Organic Chemistry

It's all about the charges!

Hydrocarbons

So far, we've mostly looked at hydrocarbons: alkanes, alkenes, alkynes, and benzene.

Hydrocarbons are NON-polar molecules: the C-H bond has an electronegativity difference of less than 0.5 (2.5-2.1 =0.4)

While alkenes and alkynes have "extra" electrons in the double (triple) bonds, there is still no real polarity or charge separation in the molecules.

Alkyl Halides

We did talk about halo-alkanes (called alkyl halides) which are alkanes with a halogen attached. These molecules do, in fact, have polar bonds: C-Br, C-I, C-Cl are all polar bonds.

Carbon is slightly positive, the halogen is slightly negative.

Reactions of polar bonds

In general, polar bonds undergo substitution reactions. The mechanism for such reactions can be varied, but follows one of two routes. The "positive" route:

$R\text{-}CH_2\text{-}Br + X^+ \rightarrow R\text{-}CH_2^+ + X\text{-}Br$

$R\text{-}CH_2^+ + Y^- \rightarrow R\text{-}CH_2Y$

E.g.

$R\text{-}CH_2\text{-}Br + HCl \rightarrow R\text{-}CH_2\text{-}Cl + H\text{-}Br$

Reactions of polar bonds

Along with the "positive" route, there's also the "negative route" where a negative ion pushes out the negative halogen:

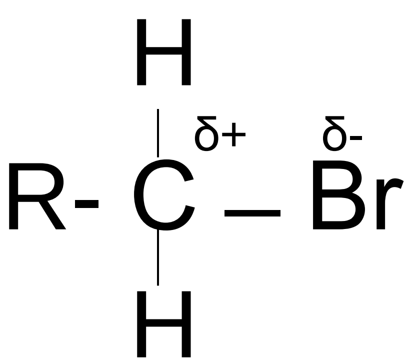
$R\text{-}CH_2\text{-}Br + Y\text{-} \rightarrow R\text{-}CH_2\text{-}Y + Br^-$

E.g.

$R\text{-}CH_2\text{-}Br + NaOH \rightarrow R\text{-}CH_2\text{-}OH + Na\text{-}Br$

Just the charges, ma'am!

In either case, it's just the attraction of opposite charges that makes the reaction go!

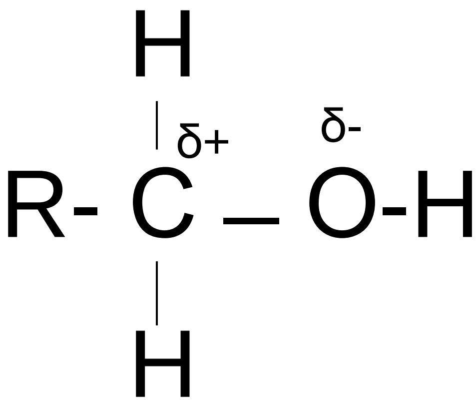


Any negative charge heads for the C, any positive charge heads for the Br-.

Some other polar functional groups

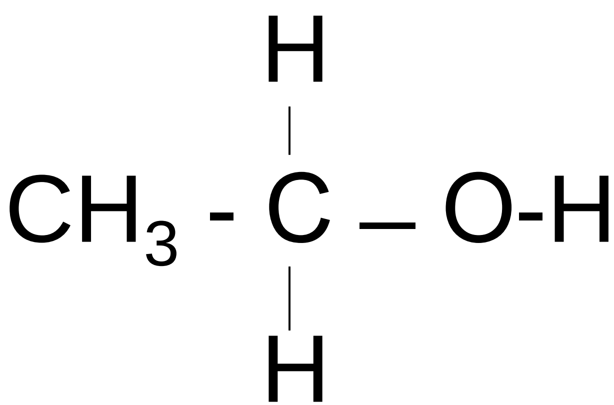
Alcohols (-OH)

The hydroxide group is a negative ion. When the oxygen is bonded to a carbon backbone, the resulting bond is polar.



Naming alcohols.

To name an alcohol, we start with the name of the alkane it is attached to, then drop the "-e" and add "-ol"



Ethane + -OH = ethanol

The position of the –OH gets numbered like anything else…

$CH_3 - CH_2 - CH_2 - O\text{-}H$ 1-propanol

$CH_3 - CH - CH_3$ 2-propanol

(with OH attached to the central CH)

OH

Reactions of alcohols

Substitution

$$R\text{-}CH_2\text{-}OH + HBr \rightarrow R\text{-}CH_2\text{-}Br + H_2O$$

Elimination

$$CH_3CH_2CH_2OH + H_2SO_4 \rightarrow CH_3CH{=}CH_2 + H_2O$$

These are competing reactions, depending on the exact conditions you will get either product, or BOTH!

“Oxidation” of Alcohols

Organic chemistry looks at “oxidation” differently than we discussed in redox reactions where “oxidation” was all about losing electrons.

In Organic Chemistry, “oxidation” is all about gaining OXYGEN!

The more oxygen attached to the carbon, the more “oxidized” the carbon is considered.

CH_3CH_3 no oxygen, lowest oxidation possible

CH_3CH_2OH 1 oxygen, it is “oxidized” ethane

$CH_3CH_2C{=}O$ 2 oxygens (2 bonds, so 2 O)
|
H

$CH_3CH_2C{=}O$ 3 oxygens (high as it gets)
|
OH

How do we oxidize it?

With a strong oxidizer!

Strong oxidizers are typically metal ions (like Cr^{3+} or Mn^{7+}) with a lot of oxygens on them:

MnO_4^- or $Cr_2O_7^{2-}$

$$CH_3CH_2OH \xrightarrow{Na_2Cr_2O_7} CH_3CH_2COOH$$

same as

$$CH_3CH_2C{=}O$$
$$|$$
$$OH$$

A weaker oxidizer (like HNO_3 or PCC) would take it up in oxidation, but not all the way!

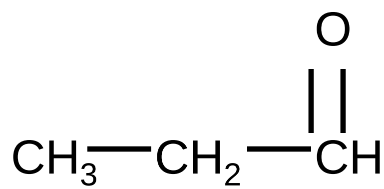
Aldehydes and Ketones

-C=0   (a “carbonyl” group)

|

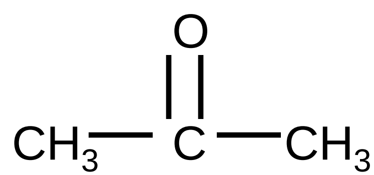
An aldehyde is a terminal carbonyl.

CH_3CH_2CHO



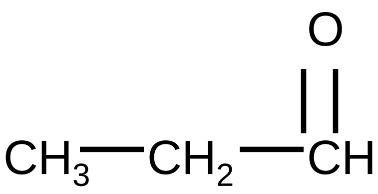
A ketone is an internal carbonyl.

CH_3COCH_3



Naming Aldehydes

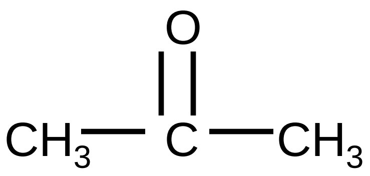
An aldehyde is named by taking the root alkane, dropping the "-e" and adding "-al". The carbonyl is considered the "1" position, so there is no ambiguity in numbering.



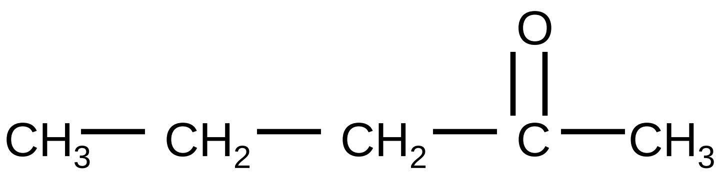
propanal

Naming ketones

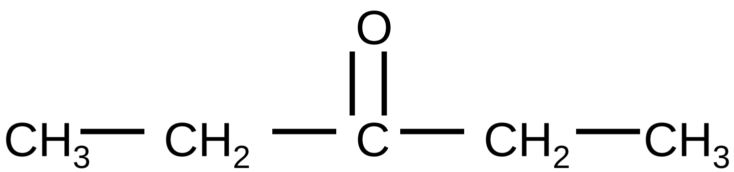
A ketone is named by taking the root alkane, dropping the “-e” and adding “-one”. The position must be numbered in larger alkanes.



propanone
or
2-propanone



2-pentanone



3-pentanone

Reactions of Aldehydes and Ketones

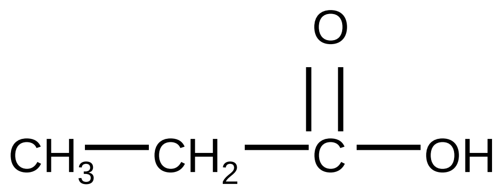
We won't worry about that until next year!

Carboxylic Acids

A carboxylic acid is also a carbonyl containing compound, but it also has a hydroxide group on the carbonyl carbon.

They are named by dropping the “-e” and adding “-oic acid”

Again, the position normally need not be numbered as it is always the “1” position.



Propanoic acid

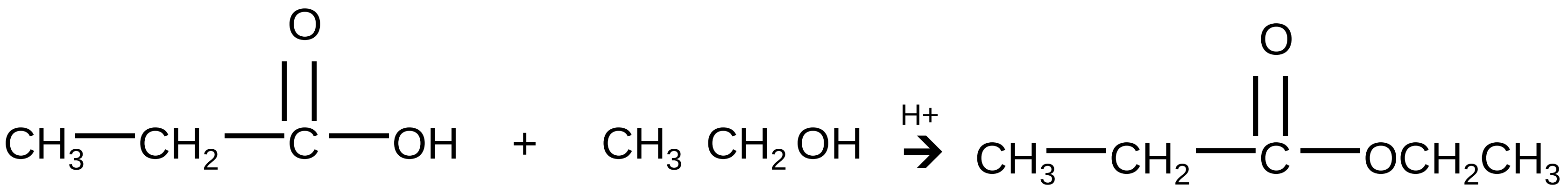
Esters

An “ester” is a product of the dehydration of a carboxylic acid and an alcohol.

Esters usually have pungent, fruity aromas.

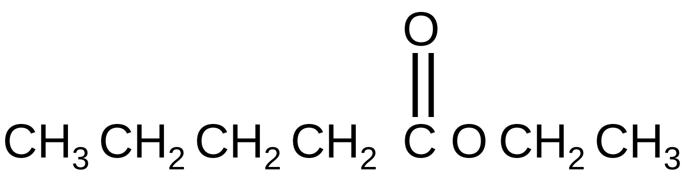
Ethylbutanoate is pineapple smell. Methylbutanoate is apple.

Esters are named by combining the name of the carboxylic acid and alcohol that they came from, using the carboxylic acid as the root (drop the “-oic acid” and add “-oate” and the alcohol as a prefix.

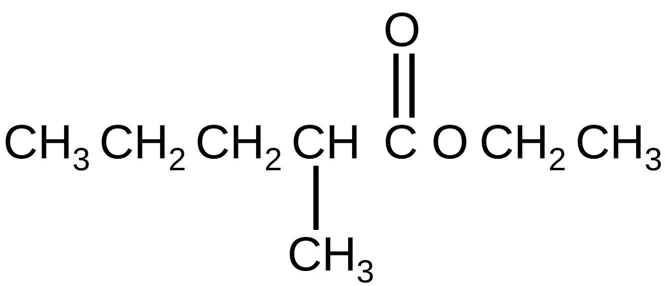


Propanoic acid　　Ethanol　　Ethyl propanoate.

What would you call this molecule?



Ethyl pentanoate



2-methyl-ethyl pentanoate

The carbonyl is considered the 1-position

Ethers

Ethers are kind of like baby esters! If you dehydrate two alcohols, you get an ether!

$$CH_3OH + CH_3CH_2OH \longrightarrow CH_3\ CH_2\ O\ CH_3$$

Methyl ethyl ether

Ethers are named by naming the 2 alcohols separately as substituent groups (in alphabetical order)and adding “ether”

More ethers

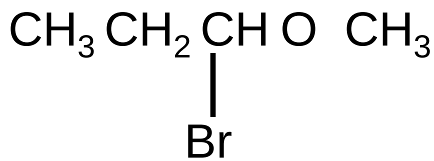
- Name this!

$CH_3 CH_2 O CH_2 CH_2 CH_3$

Methyl propyl ether

$CH_3 O CH_3$

Dimethyl ether



1-bromoethyl methyl ether

The “O” position is always at the “1” position.

Amines

Contain $–NH_2$ group or a substituted version ($-NHCH_3$, $-N(CH_3)_2$)

Are named by naming the corresponding alkane and adding amine.

$CH_3CH_2NH_2$ Ethylamine

Amines are bases!!! (Think NH_3)

Amine chemistry is dictated by the “N” and the resulting basicity.

Amines and carboxylic acids are very important in biochemistry.