LAB: Reactions of some Hydrocarbons

Introduction

Hydrocarbons are those compounds containing hydrogen and carbon only. The reactions of hydrocarbons with reagents such as $H_{2(g)}$, $Br_{2(l)}$, hydrogen halides, HX, with water (with $H_2SO_{4(aq)}$), has already been considered in the class. In this lab, both the reagents considered and the compounds on which the reaction might occur will be limited.

In this **lab you will used:** ***cyclohexane,*** C_6H_{12}, as an example of a cyclic, saturated hydrocarbon, ***cyclohexene,*** C_6H_{10}, as an example of an unsaturated hydrocarbon, ***methylbenzene (toluene),*** $C_6H_5CH_3$, as an example of an aromatic hydrocarbon.

Alkanes and cycloalkanes are called ***saturated hydrocarbons*** because their molecules are made up single bonds only and the compounds are generally quite unreactive towards oxidizing agents or even concentrated sulphuric acid.

Alkenes and cylcoalkenes are ***unsaturated hydrocarbons*** because they contain carbon-carbon double or triple bonds, which are very reactive sites. Thus, atoms or groups can be added across the double or triple bonds to form more saturated compounds.

Aromatics, such as toluene contain a ***benzene*** ring structure. Reactions of aromatics are principally substitutions.

There are **reactions which may be eliminated in the lab:** hydrogenation (this requires n expensive metal catalyst), polymerization (this requires special conditions and equipment), and the addition of hydrogen halides (requires dangerous gaseous compounds).

The decolourization of bromine, $\mathbf{Br_2}$, dissolved in a solvent, such as trifluorotrichloroethane,(TTE), can be used as a test for unsaturation. A further test for unsaturation is the reaction of dilute acidified ***potassium permanganate,*** $KmnO_4$, solution with an unsaturated hydrocarbon. Under suitable conditions water may also add to alkenes in the presence of $H_2SO_{4(aq)}$, at a reasonable reaction rate. Such conditions might involve adding energy by means of higher temperature or light, or different concentrations of reagent and/or reactant, or a different length of time.

You will be provided with the following reagents:

Cyclohexane, cyclohexene, methylbenzene (toluene), bromine in TTE, $H_2SO_{4(aq)}$ (9M), $KmnO_{4(aq)}$, $HCl_{(aq)}$, (12 M).

Planning

Investigate the conditions under which Br_2, $H_2SO_{4(aq)}$/ H_2O, $KmnO_4$ might react with each of the organic reactants. You need to consider what conditions might be varied, and how. Safety concerns are crucial. Hydrocarbons are flammable and must be kept out of the atmosphere as much as possible. No open flames should be used. Bromine is corrosive and very volatile. Concentrated acids may char your skin and decompose your clothes. Your procedure must take these problems into account. You must obtain my approval before starting the experiment. I will prohibit any procedure that I consider dangerous. Time will be saved if you show me your procedure ***before*** you come to the lab. Your procedure should indicate the amounts and concentrations of materials to be used. This smaller the scale the better!

Write-Up

This experiment will be marked on Planning b), Data Collection, Conclusion and Evaluation; these should constitute the main part of your report.

Extension

1. a) Give structural diagram for each of the hydrocarbons used.
   b) Which of the above hydrocarbons contain double bonds?
2. Which of the hydrocarbons were readily oxidized by the potassium permanganate solution? Give a reason for your answer.
3. Which of the hydrocarbons were reactive to the bromine solution? Given a reason for your answer?
4. What is the relationship between the reactivity noted in question #2 and #3 and the structure noted in question #1?
5. Name the type of reaction that occurred in question # 3 above.
6. Look up the bond energies of the C-C single, double and the resonant double bonds in benzene in your IB Data Book. What does this suggest about the reactivity of alkanes compared to alkenes? Account for the bond length in benzene.
7. Account for the absence of reactivity of toluene with the test reagents.
8. Which of the tests you performed are likely to be positive with the following:
   a) gasoline
   b) linseed oil

   Explain your answer.

9. Under what conditions might the saturated hydrocarbons react with bromine? What does this suggest about the reaction mechanism of a saturated alkane with a halogen?
10. a) What are the products of complete combustion of a hydrocarbon?
    b) Use your text book to write full ***thermochemical*** equations for the combustion of methane, ethane and propane.
    c) How do your answers to part 10b), above relate to the use of the alkenes?