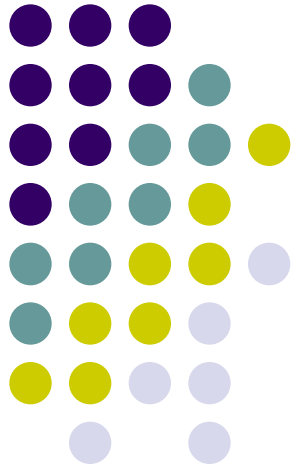
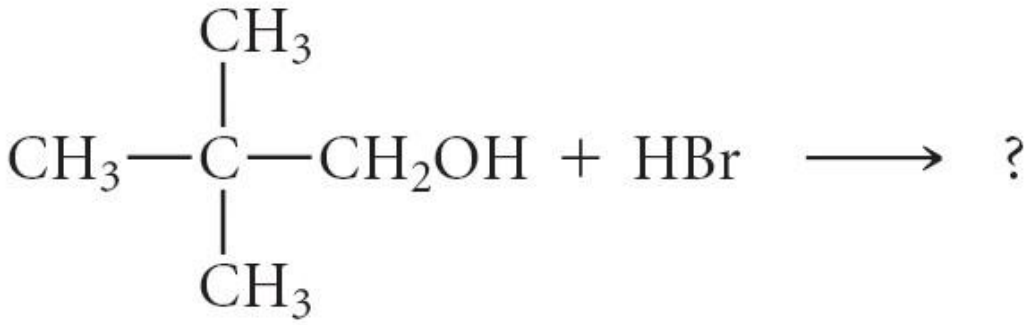
Organic Chemistry

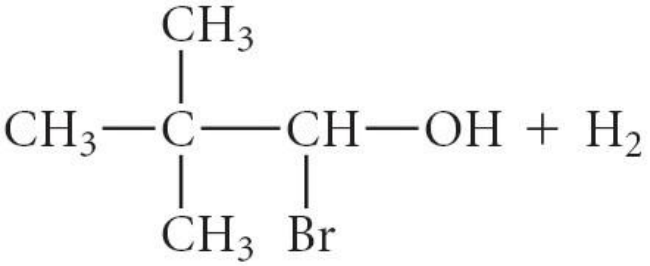
It’s all about the charges!



Predict the products:



A



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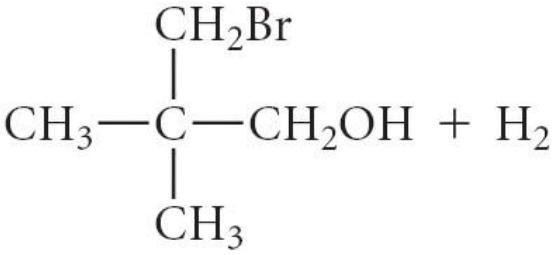

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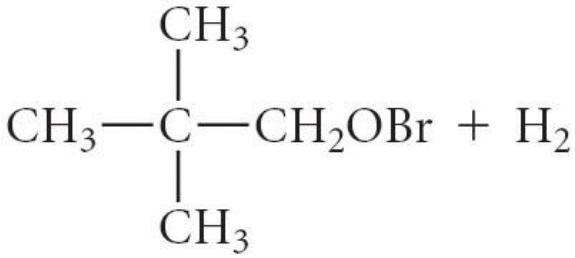

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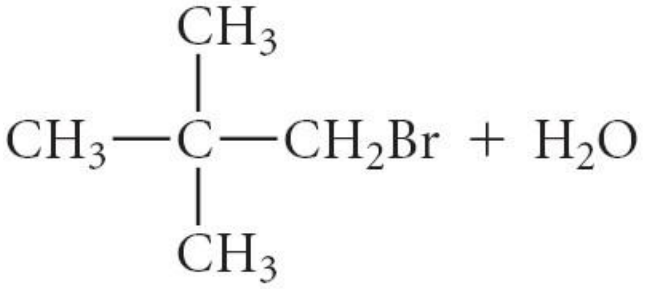

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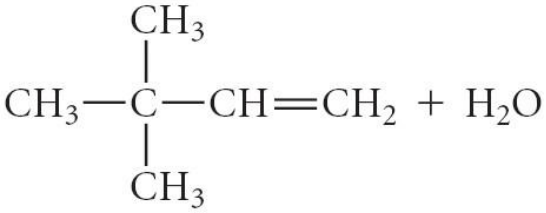


Resonance Hybrid

- the true structure of benzene is a resonance hybrid of two structures

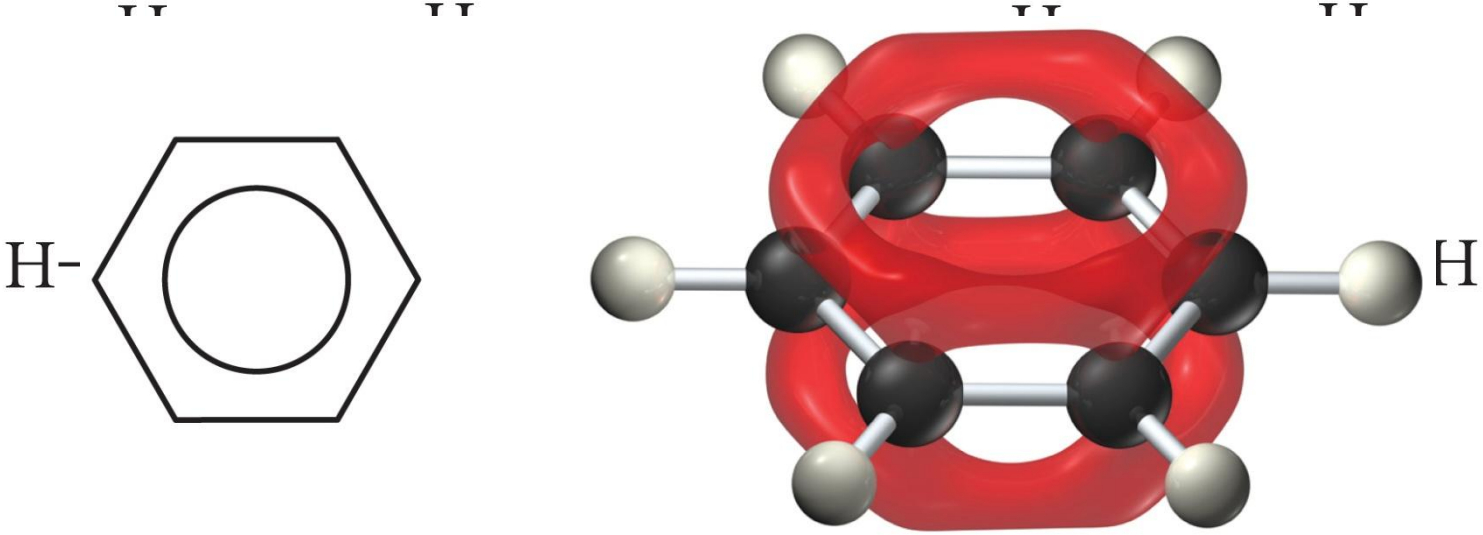
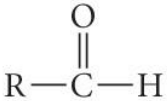
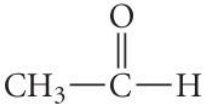
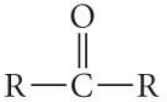
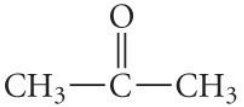
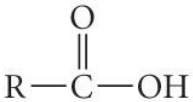
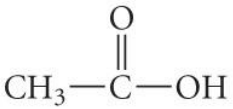
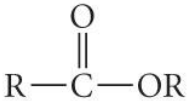
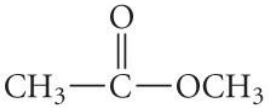
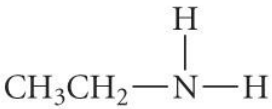
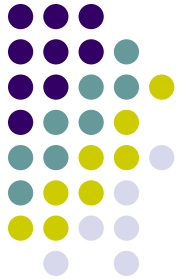


TABLE 20.10 Some Common Functional Groups

Family	General Formula*	Condensed General Formula	Example	Name
Alcohols	R—OH	ROH	CH_3CH_2OH	Ethanol (ethyl alcohol)
Ethers	R—O—R	ROR	CH_3OCH_3	Dimethyl ether
Aldehydes		RCHO		Ethanal (acetaldehyde)
Ketones		RCOR		Propanone (acetone)
Carboxylic acids		RCOOH		Ethanoic acid (acetic acid)
Esters		RCOOR		Methyl acetate
Amines		R_3N		Ethylamine

*In ethers, ketones, esters, and amines, the two R groups may be the same or different.

“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.

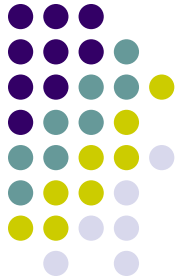
CH_3CH_3 no oxygen, lowest oxidation possible

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

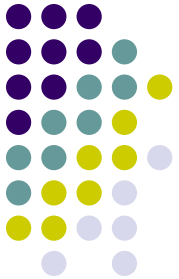
How do we oxidize it?



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

$$CH_3CH_2\underset{\displaystyle OH}{\underset{|}{C}}=O$$

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

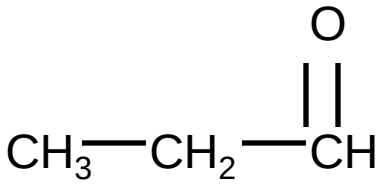
Aldehydes and Ketones

-C=0 (a “carbonyl” group)

|

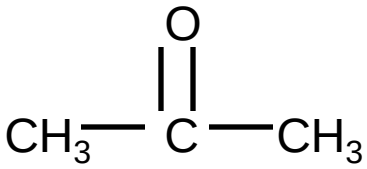
An aldehyde is a terminal carbonyl.

CH_3CH_2CHO



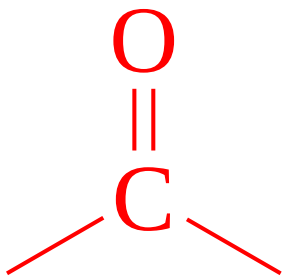
A ketone is an internal carbonyl.

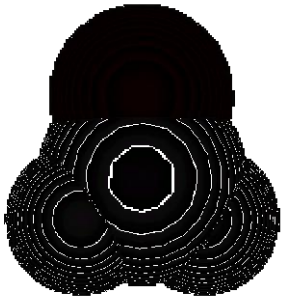
CH_3COCH_3



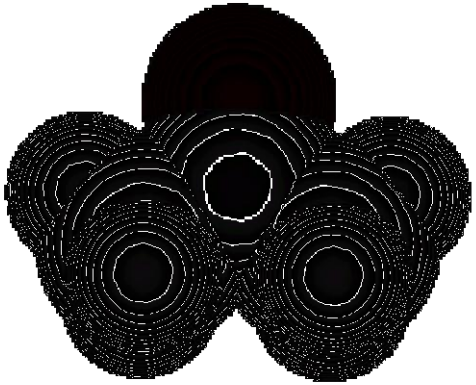
Aldehydes and Ketones

- contain the **carbonyl** group
- aldehydes = at least 1 side H
- ketones = both sides R groups
- many aldehydes and ketones have pleasant tastes and aromas
- some are pheromones
- formaldehyde = $H_2C{=}O$
  - pungent gas
  - formalin = a preservative
  - wood smoke, carcinogenic
- acetone = $CH_3C(=O)CH_3$
  - nail-polish remover





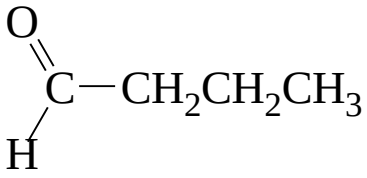
formaldehyde

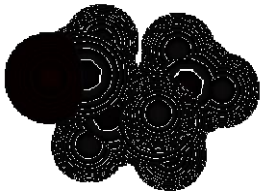


acetone

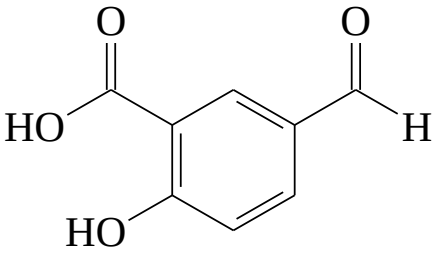
Aldehyde Odors and Flavors

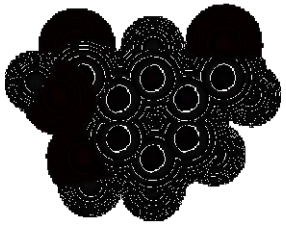
- butanal = butter



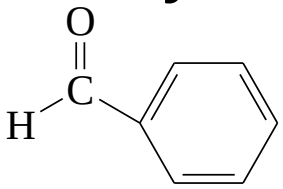


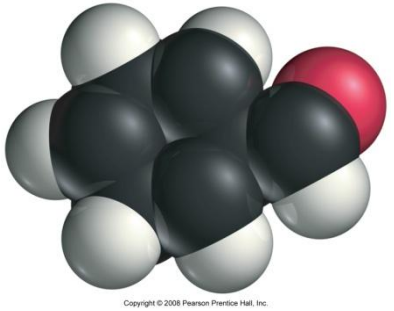
- vanillin = vanilla



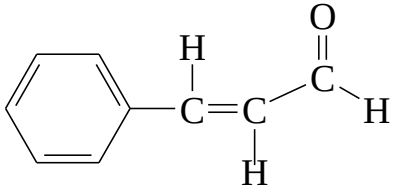


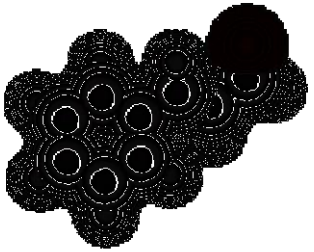
- benzaldehyde = almonds





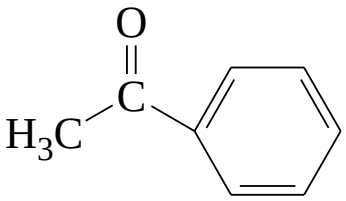
- cinnamaldehyde = cinnamon



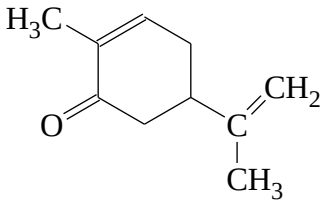


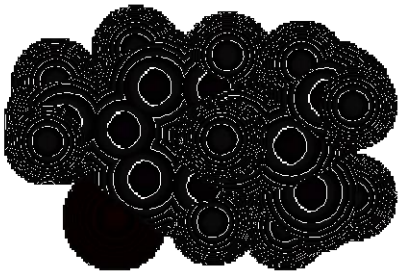
Ketone Odors and Flavors

- acetophenone = pistachio

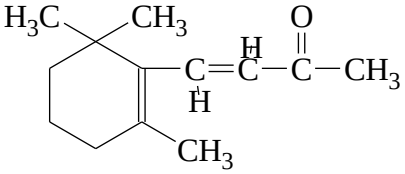


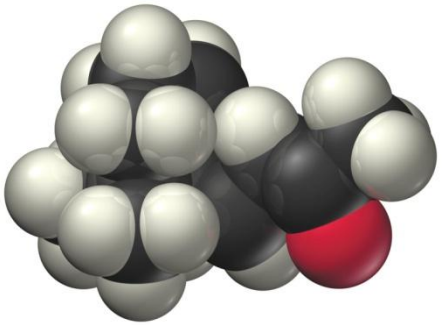
- carvone = spearmint



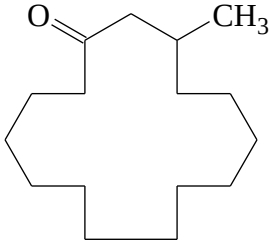


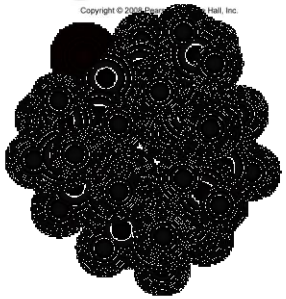
- ionone = raspberries





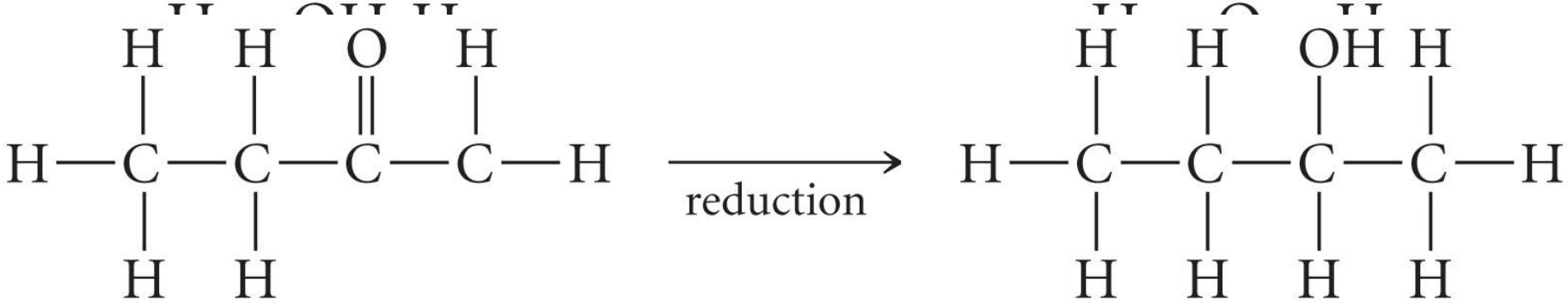
- muscone = musk





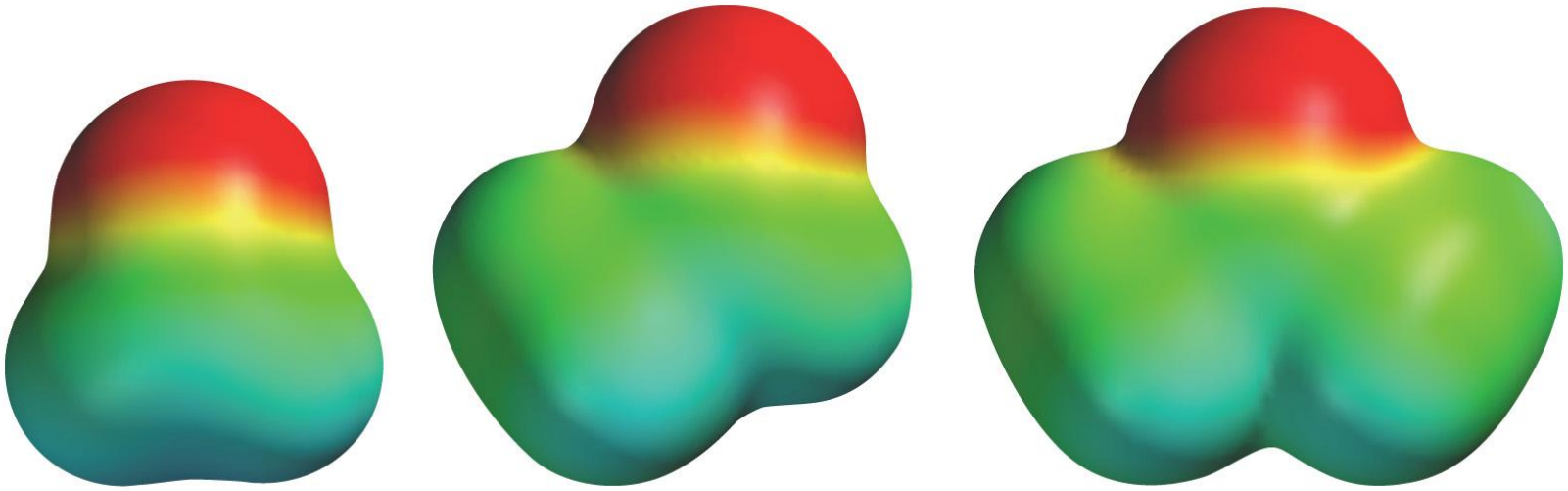
Reactions

- aldehydes and ketones are generally synthesized by the oxidation of alcohols
- therefore, reduction of an aldehyde or ketone results in an alcohol



2-Butanone 2-Butanol

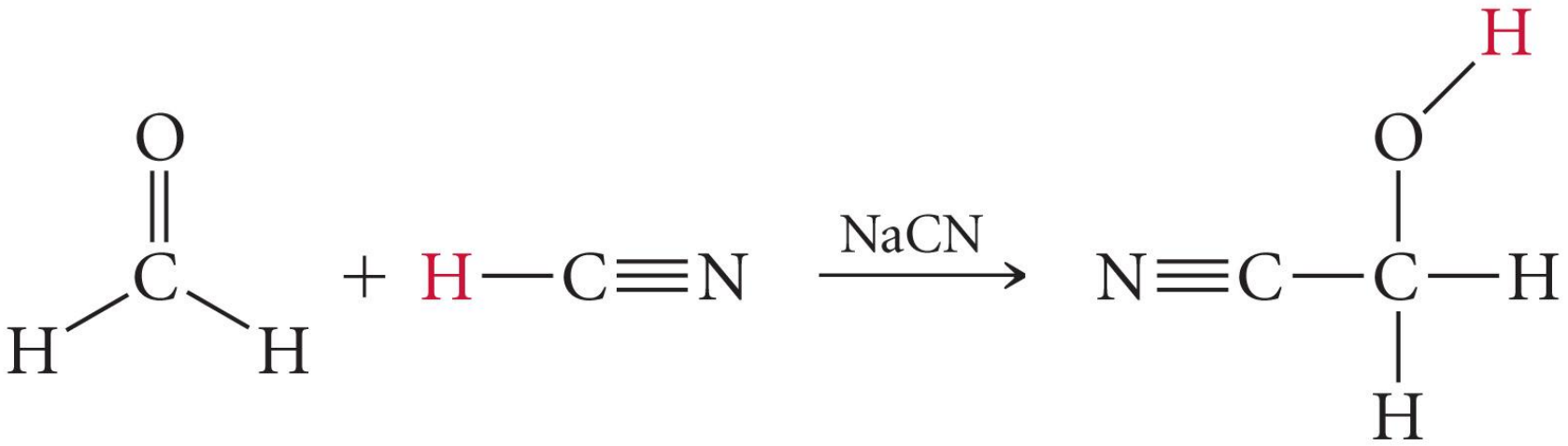
Carbonyl Group



Formaldehyde Acetaldehyde Acetone

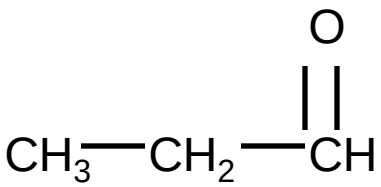
C=O group is highly polar
many reactions involve addition across C=O,
with positive part attached to O

Addition to C=O



Naming Aldehydes

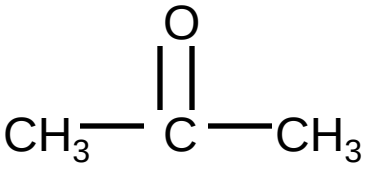
An aldehyde is named by taking the root alkane, dropping the “-e” and adding “-al”. The carbonyl is considered the “1” position, so there is no ambiguity in numbering.



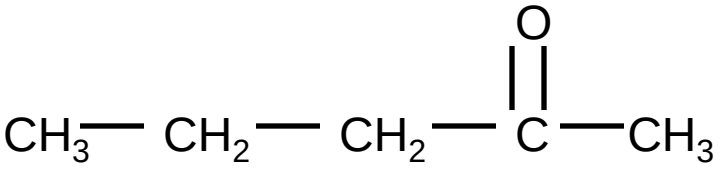
propanal

Naming ketones

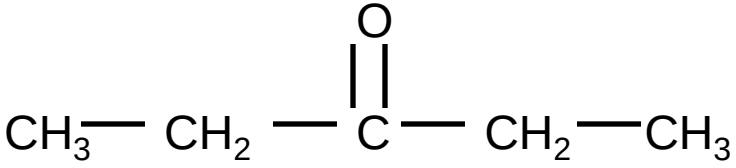
A ketone is named by taking the root alkane, dropping the “-e” and adding “-one”. The position must be numbered in larger alkanes.



propanone
or
2-propanone



2-pentanone



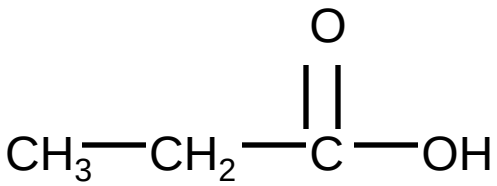
3-pentanone

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”

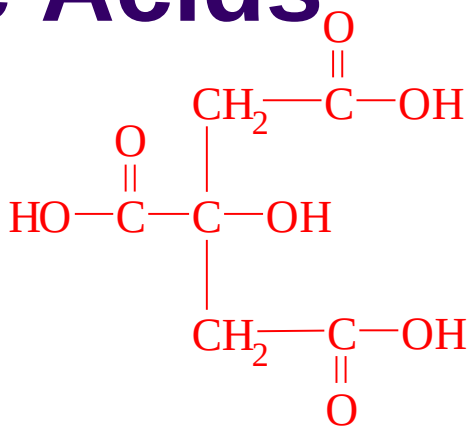
Again, the position normally need not be numbered as it is always the “1” position.

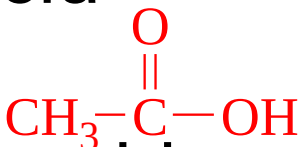


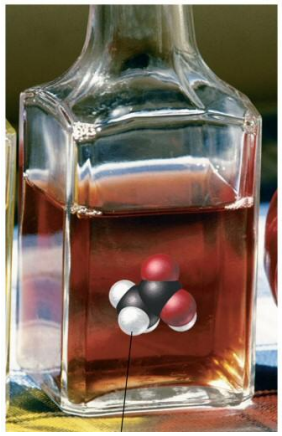
Propanoic acid

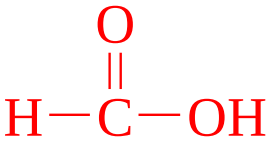
Carboxylic Acids

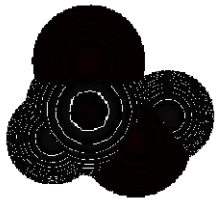
- RCOOH
- sour tasting
- weak acids
- citric acid
  - found in citrus fruit
- ethanoic acid = acetic acid
  - vinegar
- methanoic acid = formic acid
  - insect bites and stings





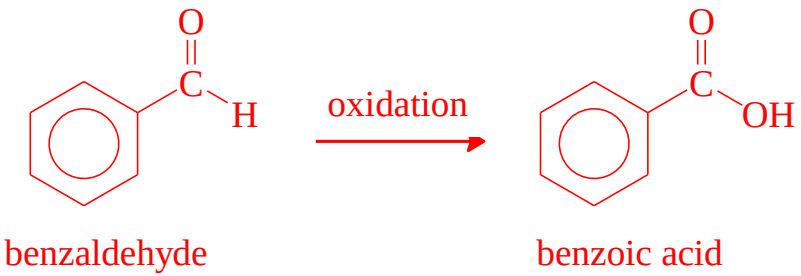






Carboxylic Acids

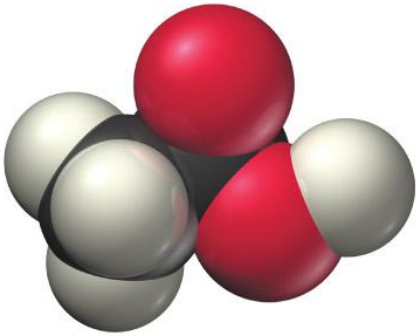
- made by the oxidation of aldehydes and alcohols
  - OH on the end of the chain
- always on main chain
  - has highest precedence
- C of group always C1
  - position not indicated in name
- change ending to **oic acid**

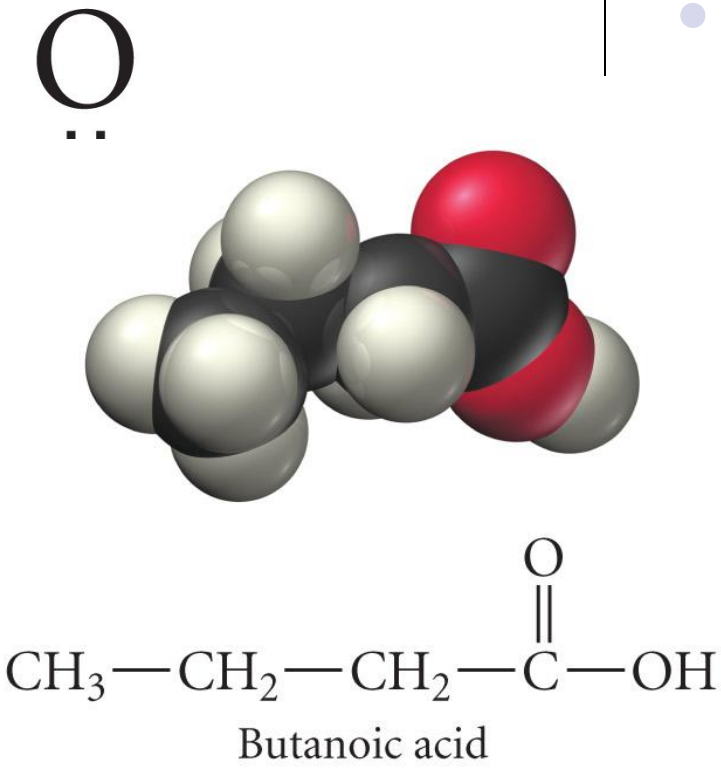


benzaldehyde benzoic acid

ethanol ethanoic acid

Naming Carboxylic Acids



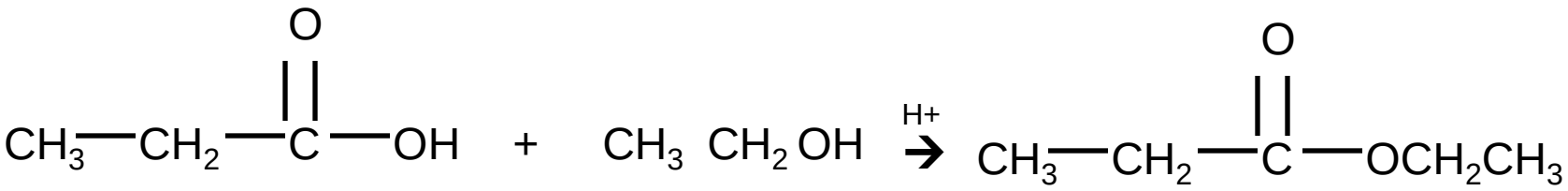


Esters

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.



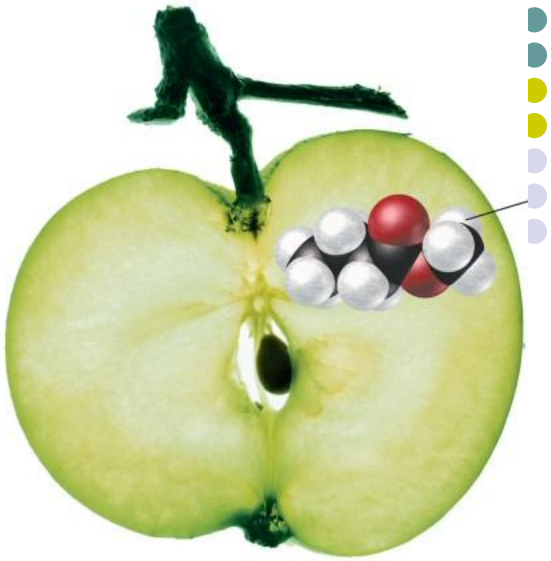
Propanoic acid Ethanol Ethyl propanoate.

Esters

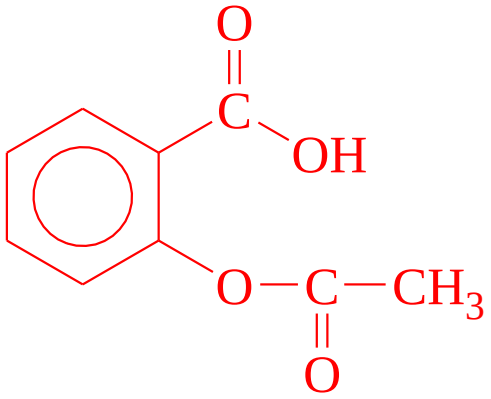
- R–COO–R
- sweet odor
- made by reacting carboxylic acid with an alcohol

$R_aCOOH + R_bOH \Leftrightarrow R_aCOOR_b + H_2O$

- name alkyl group from alcohol, then acid name with **oate** ending
  - precedence over carbonyls, but not carboxylic acid
  - number from end with ester group

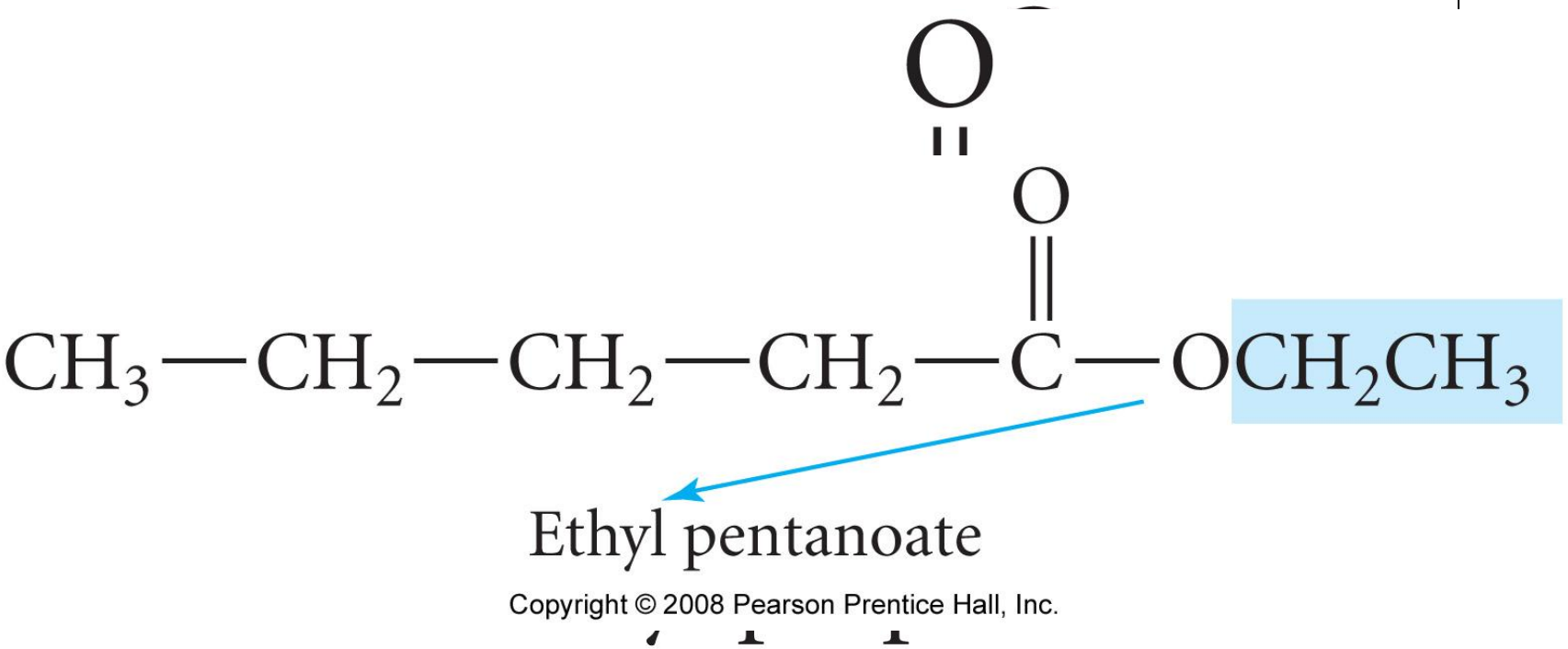


methyl butanoate



aspirin

Naming Esters



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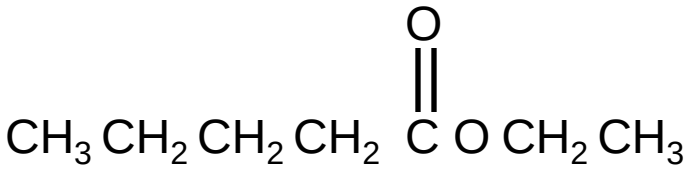
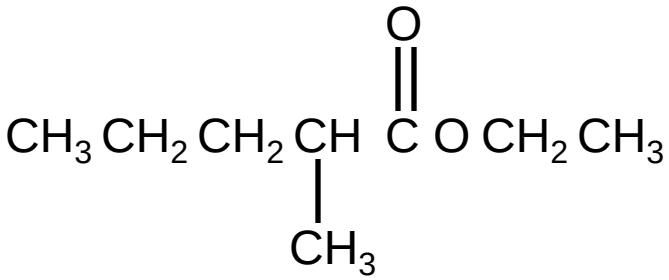
What would you call this molecule?



Ethyl pentanoate

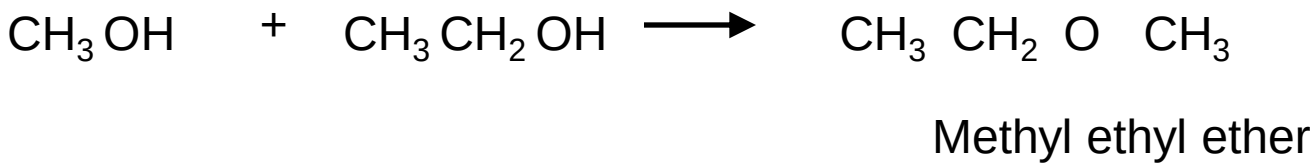


2-methyl-ethyl pentanoate

The carbonyl is considered the 1-position

Ethers

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



Methyl ethyl ether

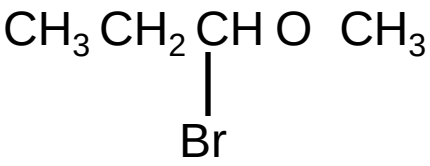
Ethers are named by naming the 2 alcohols separately as substituent groups (in alphabetical order)and adding “ether”

More ethers

- Name this!

Methyl propyl ether

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

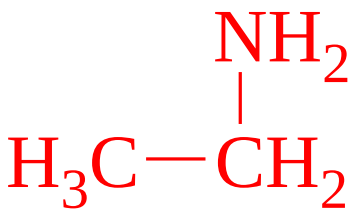
Amines are bases!!! (Think NH_3)

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

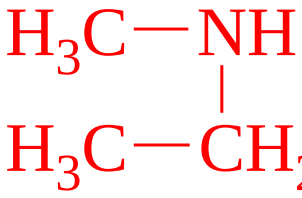
Amines and carboxylic acids are very important in biochemistry.

Amines

- N containing organic molecules
- very bad smelling
- form when proteins decompose
- organic bases
- name alkyl groups attached to the N, then add the word **amine** to the end



ethylamine



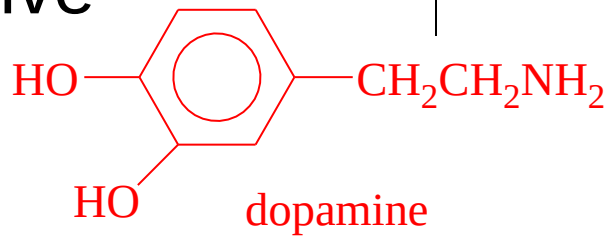
ethylmethylamine

putrescine

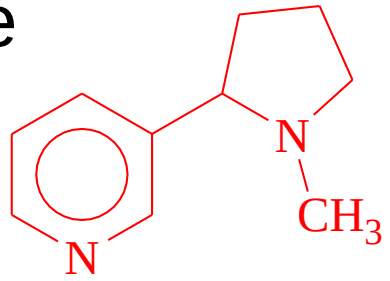
cadaverine

Amines

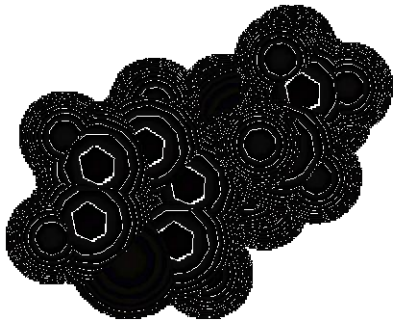
- many amines are biologically active
  - dopamine – a neurotransmitter
  - epinephrine – an adrenal hormone
  - pyridoxine – vitamin B_6
- **alkaloids** are plant products that are alkaline and biologically active
  - toxic
  - coniine from hemlock
  - cocaine from coca leaves
  - nicotine from tobacco leaves
  - mescaline from peyote cactus
  - morphine from opium poppies



dopamine



nicotine



Amine Reactions

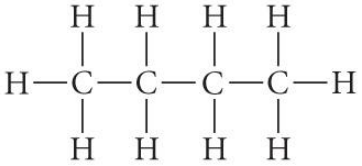
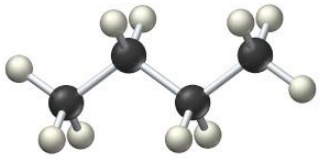
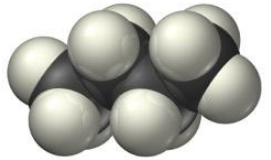
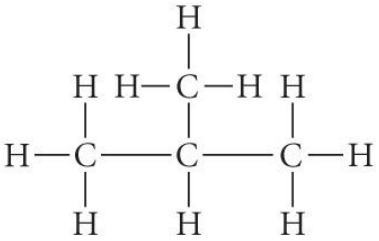
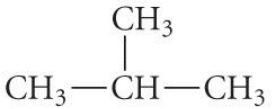
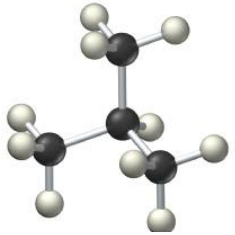
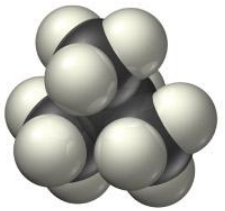
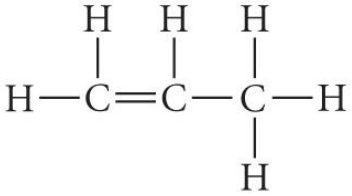
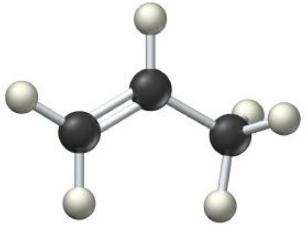
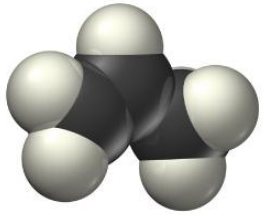
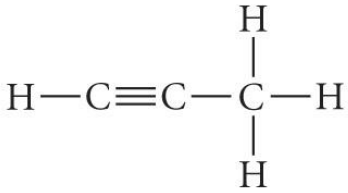
- weak bases
  - react with strong acids to form ammonium salts

$$RNH_2 + HCl \rightarrow RNH_3^+Cl^-$$

- react with carboxylic acids in a condensation reaction to form **amides**

$$RCOOH + HNHR' \Leftrightarrow RCONHR' + H_2O$$

Formulas

	Structural formula	Condensed structural formula	Carbon skeleton formula	Ball-and-stick model	Space-filling model
Butane		$CH_3—CH_2—CH_2—CH_3$			
Isobutane					
Propene		$CH_2=CH—CH_3$			
Propyne		$CH≡C—CH_3$