<u>AP Chemistry Chapter 22 - Organic Chemistry</u>

22.1 Alkanes: Saturated Hydrocarbons

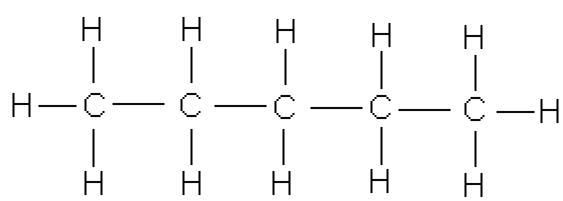
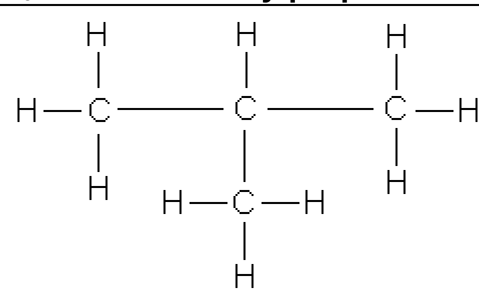
A. Straight-chain Hydrocarbons

1. Straight-chain alkanes have the formula C_nH_{2n+2}
2. Carbons are *sp*^{3} hybridized

The First 10 Alkanes		
# of Carbons	*Name*	*Formula* (C_nH_{2n+2})
1	Methane	CH_4
2	Ethane	C_2H_6
3	Propane	C_3H_8
4	Butane	C_4H_{10}
5	Pentane	C_5H_{12}
6	Hexane	C_6H_{14}
7	Heptane	C_7H_{16}
8	Octane	C_8H_{18}
9	Nonane	C_9H_{20}
10	Decane	$C_{10}H_{22}$

B. Structural Isomers

1. Same formula, but the atoms are bonded together in a different order
2. Different bonding order results in different properties

C_4H_{10} **Butane**	C_4H_{10} **2-methylpropane**
	

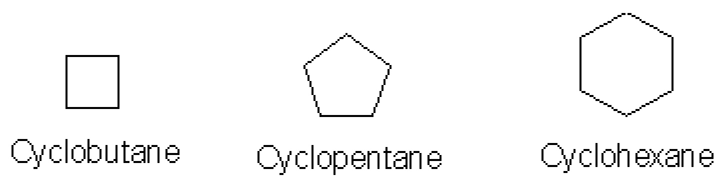
C. Rules for Naming Alkanes (Nomenclature)

1. For a branched hydrocarbon, the longest continuous chain of carbon atoms gives the root name for the hydrocarbon
2. When alkane groups appear as substituents, they are named by dropping the *-ane* and adding *-yl*.
3. The positions of substituent groups are specified by numbering the longest chain of carbon atoms sequentially, starting at the end closest to the branching.
4. The location and name of each substituent are followed by the root alkane name. The substituents are listed in alphabetical order (irrespective of any prefix), and the prefixes *di-, tri-*, etc. are used to indicate multiple identical substituents.

D. Reactions of Alkanes
    1. Combustion reactions
        a. $2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(g)$
    2. Substitution reactions
        a. $CH_4 + Cl_2 \xrightarrow{hv} CH_3Cl + HCl$
        methane chloromethane

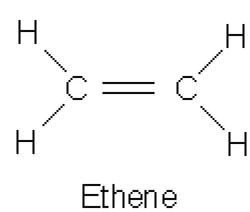
    3. Dehydrogenation reactions
        a. $CH_3CH_3 \xrightarrow{Cr_2O_3 \;\; at \;\; 500°C} CH_2 = CH_2 + H_2$
        ethane ethylene

E. Cyclic Alkanes (Cycloalkanes)
    1. Alkanes in which the carbon atoms are arranged in a ring, or cyclic, structures

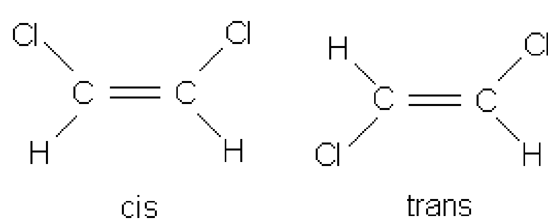


        a. The 90° angle in cyclobutane is not nearly tetrahedral, therefore the molecule is quite unstable
    2. Nomenclature
        a. Rings are numbered to give the smallest substituent numbers possible
        b. Largest substituents are given the lowest possible numbers

22.2 Alkenes and Alkynes
A. Alkenes
    1. Hydrocarbons that contain double bonds
        a. The simplest alkene is ethene, or ethylene (C_2H_4)
        b. Alkenes are nonpolar molecules



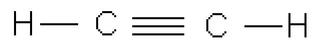
B. Geometric Isomers
    1. Isomers in which the order of atom bonding is the same but the arrangement of atoms in space is different
    2. A molecule can have a geometric isomer only if two carbon atoms in a rigid structure each have two different groups attached



Cis 1,2-dichloroethane *Trans* 1,2-dichloroethane

3. In some isomer pairs, one isomer is biologically active, while the other is not (specificity of enzymes is the cause)

C. Alkynes
   1. Hydrocarbons with triple covalent bonds
      a. The simplest alkyne is ethyne, or acetylene (C_2H_2)



Ethyne

      b. Alkynes are nonpolar molecules

D. Reactions of Alkenes and Alkynes
   1. Addition reactions
      a. Hydrogenation

$$CH_2 = CHCH_3 + H_2 \xrightarrow{Catalyst} CH_3CH_2CH_3$$

Propene → Propane

      b. Halogenation

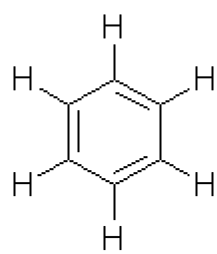
$$CH_2 = CHCH_2CH_2CH_3 + Br_2 \rightarrow CH_2BrCHBrCH_2CH_2CH_3$$

1-Pentene → 1-2-dibromopentene

      c. Polymerization
         (1) small molecules are joined together to form a large molecule

22.3 Aromatic Hydrocarbons

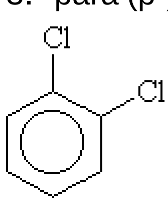
A. Structure of Aromatics
   1. Hydrocarbons with six-membered carbon rings and delocalized electrons
      a. The simplest aromatic hydrocarbon is benzene (C_6H_6)



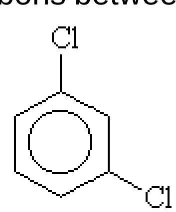
Benzene

      b. Aromatic hydrocarbons are nonpolar molecules

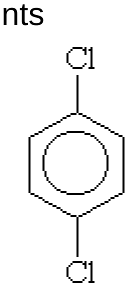
B. Geometric Isomerism
   1. ortho (o-) = two adjacent substituents
   2. meta (m-) = one carbon between substituents
   3. para (p-) = two carbons between substituents



o-dichlorobenzene



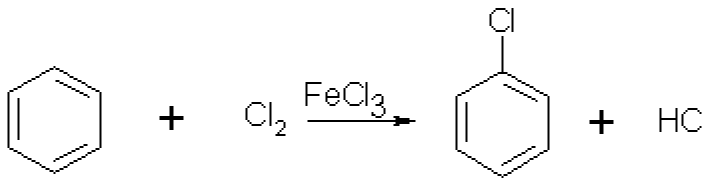
m-dichlorobenzene



p-dichlorobenzene

C. Reactions of Aromatic Hydrocarbons

1. Substitution reactions



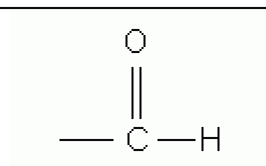
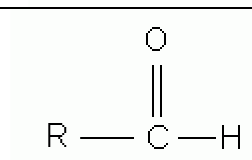
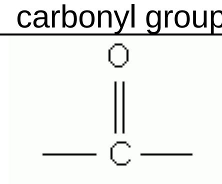
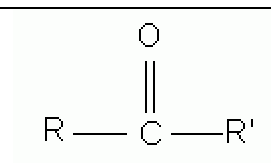
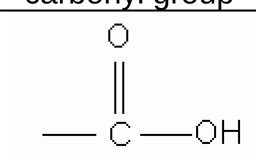
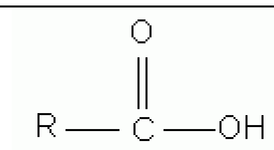
22.4 The Petrochemical Industry

<u>A Brief Narrative</u>:

Petroleum contains molecules that vary from short chain (1 to 4 carbons) to very long chains (greater than 25 carbons). In the nineteenth century, kerosene and gas oil were the most desirable "fraction" of petroleum. With the advent of the internal combustion engine, the shorter chain molecules that make up gasoline became more important. Until that time they were considered a waste product of the purification of kerosene.

Rather than waste the kerosene-gas oil fraction, refineries take the long chain molecules and break them into the smaller molecules of gasoline in a process called "cracking".

22.5 Hydrocarbon Derivatives

Classes of Organic Compounds		
Class	Functional Group	General Formula
Alcohol	—OH hydroxyl group (-OH)	R—OH
Alkyl halide	—X	R—X
Ether	—O—	R—O—R'
Aldehyde	 carbonyl group	
Ketone	 carbonyl group	
Carboxylic acid	 carboxyl group	

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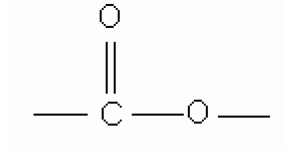
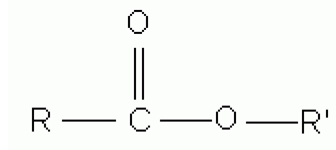
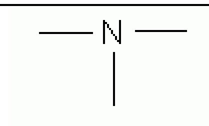
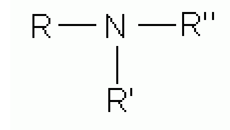
<tr><td>Ester</td><td></td><td></td></tr>
<tr><td>Amine</td><td>
amine group</td><td></td></tr>
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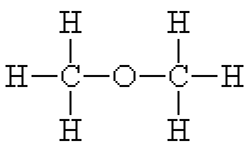
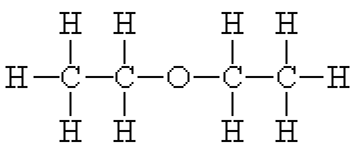
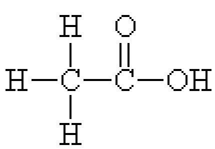
Examples:



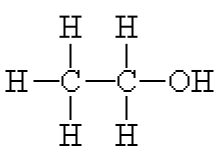
Class: Ether Name: dimethylether



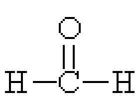
Class: Ether Name: diethylether



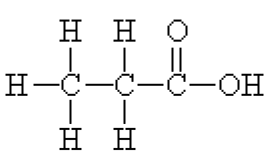
Class: Carboxylic acid Name: ethanoic acid



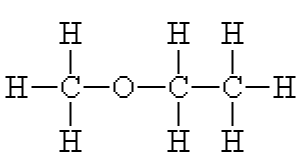
Class : Alcohol Name: ethanol (ethyl alcholol)



Class: Aldehyde Name: methanaldehyde



Class: Carboxylic acid Name: propanoic acid



Class: Ether Name: ethylmethylether