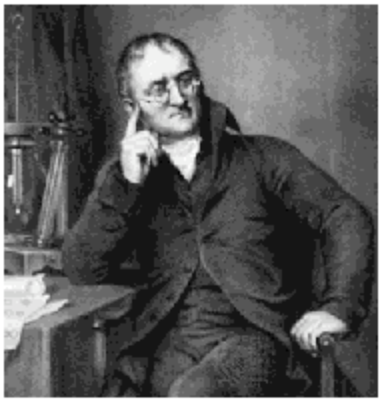
Chem 220 - Organic Chemistry

Problem Set 1

Chapters 1 and 2, Structure, Bonding, Reactivity

Due: Monday, September 13, 2010



John Dalton

(1766-1844)

John Dalton's formulation of an Atomic Theory in the first decade of the 19th century provided a theoretical basis for understanding chemical behavior. In addition to defining the Law of Multiple Proportions, he also formulated the Rule of Greatest Simplicity, which held that water was a binary compound, OH. (Note: Dalton did not use our modern symbols, which came to us from Berzelius, but rather circles that were distinguishable from one another.) Dalton established the combining masses of H to O in water as ~1:6. This ratio was later refined to 1:8. Dalton postulated that in a molecules comprised of two different atoms, the simplest one in the series would be binary. While this rule applied to CO and CO_2, it did not apply to the pair, water and hydrogen peroxide. Thus, water, according to Dalton, was OH. The Rule of Greatest Simplicity, which was at odds with Gay-Lussac's Law of Combining Volumes of Gases that demonstrated the volume of hydrogen produced upon electrolysis of water was twice that of oxygen, was dismissed by Dalton as a faulty result. Moreover, although there was agreement regarding the combining masses of atoms in the first half of the nineteenth century, there was disagreement as to the unit mass of the common atoms encountered in organic chemistry: hydrogen (1), carbon (2x6 or 1x12), oxygen (2x8 or 1x16). Since hydrogen was the lightest of the elements, it was assigned a mass of one (Prout's Hypothesis), a notion that is unrelated to today's mass of hydrogen owing to the presence of a single proton in the hydrogen nucleus.

Berzelius's proposal of a mass scale based upon O = 100 would have worked as well.

For a Brief History of Organic Chemistry (PowerPoint), click here.

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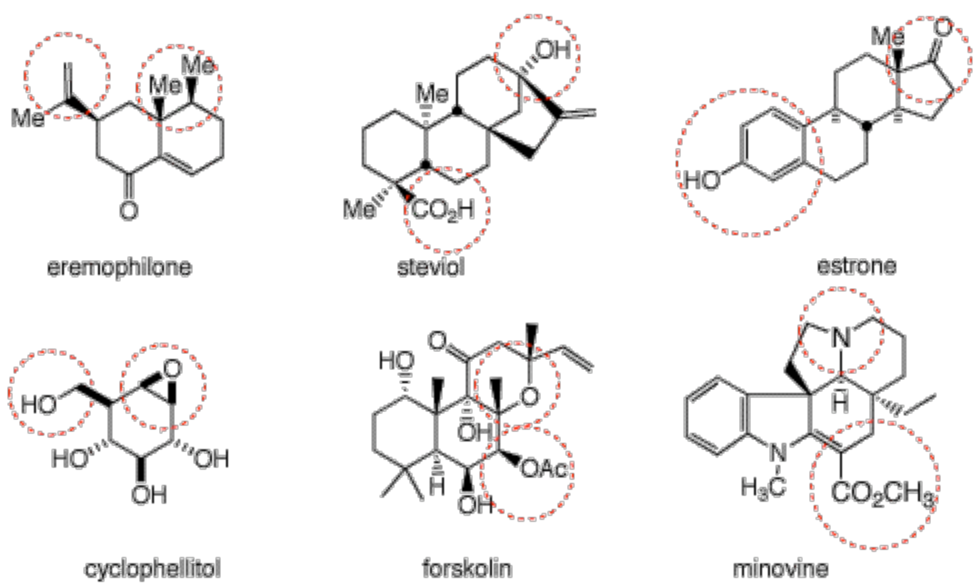
1. The chemical structures shown below all occur in nature. They have also been made (synthesized) by chemical means from simpler organic compounds in this department over the past 40 years. [See the background on the website homepage.] You will learn about Classes of Compounds one class at a time 40 years. They will be for the most part mono-functional compounds. All of the compounds shown below are multi-functional compounds.

a) Identify the Class of Compound of the functionality present with in each of the circles. Print this page and use it to designate answers. [See the inside front cover of your textbook for Classes of Compounds, Functional Groups and Abbreviations.]

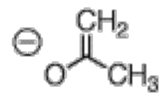
b) You should have identified two alcohols [ROH, where R = alkyl (aliphatic), **not** aryl (aromatic)]. Of these two alcohols, one is said to be primary, the other tertiary. Why? Is there another primary alcohol in the structures? Another tertiary alcohol? Are there any secondary alcohols?

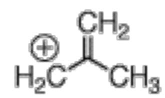


2. Draw resonance structures (if they exist) for the following compounds. Include all formal charges.

a) CH_2N_2 (C-N-N atom connectivity, diazomethane)

b) $(CH_3)_2SBH_3$ (borane dimethylsulfide)

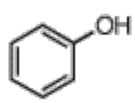
c) 

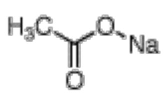
d) 

3. For each of the following acid/base reactions, provide appropriate equilibrium arrows reflecting the position of the equilibrium. For the right side of the equilibrium, provide the conjugate acids and bases. Estimate the equilibrium constant for each reaction. The pKa table will be of help.

a) $CH_3CH_2CH_2CH_2Li$ + C_2H_5OH

b) NH_3 + NaC≡CH

c) CH_3ONa + 

d) 

\+ H_2O

4. Arrange the eight acids and conjugate acids in problem #3 in order of increasing acidity (decreasing pKa).

5. Draw an orbital picture for the alkyne, 2-butyne (CH_3CCCH_3). Identify σ- andπ-bonds and hybridization.

6. A normal alkane, C_nH_{2n+2}, is found to have a vapor density of 2.52 mg/mL at 250^{o}C and 720 mm pressure. Using the ideal gas law, determine the structure of the alkane. (In the early 19th century, the vapor density of an unknown liquid was compared to the vapor density of air to determine the liquids molecular weight.)