate is a strong oxidizing agent and must be disposed of in its waste container - do not put into organic waste container.

SOLUBILITY TESTS

Procedure:

1. **Physical Properties of Alkanes and Alkenes**: Place about 10 drops of cyclohexane, toluene and cyclohexene in three separate, clean dry test tubes. Compare the odors of the three hydrocarbons.

   Add about 10 drops of water to each test tube. Shake the test tube and note whether the hydrocarbon dissolves. Also note if the hydrocarbon is more or less dense than water.

   Repeat the solubility test with methylene chloride, CH₂Cl₂, with fresh samples of the hydrocarbons in clean test tubes. Do the hydrocarbons dissolve in CH₂Cl₂?
REATIONS

Reactions to Distinguish between Alkanes, Alkenes and Arenes:

a. Reaction with Bromine

Place 10 drops each of cyclohexane, cyclohexene and toluene in separate clean, dry test tubes, and to each add 2 drops of dilute bromine in methylene chloride. Observe whether a reaction (bromination) occurs (did the bromine color dissipate).

b. Reaction with Potassium Permanganate

Determine if the three hydrocarbons react with potassium permanganate, KMnO₄. Dissolve 6 drops of each hydrocarbon in 2 mL of ethyl alcohol (a solvent) in separate test tubes, and add 2 drops of 2% KMnO₄ solution. Is the purple color of the KMnO₄ solution replaced by a brown precipitate? For a positive test, a reaction should occur in one minute or less. The solvent, ethyl alcohol, reacts slowly with KMnO₄, producing a brown color in about 5 minutes.

Lab report: Due 1 week from the completion of lab (Jan 26). Each pair turns in 1 report together.

Photocopy and attached the pages of your lab notebook pertaining to this experiment.

Write out the solubility results and comment on the outcome; did the results make sense? Why or why not?

Write the reaction equations to illustrate the reaction of bromine with cyclohexane, toluene and cyclohexene (Draw the structures of the reactants and products). If there was “no reaction” write NR.

Briefly comment on the reactivity of alkanes, alkenes and aromatics.