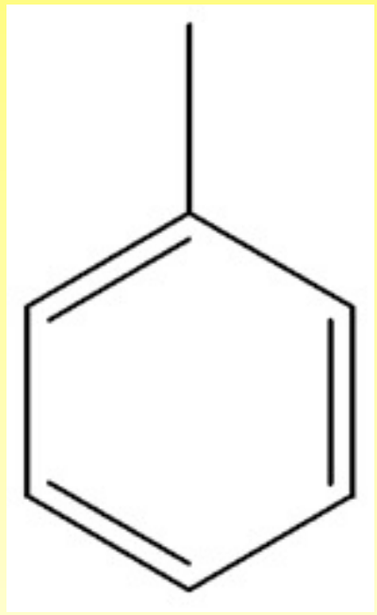
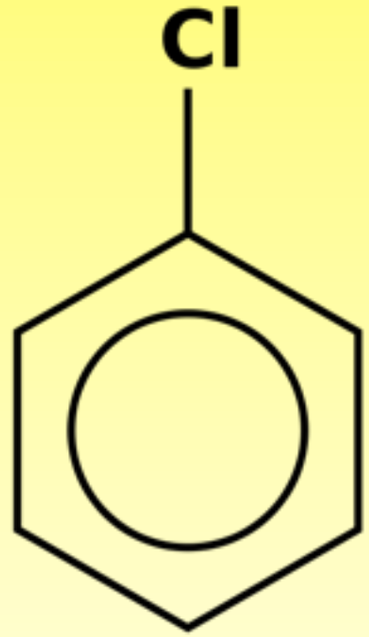
FUNCTIONAL GROUPS

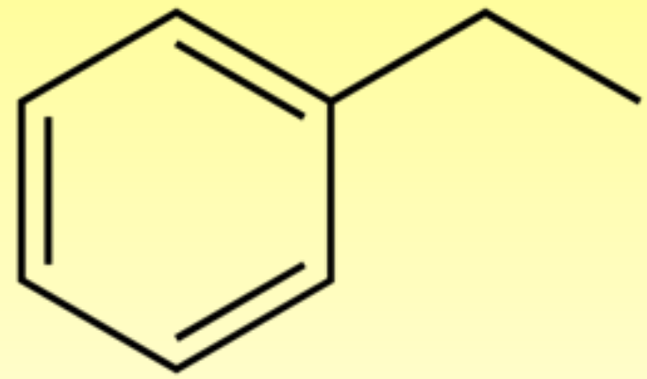
- **Functional groups** are groups of atoms other than carbon and hydrogen linked to a hydrocarbon
- They are where the **real** chemistry happens
- They also give a compound distinct properties, like melting points, boiling points and reactivity
- R is often used to represent a chain of hydrocarbons instead of writing them all out

AROMATICS

With side-chains, aromatic naming follows similar rules as for C-chains.

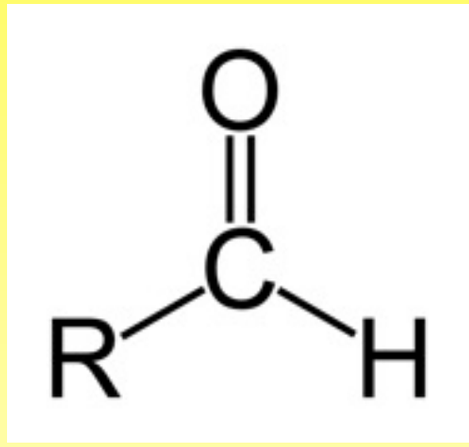




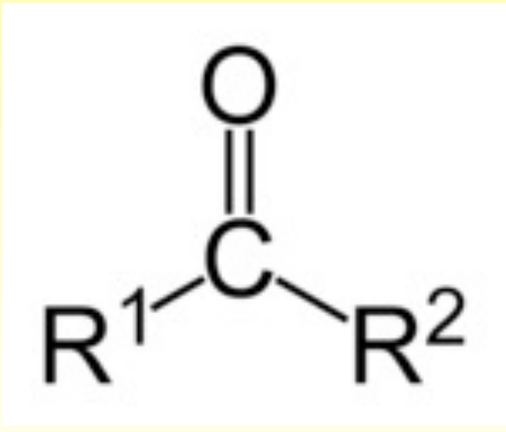


CARBONYL GROUPS

- Carbonyl group is C=O
- There are 2 classes of organic compounds which contain this:
  - Aldehydes - contain C=O at the END of a chain

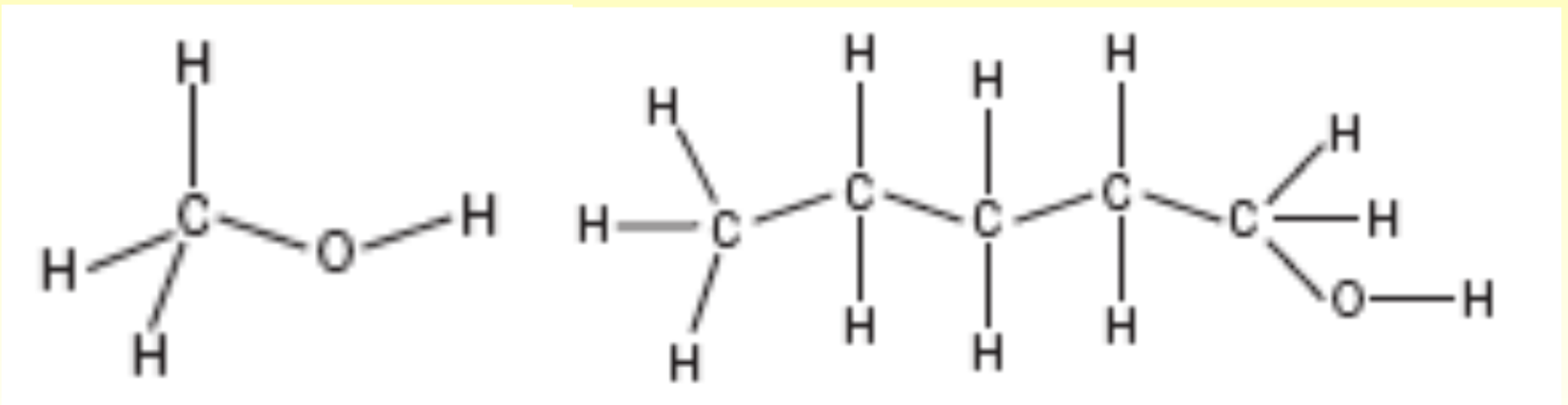


  - Ketones - contain C=O in the middle of a chain



ALCOHOLS

- Alcohols contain a hydroxyl (OH) group connected to carbon #1
- General formula is R - OH where R is a hydrocarbon
- Suffix is “ol”
- Prefixes remain the same
- Name these!



CLASSIFYING ALCOHOLS

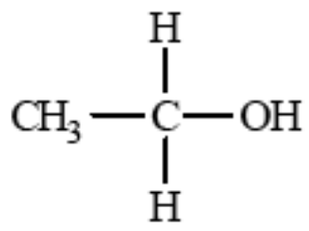
- Alcohols are classified according to how many carbons the first carbon is attached to.

1) **Primary alcohol**-one in which the carbon to which the OH group is attached is attached to only ONE other C atom.

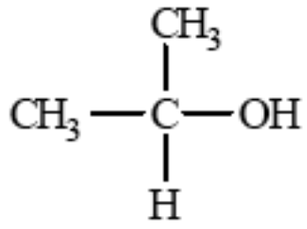
2) **Secondary alcohol**-one in which the carbon to which the OH group is attached is attached to only TWO other C atoms.

3) **Tertiary alcohol**-one in which the carbon to which the OH group is attached is attached to only THREE other C atoms.

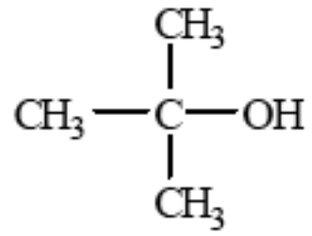
1 alkyl group ------> primary



2 alkyl groups ------> secondary



3 alkyl groups ------> tertiary

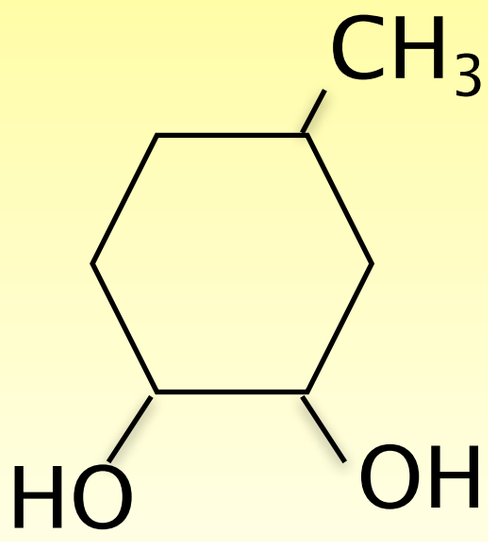


ALCOHOLS

a) $CH_3CHOHCH_3$

b) $CH_2=CHCH_2CH_2OH$

c)



ALCOHOLS

Draw the following molecules:

a) 3-ethylhexan-1-ol

b) 2,3,3-trimethylpentan-1-ol

c) 3-ethyl-2,4-dimethyl-5-propyl-6-octyne-1,2,5-triol

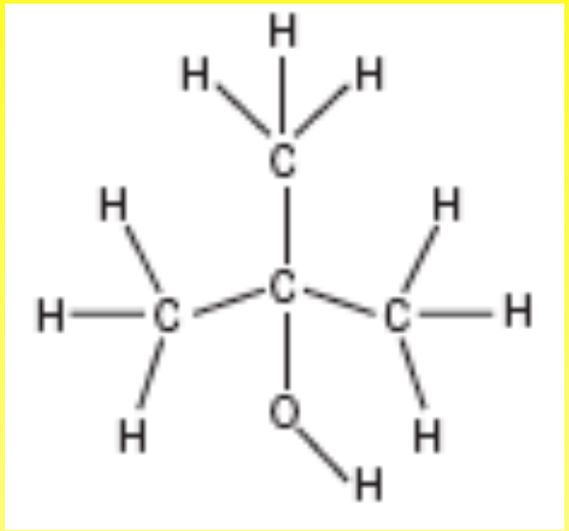
ALCOHOLS

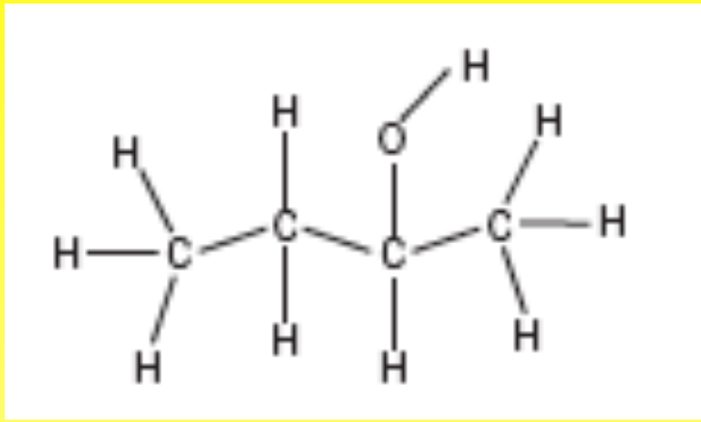
d) hepta-1,5-dien-3-ol

e) Cyclopentan-1,2,3-triol

ALCOHOLS

- Name these alcohols:





- Draw these alcohols:
  - 5-ethyl-3-methyl-2,3-nonanediol
  - 3,4-dimethylhexan-2-ol

For each of the molecules below, state whether they are primary, secondary or tertiary alcohols.

a $CH_3CH_2C(CH_3)OHCH_3$

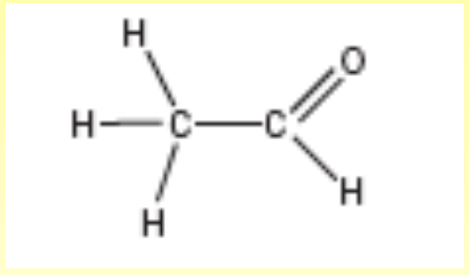
b $CH_3CH_2CHOHCH_2CH_3$

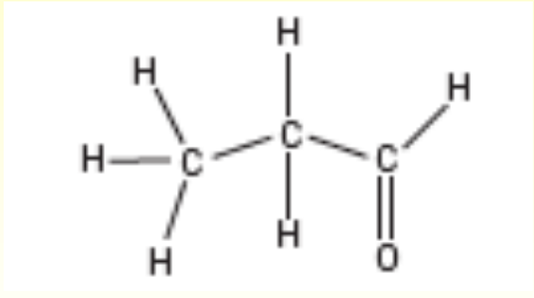
c CH_3CH_2OH

d $CH_3C(CH_3)OHCH_3$

ALDEHYDES

- Suffix: “al”
- Carbon which is bonded to oxygen MUST be counted as number 1. Always. No exceptions. This means no number is needed to indicate where the oxygen is.
- In the condensed form, abbreviated at CHO (avoiding confusion with alcohols)
- ie) Ethanal
- Draw & name: C_2H_5CHO
- Draw: 4-methylpentanal

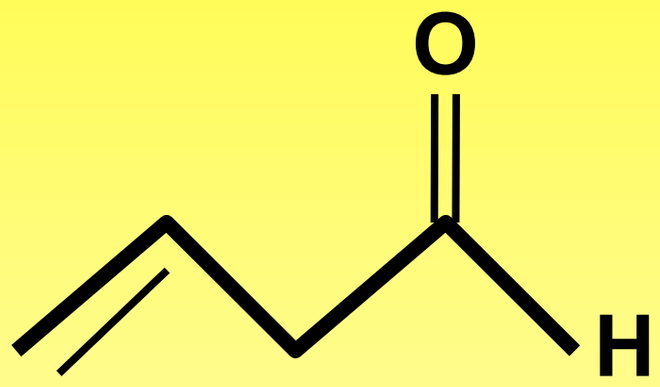




ALDEHYDES

Redraw and name the following compound:

$CH_2=CHCH_2CHO$



ALDEHYDES

Draw and name all aldehydes with the formula $C_5H_{10}O$.

KETONES

- Suffix: “one”
- Carbon which is bonded to oxygen MUST be indicated by a number
- In the condensed form, abbreviated at CO.
- ie) Propanone - why no number?
- Draw & name: $C_3H_7COCH_3$
- Draw: Hexan-3-one

KETONES

Redraw and name the following compound:

$(CH_3)_2CHCH_2COC(CH_3)_3$

KETONES

Draw the following compounds:

a) 2-methyl-cyclohexan-1,4-dione

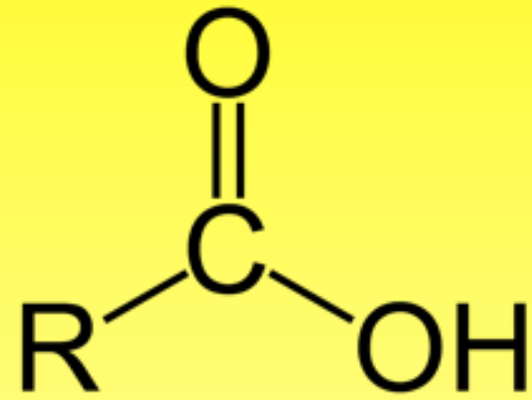
b) 4-ethyl-2-methylcyclopentanone

KETONES

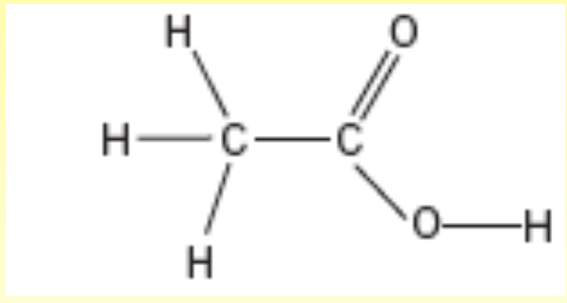
c) all ketones with the formula $C_5H_{10}O$

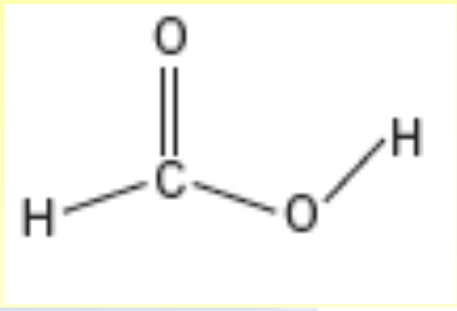
CARBOXYLIC ACIDS

- A carboxylic acid is an organic acid which contains the functional group



- Suffix used “oic acid”
- Abbreviated R-COOH
- Numbers are not required because the first carbon MUST be the one bonded to the oxygen and hydroxyl group

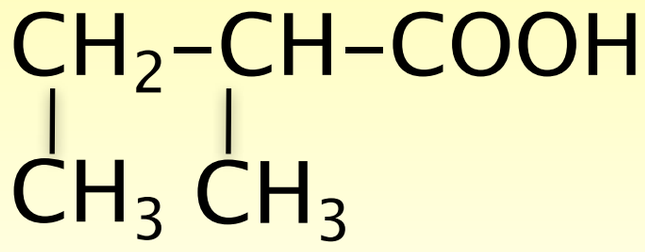




CARBOXYLIC ACIDS

a) What is the structural formula for prop-2-enoic acid?

b) What is the IUPAC name for the following acid?



PROPERTIES OF CARBOXYLIC ACIDS

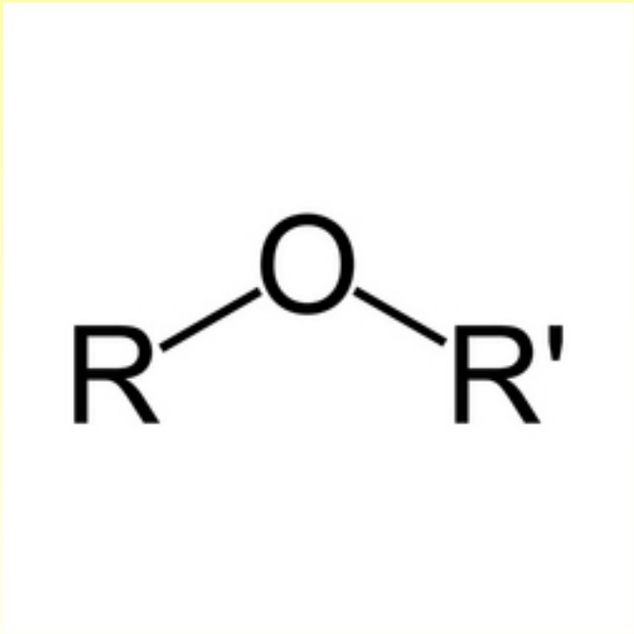
- Since they contain both C=O and OH, they can form strong hydrogen bonds
- Carboxylic acids will have the highest melting point of all comparable organic compounds

- 1) Order the following in ascending order of boiling point: Propanal, propanol, propanoic acid, propane
- 2) Does 3-pentanoic acid exist? If yes, draw it. If no, explain why.

ETHERS

When two hydroxyl groups react, an ether group (C-O-C) bond is produced and water is released.

$H_3C\text{-}OH + HO\text{-}CH_3 \rightarrow H_3C\text{-}O\text{-}CH_3 + H_2O$



ETHERS

IUPAC naming system

i. The root of the chemical is the longer C-chain

ii. The prefix of the compound is the shorter C-chain

iii. The prefix and the root are separated by the term "oxy"

ETHERS

Common naming system

This system uses the name "ether" as the root and the alkyl names as prefixes.

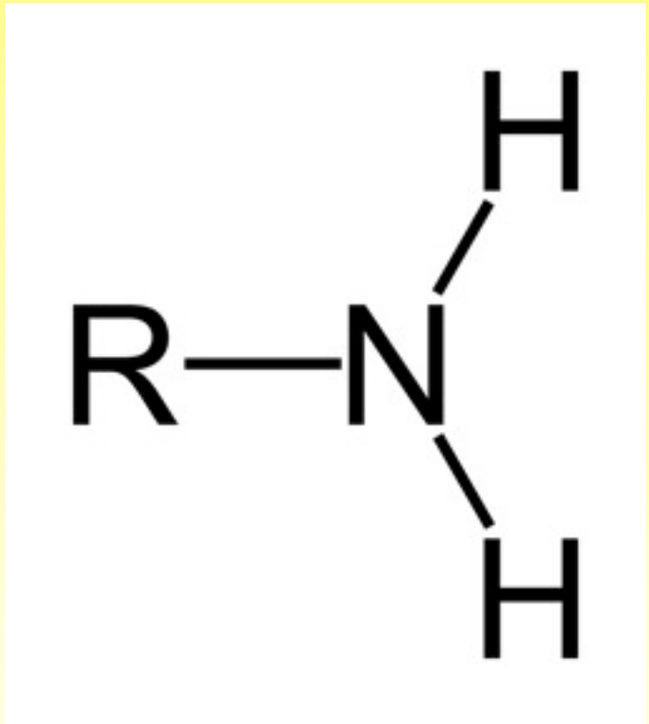
CH_3-O-C_2H_5 methoxyethane

C_2H_5-O-C_2H_5 ethoxyethane

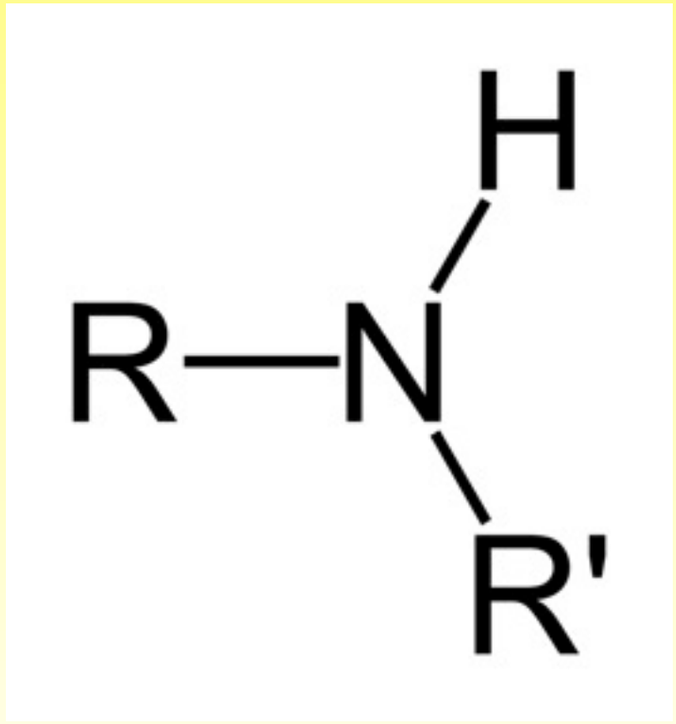
AMINES

All amines are essentially derived from NH_3.

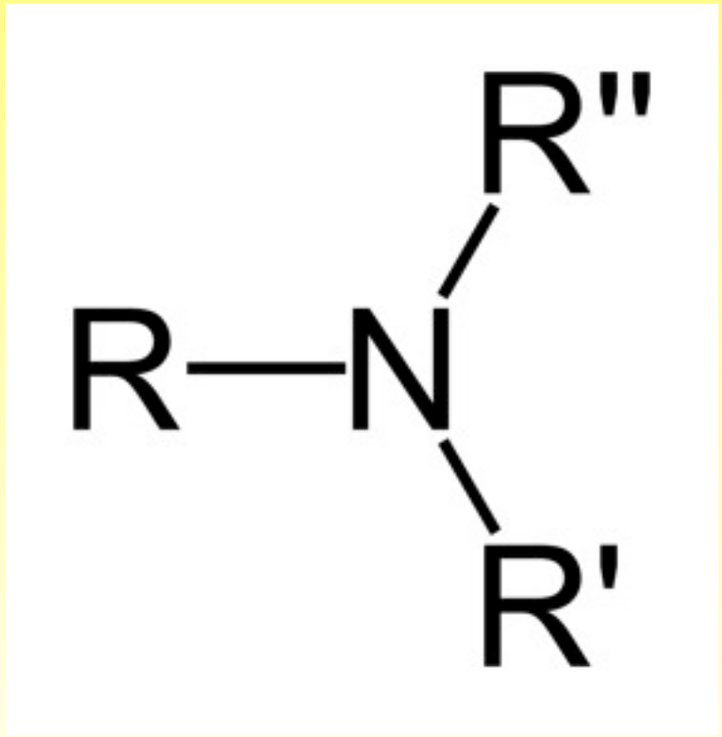
Depending on the number of carbon side-chains off of the N, we can form different types of amines.



primary amine



secondary amine



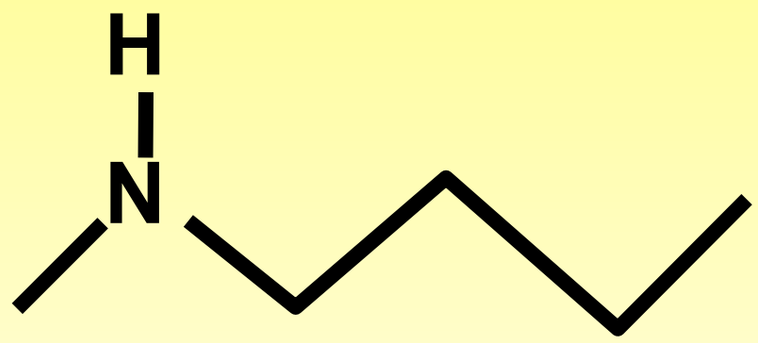
tertiary amine

AMINES

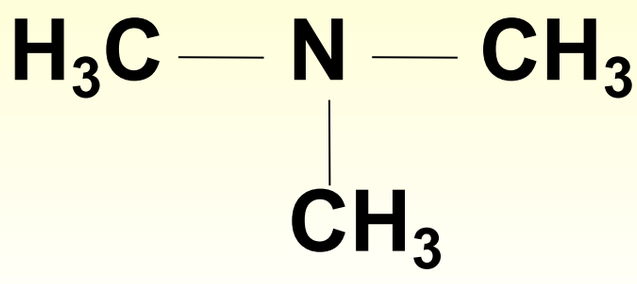
IUPAC naming system

If there are carbon side-chains off of the N-group, it is denoted by an "N-" prefix.

N-methylbutanamine

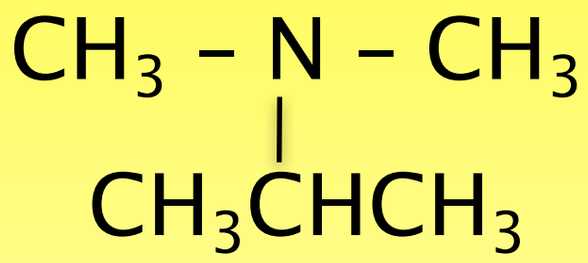


N,N-dimethylmethanamine

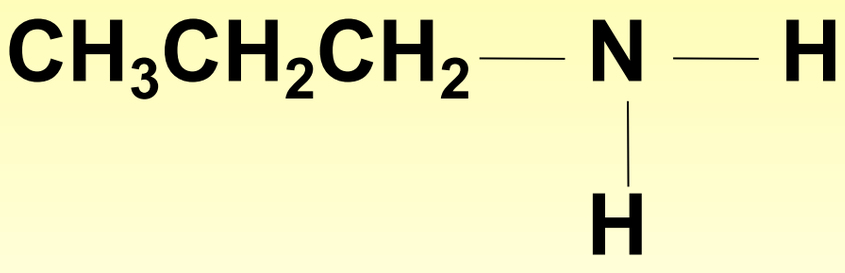


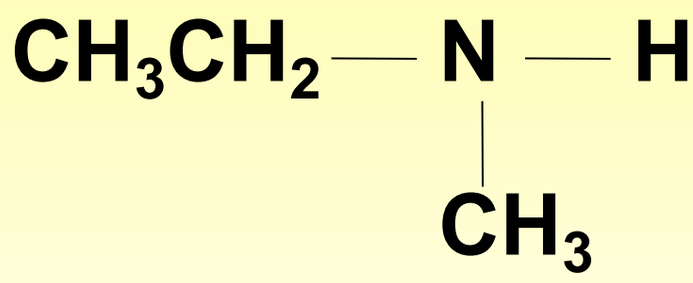
AMINES

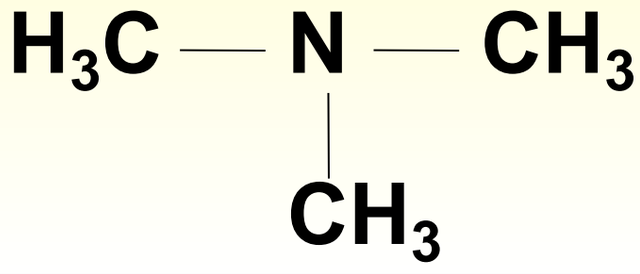
Write the IUPAC and the common name for the following molecule.



Draw a 1°, 2° and 3° amine which each contain a total of three carbons.







ESTERS

Esters (RCOOR') are formed through the condensation reaction between a hydroxyl group and a carboxylic acid group.

$$CH_3\text{-}OH + HOOCH_3 \xrightarrow[\text{Heat}]{\text{Conc. } H_2SO_4} CH_3\text{-}OOCH_3 + H_2O$$

This condensation reaction is also known as an esterification reaction.

ESTERS

<u>IUPAC naming system</u>

i.The alcohol becomes the alkyl group.

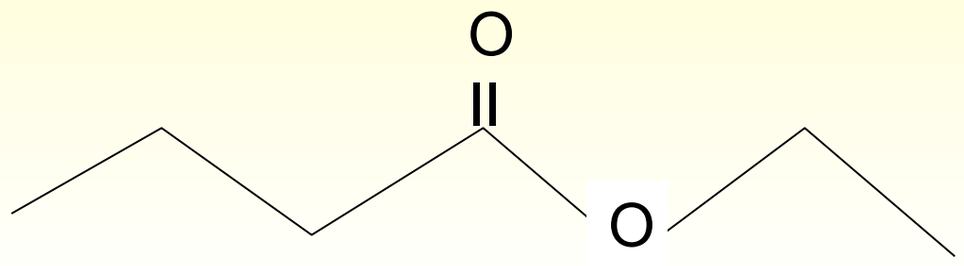
ii.The carboxylic acid is the root, but the "-oic acid" is changed to "-oate".

ESTERS

Name the reactants and identify and name the products of the reaction.

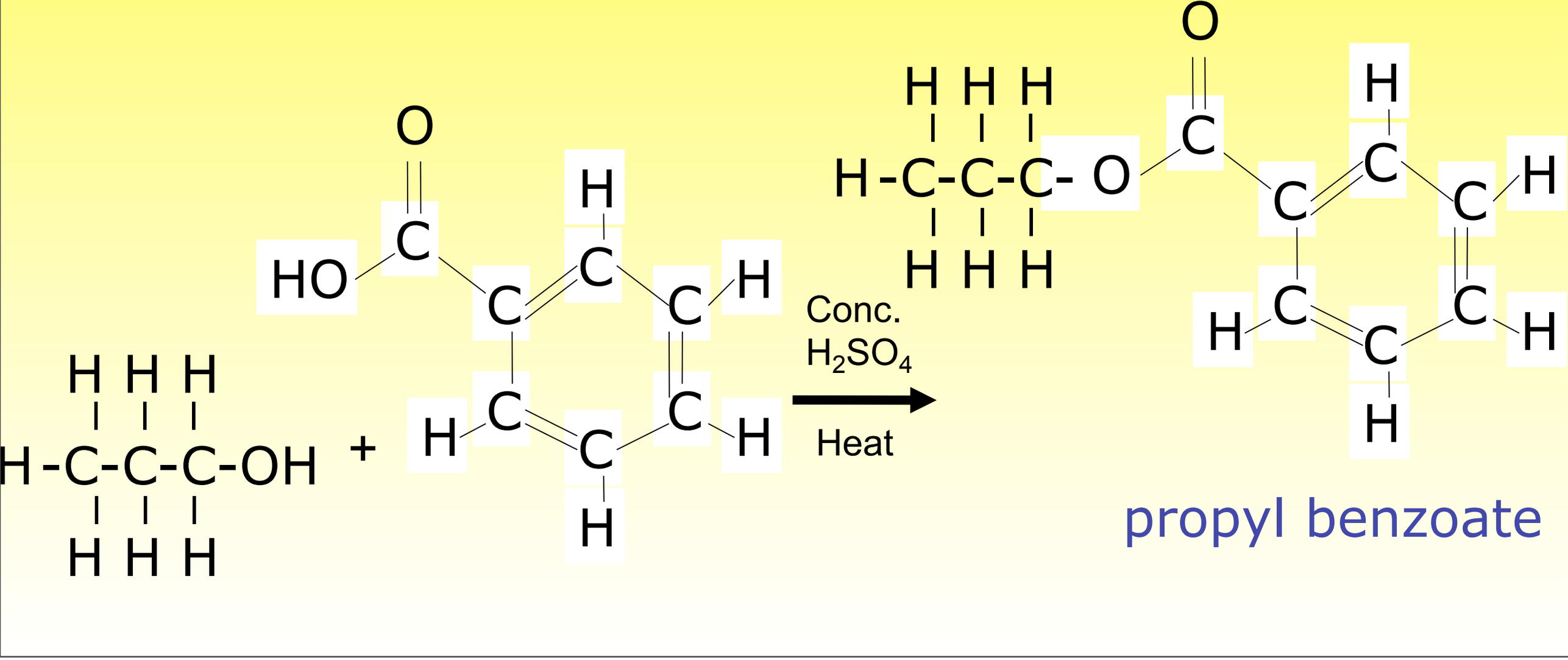
$CH_3CH_2CH_2COOH + CH_3CH_2OH$

$$\xrightarrow[\text{Heat}]{\text{Conc. } H_2SO_4} CH_3CH_2CH_2COOCH_2CH_3 + H_2O$$



ESTERS

Draw the structural diagram and write the IUPAC name for the ester formed in the reaction between 1-propanol and benzoic acid.



propyl benzoate

AMIDES

Amides (RCONHR') are produced due to the condensation between a carboxylic acid and an amine / ammonia.

$$HCOOH + H\text{-}NH_2 \rightarrow HCONH_2 + H_2O$$

IUPAC naming system

i. The amine becomes the alkyl group.

ii. The carboxylic acid is the root, but the "-oic acid" is changed to "-amide".

AMIDES

Example #5

Name the reactants and identify and name the products of the reaction.

i. $CH_3COOH + NH_3 \rightarrow$ $CH_3CONH_2 + H_2O$

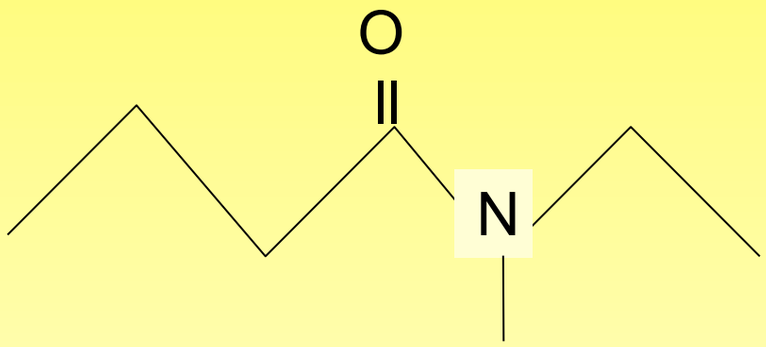
ii. $CH_3CH_2CH_2COOH + CH_3NH_2 \rightarrow$

$CH_3CH_2CH_2CONHCH_3 + H_2O$

AMIDES

Redraw and name (IUPAC) the following amides.

i. $CH_3CH_2CH_2CON(CH_3)CH_2CH_3$



ii. $CH_3CH_2CH_2CON(CH_2CH_3)_2$