**CHEM 132 Lab #1**

**Hydrocarbons**

**Background**

The number of known organic compounds totals into the millions. Of these compounds, the simplest types are those which contain only hydrogen and carbon atoms. These are known as hydrocarbons*.* Because of the number and variety of hydrocarbons that can exist, some means of classification is necessary.

One means of classification depends on the way in which carbon atoms are connected. Chainaliphatic hydrocarbons are compounds consisting of carbons linked either in a single chain or in a branched chain. Cyclichydrocarbons are aliphatic compounds that have carbon atoms linked in a closed polygon (also referred to as a ring*).* For example, hexane (single) and 2-methylpentane (branched) are chain aliphatic molecules, while cyclohexane is a cyclic aliphatic compound.



Another means of classification depends on the type of bonding that exists between carbons. Hydrocarbons which contain only carbon-to-carbon single bonds are called alkanes*.* These are also referred to as saturatedmolecules. Hydrocarbons containing at least one carbon-to-carbon double bond are called alkenes*,* and those compounds with at least one carbon-to-carbon triple bond are called alkynes*.* These are compounds that are referred to as unsaturatedmolecules. Finally, a class of cyclic hydrocarbons that contain a closed loop (sextet) of electrons are called aromatic.

With so many compounds possible, identification of the bond type is an important step in establishing the molecular structure. Quick, simple tests on small samples can establish the physical and chemical properties of the compounds by class.

Some of the observed physical properties of hydrocarbons result from the nonpolar character of the compounds. In general, hydrocarbons do not mix with polar solvents such as water or ethyl alcohol. On the other hand, hydrocarbons mix with relatively nonpolar solvents such as ligroin (a mixture of alkanes), carbon tetrachloride (CC14), or dichloromethane (CH2Cl2). Since the density of most hydrocarbons is less than that of water, they will float. 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 additionof 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. Aromatic compounds, with a higher carbon­-to-hydrogen ratio than nonaromatic compounds, burn with a sooty flame as a result of unburned carbon particles being present. These compounds undergo substitutionin the presence of catalysts rather than an addition reaction.

1. **Combustion** The major component in "natural gas" is the hydrocarbon methane (CH4). Other hydrocarbons used for heating or cooking purposes arc propane (C3H8) and butane (C4H10). The products from combustion are carbon dioxide and water (heat is evolved, also).

CH4 + 2O2 → CO2 + 2H2O + Heat

CH3CH2CH3 + 5O2 →3CO2 + 4H2O + Heat

2**. Reaction with bromine:** Unsaturated hydrocarbons react rapidly with bromine in a solution of carbon tetrachloride or cyclohexane. 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 have only single C—C bonds present, 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.

C6H5-H + Br2 → C6H5-Br + HBr

*Note that a substitution reaction has taken place and the gas HBr is produced.*

1. **Reaction with concentrated sulfuric acid:**Alkenes react with cold concentrated sulfuric acid by addition. Alkyl sulfonic acids form as products and are soluble in H2SO4.



Saturated hydrocarbons are unreactive (additions are not possible); alkynes react slowly and require a catalyst (HgSO4); aromatic compounds also are unreactive since addition reactions are difficult.

1. **Reaction with potassium permanganate:** Dilute or alkaline solutions of KMnO4 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 KMnO4 and the formation of the brown precipitate manganese dioxide, MnO2.



**Procedure**

**Objectives**

* 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

**CAUTION!**

*Assume the organic compounds are highly flammable. Use only small quantities. Keep away from open flames. Assume the organic compounds are toxic and can be absorbed through the skin. Avoid contact; wash if any chemical spills on your person. Handle concentrated sulfuric acid carefully. Flush with water if any spills on your person. Potassium permanganate and bromine are toxic; bromine solutions are also corrosive. Although the solutions are diluted, they may cause burns to the skin.* ***Wear gloves when working with these chemicals****.*

**Chemicals and Equipment**

1. 1% aqueous KMnO4
2. 1% Br2 in cyclohexane
3. Blue litmus paper
4. Concentrated H2SO4
5. Cyclohexene
6. Hexane
7. Aluminum chloride
8. Test tubes
9. Ligroin
10. Toluene
11. Unknowns A, B, and C
12. Watch glasses
13. Ice

**General instructions**

1. The hydrocarbons hexane, cyclohexene, and toluene (alkane, alkene, and aromatic) are available in dropper bottles.
2. The reagents 1% Br2 in cyclohexane, 1% aqueous KMn04, and concentrated H2SO4 are available in dropper bottles.
3. Unknowns are in dropper bottles labeled A, B, and C. They may include an alkane, an alkene, or an aromatic compound.
4. Test tubes of 100 X 13 mm will be suitable for all the tests. When mixing the components, grip the test tube between thumb and forefinger; it should be held firmly enough to keep from slipping but loosely enough so that when the third and fourth fingers tap it, the contents will be agitated enough to mix.
5. Record all data and observations in the appropriate places on the Data Sheet.
6. Dispose of all organic wastes as directed by the instructor. **Do not pour into the sink!**

**Physical Properties of Hydrocarbons**

1. **Water solubility of hydrocarbons.**
2. Label six test tubes with the name of the substance to be tested. Place into each test tube 5 drops of the appropriate hydrocarbon: hexane, cyclohexene, toluene, unknown A, unknown B, unknown C.
3. Add about 5 drops of water dropwise into each test tube. Water is a polar solvent. Is there any separation of components? Which component is on the bottom; which component is on the top? Mix the contents as described above.
4. What happens when the contents are allowed to settle? 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. Save these solutions for comparison with the next part.
5. **Solubility of hydrocarbons in ligroin**.
6. Label six test tubes with the name of the substance to be tested. Place into each test tube 5 drops of the appropriate hydrocarbon: hexane, cyclohexene, toluene, unknown A, unknown B, unknown C.
7. Add about 5 drops of ligroin dropwise into each test tube. Ligroin is a nonpolar solvent. Is there a separation of components? Is there a bottom layer and top layer?
8. Mix the contents as described above. Is there any change in the appearance of the contents before and after mixing? Compare these test tubes to those from the previous part. Record your observations. Can you make any conclusion about the density of the hydrocarbons from what you actually see?

**Chemical Properties of Hydrocarbons**

1. **Combustion.**

The instructor will demonstrate this test in the fume hood. Place 5 drops of each hydrocarbon and unknown on separate watch glasses. Carefully ignite each sample with a match. Observe the flame and color of the smoke for each of the samples.

1. **Reaction with bromine.**
2. Label six clean, dry test tubes with the name of the substance to be tested. Place into each test tube 5 drops of the appropriate hydrocarbon: hexane, cyclohexene, toluene, unknown A, unknown B, unknown C.
3. Carefully add (dropwise and with shaking) 1% Br2 in cyclohexane. Keep count of the number of drops needed to have the color persist; do not add more than 10 drops. Record your observations. To any sample that gives a negative test after adding 10 drops of bromine solution (i.e., the red color persists), add 5 more drops of 1% Br2 solution and a small quantity of aluminum chloride, the amount on the tip of a micro-spatula; shake the mixture.
4. Hold, with forceps, a piece of moistened blue litmus paper and lower it into the test tube until it is just above the surface of the liquid. Be careful and try not to touch the sides of the test tube or the liquid with the litmus paper. Record any change in the color of the solution and the litmus paper.

**Caution!** *Use 1% Br2 solution in the hood; wear gloves when using this chemical. Use the aluminum chloride in the hood: wear gloves when using this chemical. The bottle of aluminum chloride is kept in a desiccator; quickly take your sample and return the bottle to the desiccator. Do not leave the bottle open or outside the desiccator for a long time.*

1. **Reaction with KMnO4**
2. Label six clean, dry test tubes with the name of the substance to be tested. Place into each test tube 5 drops of the appropriate hydrocarbon: hexane, cyclohexene, toluene, unknown A, unknown B, unknown C. Carefully add (dropwise) 1% aqueous KMnO4 solution; after each drop, shake to mix the solutions.

1. Keep count of the number of drops needed to have the color of the permanganate solution persist; do not add more than 10 drops. Record your observations.
2. **Reaction with concentrated H2SO4**
3. Label six clean, dry test tubes with the name of the substance to be tested. Place into each test tube 5 drops of the appropriate hydrocarbon: hexane, cyclohexene, toluene, unknown A, unknown B, unknown C.
4. Place all of the test tubes in an ice bath. **Wear gloves and carefully**add (with shaking) 3 drops of cold, concentrated sulfuric acid to each test tube. Note whether heat is evolved by feeling the test tube. Note whether the solution has become homogeneous or whether a color is produced. (The evolution of heat or the formation of a homogeneous solution or the appearance of a color is evidence that a reaction has occurred.) Record your observations.
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 Data Sheet.

**Data Sheet:** Hydrocarbons

**Physical properties of hydrocarbons**

**Solubility:**Does the hydrocarbon mix with the solvent, *soluble,* or not mix with the solvent, *insoluble?* Use the observations you make for the solubility tests and determine whether the hydrocarbons are polar or non-polar substances.

**Density:**For water, is the density *greater* than water (sinks) or *less* than water (floats)? For ligroin, can you tell anything about the relative densities?

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| --- | --- | --- |
| Hydrocarbon | H2OSolubility Density | LigroinSolubility Density |
| HexaneCyclohexeneTolueneUnknown AUnknown BUnknown C |  |  |  |  |

**Chemical properties of hydrocarbons**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Hydrocarbon** | **Combustion** | **Bromine****Test** | **KMnO4****Test** | **H2SO4****Test** |
| HexaneCyclohexeneTolueneUnknown AUnknown BUnknown C |  |  |  |  |

Unknown A is\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Unknown B is\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Unknown C is\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Pre-lab:** Hydrocarbons

1. Give an example of a saturatedhydrocarbon and an unsaturatedhydrocarbon and their respective names and structures.
2. Show the structural feature that distinguishes whether a hydrocarbon is an alkane, alkene, alkyne, aromatic
3. Gasoline and water do not mix. Why?