Organic Chemistry

I. Organic chemistry - the chemistry of carbon compounds
- A. Carbon - forms 4 covalent bonds with other compounds and with other compounds
  - 1. allows for limitless combinations
- B. Organic compounds - obtained from petroleum, coal, wood, and plant products

II. Characteristics of Organic Compounds
- A. Bonding - generally nonpolar (held together by weak Van der Waals forces)
  - 1. 4 valence electrons in C
    - a. forms 4 covalent bonds
    - b. forms a tetrahedron shape
    - c. shares electrons with other carbon atoms
      - 1. carbons can share from 1 to 3 pair of electrons
        - a. a single bond up to a triple bond
- B. Compounds have molecular characteristics
  - 1. exist as gases, liquids or low melting point solids
  - 2. Solubility - nonpolar and tends to dissolve in nonpolar solvents (benzene)
  - 3. Conductivity - generally nonelectrolytes
    - a. some organic acids are weak electrolytes (CH_3COOH acetic acid)
  - 4. Melting Points - generally low melting points (< 300° C)
  - 5. Rate of Reaction - usually slower than those involving inorganic compounds
    - a. require high activation energy
    - b. do not readily form activated complexes (intermediates)
- C. Structural Formulas - a covalent bond shown as a dash in between atoms
  - 1. represents a pair of shared electrons (show variations including double and triple bonds)
  - 2. Isomers - compounds with the same molecular formula and different structural formulas (give examples of isomers)
- D. Saturated and Unsaturated Compounds
  - 1. Saturated - all single bonds
  - 2. Unsaturated - contains one or more double or triple bonds (show examples)

III. Homologous Hydrocarbon Series - contain only carbon and hydrogen (Tables P & Q)
- A. As molecular size increases, boiling and freezing points increase (increases Van der Waals)
  - 1. Alkanes (paraffin series)- (open straight or branched chains - aliphatic) (Saturated)
    - a. General Formula = C_nH_{2n+2}
    - b. use IUPAC prefixes with ane endings to name compounds (meth (1), eth (2), prop (3), but (4) (isomers start), pent (5), hex (6), hept (7), oct (8), non (9), dec (10)
    - c. Isomers
      - 1. Name the longest carbon chain using prefixes (parent chain name last)
      - 2. name the side carbons using the lowest number of carbons to get there
      - 3. If the same side group appears more than once, number each and attach the prefix di, tri, tetra, penta etc. (2, 3 dimethyl pentane)
      - 4. Halogen groups and other nonalkyl groups are also named from their positions
      - 5. If there are 2 or more different substituted groups in a name, they are arranged alphabetically
  - 2. Alkenes (ethylene or olefin series) - aliphatic unsaturated hydrocarbons with one double bond (Unsaturated)

a. General Formula = C_nH_{2n}
b. Use IUPAC prefixes with ene endings
c. Number the location of the double bond with the lowest number
d. With isomers, follow the same rules as the alkanes in identifying the side chains

3. Alkynes (acetylene series) - aliphatic unsaturated hydrocarbons with one triple bond (Unsaturated)
   a. General Formula = $C_nH_{2n\ -2}$
   b. Use IUPAC prefixes with yne endings
   c. Number the location of the triple bond with the lowest number
   d. the first member of the series is acetylene
   e. With isomers, follow the same rules as the alkanes in identifying the side chains
4. Alkyl radicals - alkane molecules with an open bond for attachment
   a. Use IUPAC prefixes with yl endings
5. ***Alkadienes - aliphatic chain of hydrocarbons containing more than one double bond***
   a. ***General Formula = $C_nH_{2n\ -2}$ (same as alkynes)***
   b. ***Use IUPAC prefixes with diene endings***
   c. ***Number the location of the double bonds with the lowest number***
6. ***Aromatics (benzene series) - cyclic series of carbon chains (ring compounds)***
   a. ***General formula = C_nH_{2n-6}***
   b. ***benzene is C_6H_6, toluene (methylbenzene) is C_7H_8 ($C_6H_5CH_3$)***
   c. ***Carbons form rings with alternating double bonds***

IV. Functional Groups - an atom or group of atoms that characterizes the structure of a family of organic compounds and determines many of their properties Table R

A. Alkyl halides – addition of a halogen to a hydrocarbon

B. Alcohol (hydroxyl group) R-OH
1. Use IUPAC prefixes with ol endings, but drop the e (ex. Ethanol)
2. Number the position of the alcohol group if it is not on the end
3. has polar and nonpolar characteristics (larger molecules are more nonpolar)
4. ***Dihydroxy Alcohols (glycols) - covalently bonded (does not dissociate)***
   a. ***Use IUPAC prefixes with diol endings and numbers indicating position (ex 1,2-ethanediol - common name is ethylene glycol (antifreeze))***
5. ***Trihydroxy Alcohols - 3 OH groups (more OH groups increases polarity of molecule)***
   a. ***Use IUPAC prefixes with triol endings and numbers indicating position (ex. 1,2,3 - propanetriol - common name is glycerol (glycerine))***
6. ***Primary Alcohols – the # of carbons touching the OH carbon is 1***
7. ***Secondary Alcohols – the # of carbons touching the OH carbon is 2***
8. ***Tertiary Alcohols – the # of carbons touching the OH carbon is 3***

C. Organic Acids (carboxyl group) R-COOH
1. Use IUPAC prefixes with oic acid endings, but drop the e
   a. (ex. CH_3COOH methanoic acid - common name is formic acid)
   b. (ex. CH_3CH_2COOH ethanoic acid - common name is acetic acid)

D. Aldehydes -(aldehyde group) CHO (double bonded)
1. Use IUPAC prefixes with al endings, but drop the e

a. (ex. CH_3CHO is methanal - common name formaldehyde)

E. Ketones (carbonyl group) -C=O

1. Use IUPAC prefixes with one endings, but drop the e

a. (ex. CH_3COCH_3 - propanone - common name is acetone

b. secondary alcohols can be oxidized to ketones

E. Ethers - R - O - R

1. Use IUPAC alkyl prefixes for each side of the oxygen and add the prefix di. End with ether.

a. (ex. $C_2H_5OC_2H_5$ - diethyl ether)

b. Primary alcohols can be dehydrated to form ethers

F. Amines – contain N (refer to Table R)

G. Amides – contain both nitrogen and oxygen

IV. Organic Reactions

A. Substitution - replacement of one kind of atom or group with another atom or group (alkanes only)

1. halogenation - replacement of hydrogen with halogens (F, Cl, or Br)

B. Addition - adding one or more atoms at a double or triple bond of an unsaturated molecule (alkene or alkyne)

1. hydrogenation - adding hydrogen (requires a catalyst and heat)
2. halogenation - adding halogens

C. Fermentation - use of enzymes to breakdown carbohydrates

1. forms alcohol and carbon dioxide

D. Esterification - reaction of a carboxylic acid with an alcohol

1. acid + alcohol ® ester + water (dehydration reaction)
2. usually form pleasant odors (perfumes)
3. conc. H_2SO_4 is used to decrease conc of H_2O and favor the forward reaction
4. fats are esters derived from glycerol and fatty acids

E. Saponification (soap) - hydrolysis of fats using hot alkali (base)

1. forms soap (salt of fatty acid) and glycerol

F. Polymerization - formation of large molecules from smaller molecules (monomers)

1. natural examples are starch, and proteins
2. (ex. Adipic Acid + Hexamethylene ® Nylon + water

a. $C_6H_{10}O_4 + C_6H_{16}N_2 \rightarrow C_{12}H_{22}O_2N_2 + nH_2O$

3. Condensation Polymers - combining monomers by dehydration reaction
4. Addition Polymers - joining of monomers by opening double or triple bonds
5. General Formula = $nC_2H_4 \rightarrow (-C_2H_4-)_n$