Alcohol Acidity

Alcohol pKa comparisons:



Methoxide vs. Isopropoxide:



Methoxide An alkoxide Isopropoxide Less stable Alkyl groups donate electrons through single bonds, destabilizing the negative charge (Inductive Effect), therefore, isopropoxide is less stable than methoxide

Increased Acidity Due to Resonance of Corresponding Anion:



- Phenol is more acidic than cyclohexanol because of negative charge stabilization by resonance.

Mechanism:







p-Nitrophenol is more acidic than phenol because on top of the resonance forms that phenol contains, *p*-nitrophenol also contains the above extra resonance form, making the proton on the alcohol even more acidic.

More examples:



- Chlorine substituent or nitro not adjacent or opposite only stabilizes by electron withdrawing effect through single bonds (Inductive Effect). As you get more resonance possibilities (nitro opposite or adjacent positions), the negative charge is more spread out across the molecules, and is more stabilized, resulting in lower pKa (more acidic).

Ethers:

Recall: The difference between ester and ethers





- Ethers are unreactive, so they are commonly used as solvents.
- Ethers have a dipole
- Ethers are "insoluble" in water (not miscible with water)
- Ethers have density $\rho < 1.0 \text{ g/cm}^3$
- Ethers are essentially inert except in the case of reacting with a strong acid

Examples of Reaction under Strongly Acidic Conditions (no reaction with base as OR minus (e.g. OCH₃ minus) is never a leaving group):



Nomenclature:

- In the absence of other functional groups, name the two alkyl groups attached to the O and add the word "ether"

Examples:



- In the presence of other functional groups, name ethers as a group, drop "yl" and add "oxy" as seen below:



methoxy



ethoxy



phenoxy

Example:





(Z)-3-methoxyhept-3-en-1-ol

- Alcohol (-OH) takes priority over other functional groups

- Number the longest C chain so as to give the OH group the lowest number possible

Carbohydrates (C_NH_{2N}O_N)

- sugars, saccharides

Nomenclature

General formula of sugars: $C_NH_{2N}O_N$ (approx.) The number of carbons is indicated as follows:

- $3 \operatorname{carbon sugar} (C_3) \operatorname{triose}$
- 4 carbon sugar (C_4) tetrose
- 5 carbon sugar (C₅) pentose
- $6 \operatorname{carbon sugar} (C_6) \operatorname{hexose}$

A familiar equation:

$$6 \text{ CO}_2 + 6 \text{ H}_2 \text{O} \xrightarrow{hv} \text{C}_6 \text{H}_{12} \text{O}_6 + 6 \text{O}_2$$

- about $4 \ge 10^{11}$ metric tons of carbon dioxide is converted into glucose by plants
- the process of photosynthesis only uses 0.02% of the suns total energy on Earth
- the sugar produced is known as D-glucose, shown below in a Fischer Projection

D-Glucose



The location of the carbonyl group is indicated by the prefix: C Aldo aldo – aldehyde C H Aldo keto – ketone

CC Keto

Note: The sugar backbone is numbered such that the C=O is assigned the lowest number possible.

Additionally, an allocation of D or L is given to indicate the stereochemistry of the highest numbered (last) stereocentre.

D sugar – highest numbered stereocentre in *R* configuration.

L sugar – highest numbered stereocentre in *S* configuration.

Example 1: Glycerol







Based on the above nomenclature, D-Fructose is a **ketohexose** (ketone, 6 carbons)

The above structure is labelled as "D" because the R configuration occurs at carbon 5 (note that carbon 6 is not a stereocentre).

D-Fructose

Example 3: D-Ribose



An aldopentose (aldehyde, 5 carbons long). At the highest numbered stereocentre (carbon 4) the stereochemistry is R.

The name of this is D-ribose (found in RNA! – deoxyribose is in DNA)

These sugars can cyclize (form rings)

- 6-ring sugar is a pyranose
- 5-ring sugar is a furanose

Hemiacetal Formation

Recall addition reaction across a double bond (i.e., ether formation)



Similarly, addition reactions can be done on carbonyls (Ketones and Aldehydes):



Example on Sugars:



- This is a favored reaction. The sugar interconverts between the linear (or open) and ring form but the ring form (hemiacetal) is generally more favored.
- If OH at the anomeric carbon (C with 2 oxygens attached) is on same side of ring as CH₂OH then the configuration called β (beta) if on opposite side it is α (alpha)
- For glucose, the alpha and beta anomer are present in the same amount. However, for other sugars, the alpha anomer is generally more favored.
- 6-Membered sugar rings are called pyranose
- 5-Membered sugar rings are called furanose

Acetal Formation

- Happens when there are more alcohols around



Example: Glucose



Mixture of anomers

More example:

