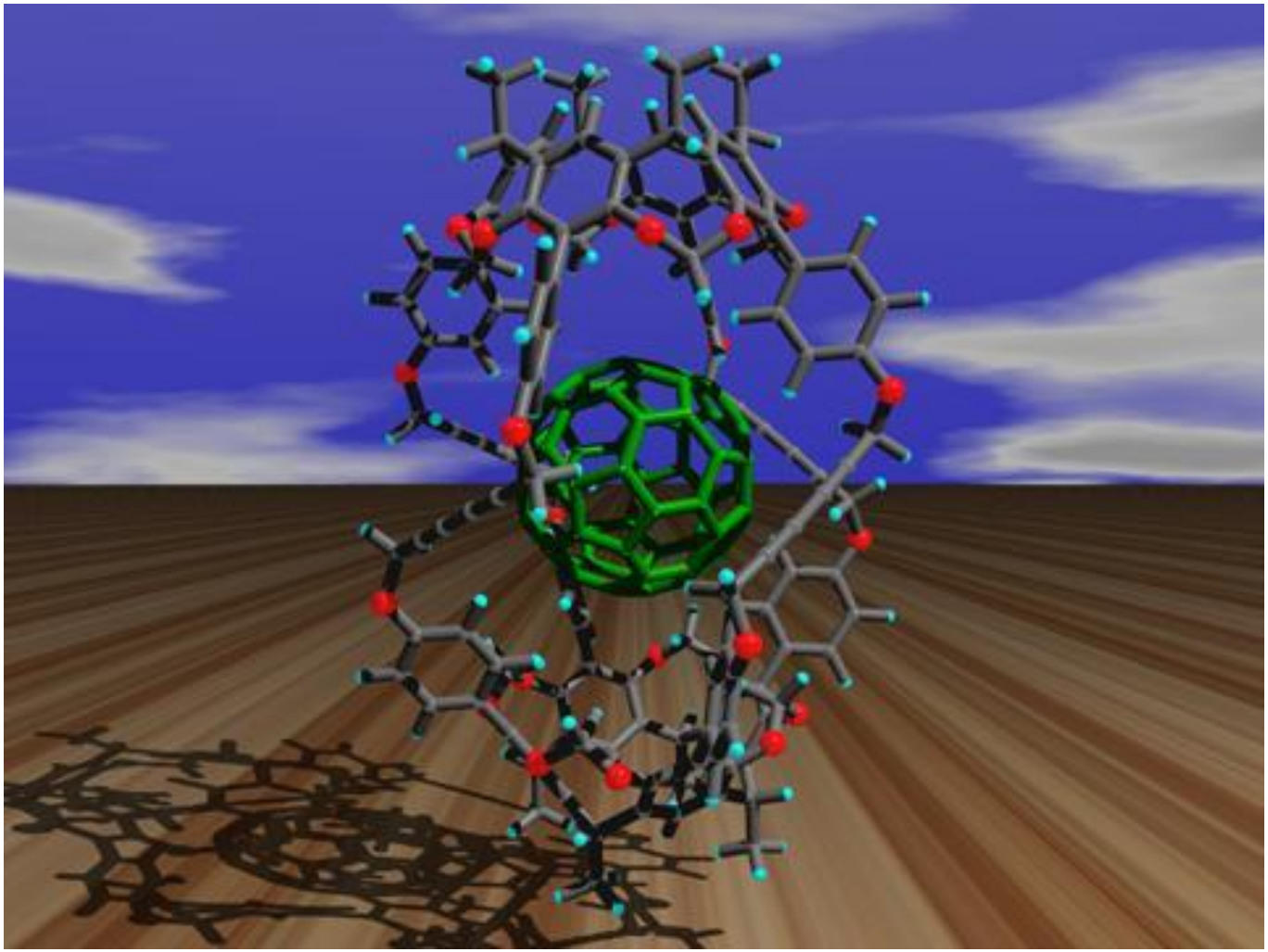
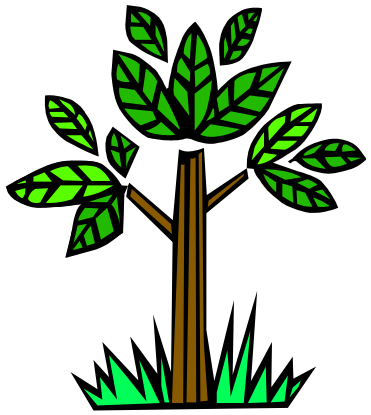
Organic Chemistry

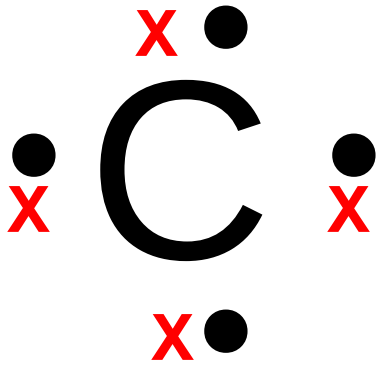


Organic Chemistry- The study of carbon & carbon compounds

- Organic compounds are the primary constituents of all living organisms.



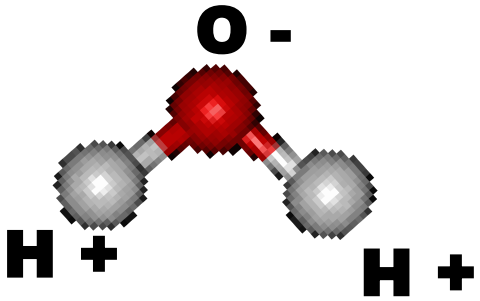
Draw an electron dot diagram of carbon.



Carbon is able to form 4 covalent bonds (4 valence electrons) with other carbon or other elements.

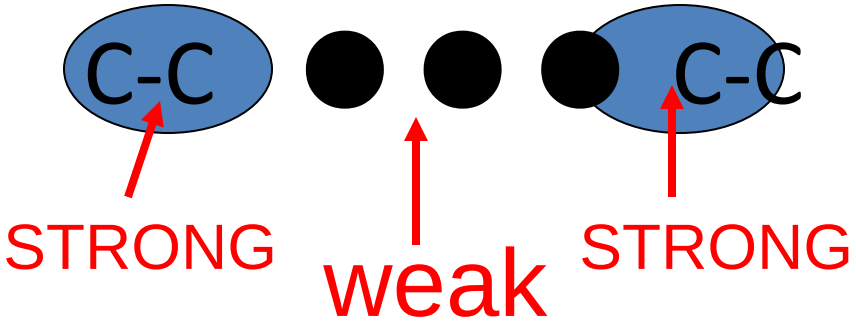
II. Characteristics of Organic Compounds

- They are nonpolar compounds – they do not dissolve in polar solvents like Water.



*remember the rule – "likes dissolve likes"

4) They have low melting points – due to weak intermolecular forces.

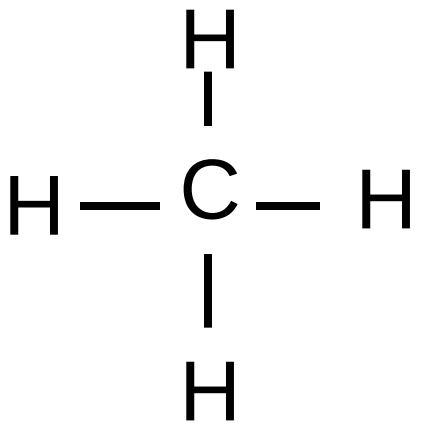


5) They react slower than ionic compounds – due to strong covalent bonds between atoms.

Structural Formulas –

A 2D model shows bonding patterns and shapes of molecules

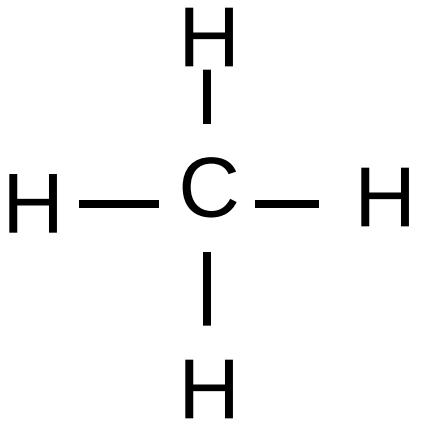
- Carbon is found in the center



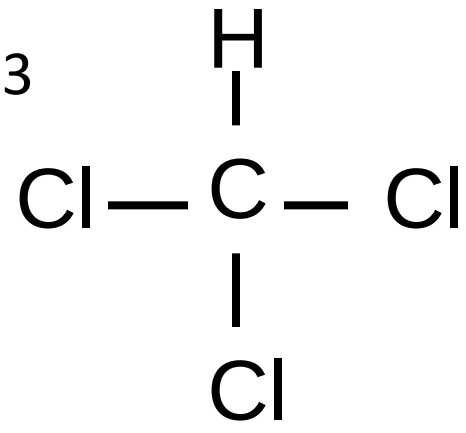
- The short line – represents a pair of electrons.

Draw the structures for each organic

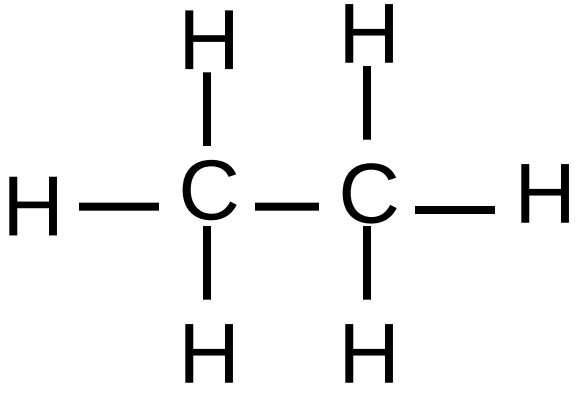
1. Methane: CH_4



2. Chloroform: $CHCl_3$



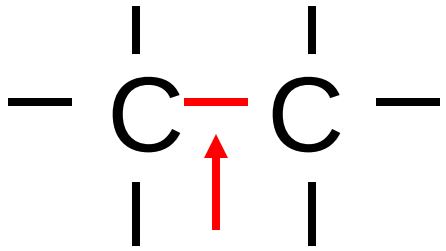
3. Ethane: C_2H_6

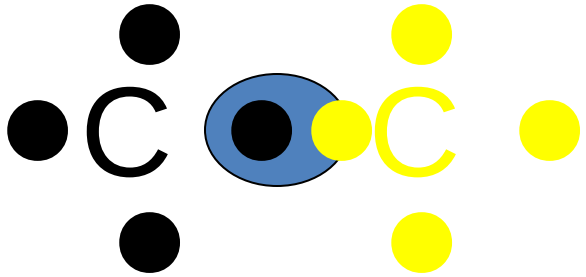


Remember : Carbon has **4** bonding sites.

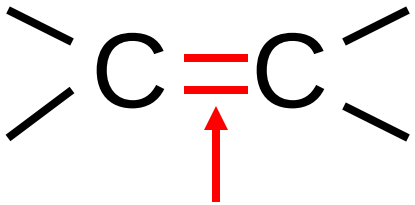
Types Of Bonds

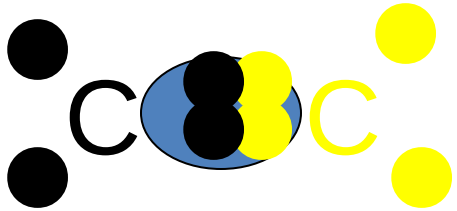
<u>Single Bond</u> – single covalent bond in which they share **1** pair of electrons. (2 e-)



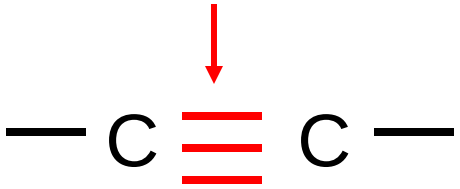


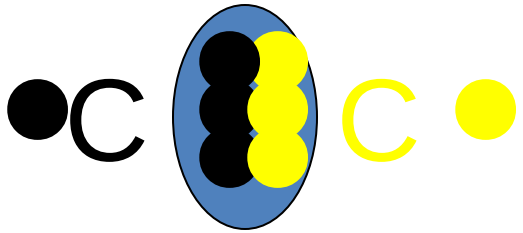
<u>Double Bond</u> – carbon atoms may share **2** pairs of electrons to form a double bond.





<u>Triple Bond</u> – carbon atoms may share **3** pairs of electrons to form a triple bond.

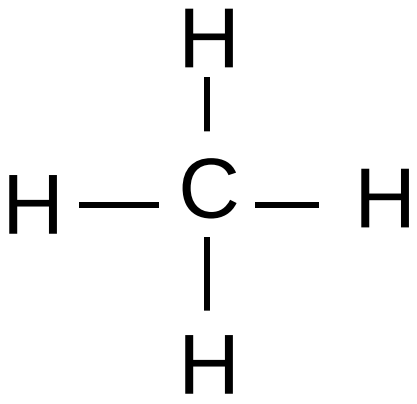




Types Of Compounds

Saturated Compound – organic compounds in which carbon atoms are bonded by SINGLE bonds.

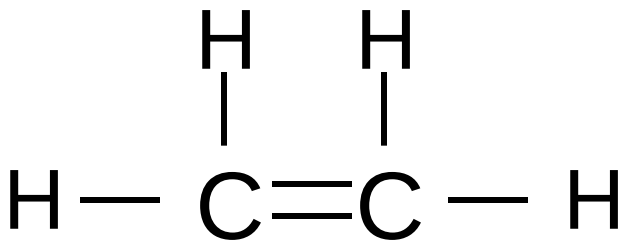
ex. Methane: CH_4



Types Of Compounds

Unsaturated Compound – compounds where carbon atoms have double or triple bonds.

ex. ethene: C_2H_4

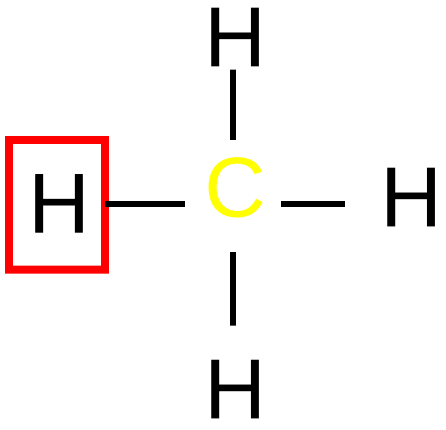


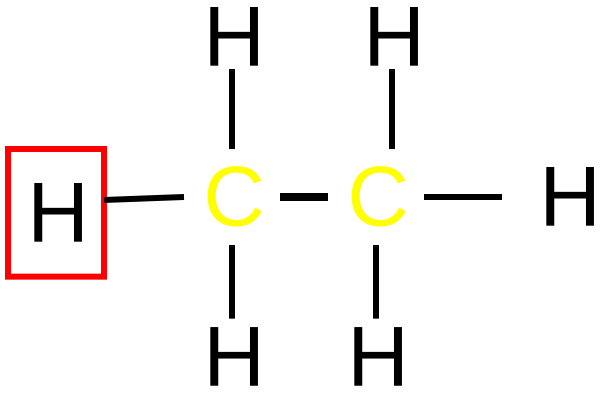
Homologous Series of Hydrocarbons

- Organic compounds can be classified into groups with related structures and properties.

***As size of molecule increases the boiling and freezing points increase.

Hydrocarbons are organic compounds that consist of only Carbon and Hydrogen atoms.





Base names

Prefix	Length of carbon chain
Meth	**1**
Eth	**2**
Prop	**3**
But	**4**
Pent	5
Hex	6
Hept	7
Oct	8
Non	9
Dec	10

Alkanes

Simplest members of the hydrocarbon family.

- contain only hydrogen and carbon
- only have single bonds
- Saturated hydrocarbons

All members have the general formula of

$$C_nH_{2n+2}$$

Twice as many hydrogen as carbon + 2

Alkanes = C_nH_{2n+2}

- A saturated hydrocarbon contains 5 carbons. What is the formula?

$C_5H_{2(5)+2}$ = C_5H_{12}

- A saturated hydrocarbon contains 20 carbons. What is the formula?

$C_{20}H_{2(20)+2}$ = $C_{20}H_{42}$

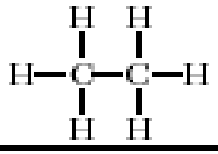
Saturated = Single

Alkanes

Table P
Organic Prefixes

Prefix	Number of Carbon Atoms
meth-	1
eth-	2
prop-	3
but-	4
pent-	5
hex-	6
hept-	7
oct-	8
non-	9
dec-	10

Table Q
Homologous Series of Hydrocarbons

Name	General Formula	Examples	
		Name	Structural Formula
alkanes	C_nH_{2n+2}	ethane	

- CH_4 = methane
- C_2H_6 = ethane
- C_3H_8 = propane
- C_4H_{10} = butane
- C_5H_{12} = pentane

Alkanes

The smaller the compound the Lower Boiling point and Melting point is (less bonds to break)

Name	BP (°C)	MP (°C)	Density
Methane	-161.7	-182.6	0.424
Ethane	- 88.6	-172.0	0.546
Propane	- 42.2	-187.1	0.582
Butane	-0.5	-135.0	0.579
Pentane	36.1	-129.7	0.626
Hexane	68.7	- 94.0	0.659
Heptane	98.4	- 90.5	0.684
Octane	125.6	- 56.8	0.703
Nonane	150.7	-53.7	0.718
Decane	174.0	-29.7	0.730

Naming Organic Compounds

- Organic compounds are named according to the IUPAC (international union of pure & applied chemistry) system of nomenclature.

Alkanes – end in ane

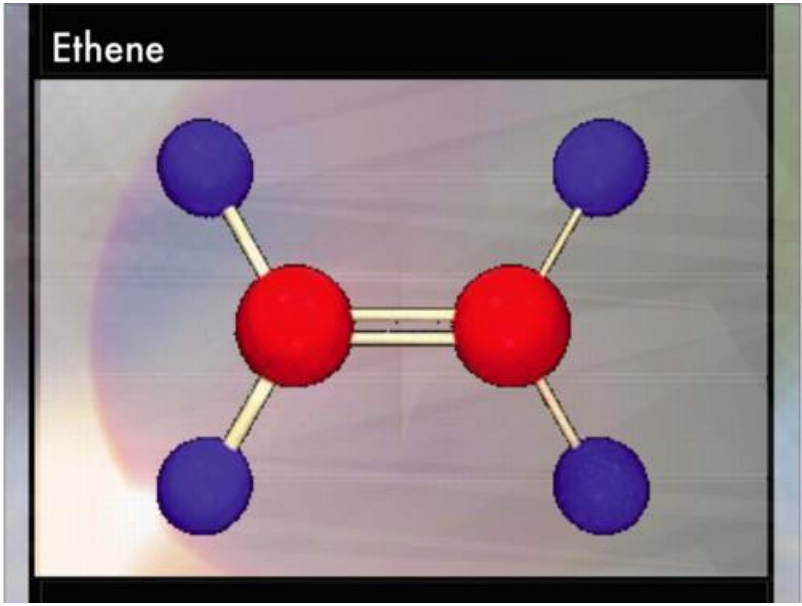
Alkenes – end in ene

Alkynes – end in yne

Alk*enes* – C_nH_{2n}

series of unsaturated hydrocarbons having one double bond (C=C)

- Also called ethylene series (IUPAC name is ethene)
- General formula C_nH_{2n}

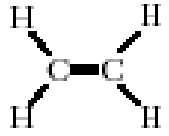


Alkenes

Table P
Organic Prefixes

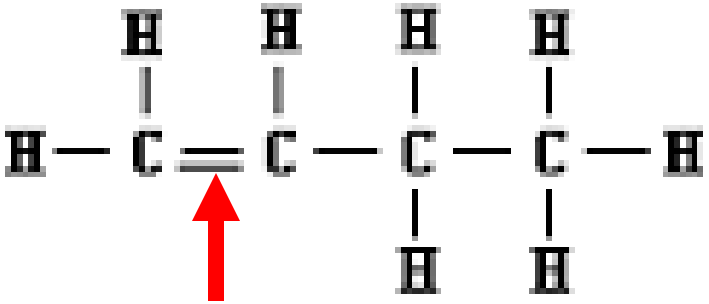
Prefix	Number of Carbon Atoms
meth-	1
eth-	2
prop-	3
but-	4
pent-	5
hex-	6
hept-	7
oct-	8
non-	9
dec-	10

Table Q
Homologous Series of Hydrocarbons

Name	General Formula	Examples	
		Name	Structural Formula
alkenes	C_nH_{2n}	ethene	

- C_2H_4 = Ethene
- C_3H_6 = Propene
- C_4H_8 = Butene
- C_5H_{10} = Pentene
- To find the number of hydrogens, double the number of carbons.

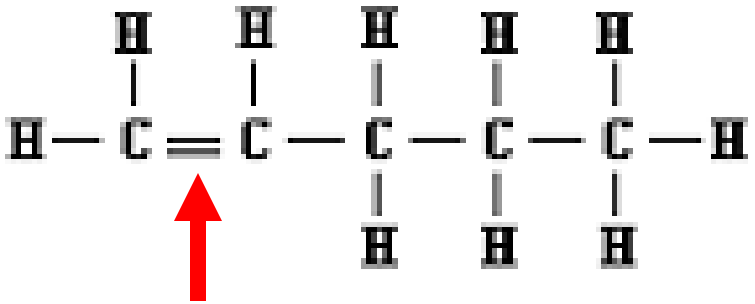
1-Butene



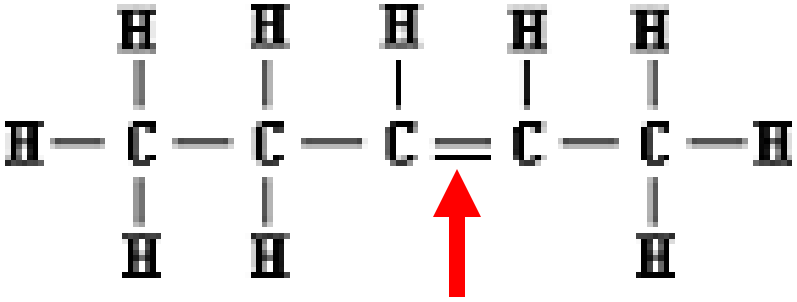
This is 1-butene, because the double bond is between the 1st and 2nd carbon from the end.

ISOMERS: Molecules have the same molecular formula, but have different structural formulas.

Pentene



This is 1-pentene. The double bond is on the first carbon from the end.

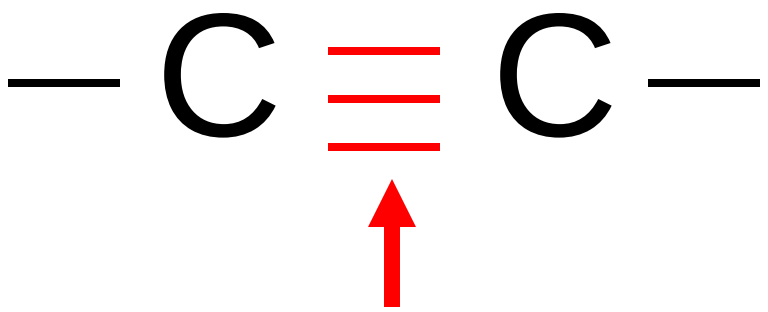


This is not another isomer of pentene. This is also 2-pentene, just that the double bond is closer to the right end.

Alk*ynes* –
a series of unsaturated hydrocarbons that contain 1 triple bond.

- Also called the acetylene series

- General formula C_nH_{2n-2}



Alkynes

Table Q
Homologous Series of Hydrocarbons

Name	General Formula	Examples	
		Name	Structural Formula
alkynes	C_nH_{2n-2}	ethyne	H—C≡C—H

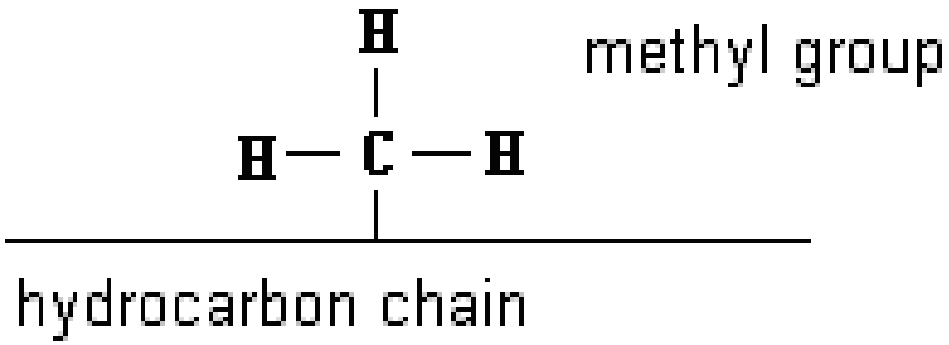
Table P
Organic Prefixes

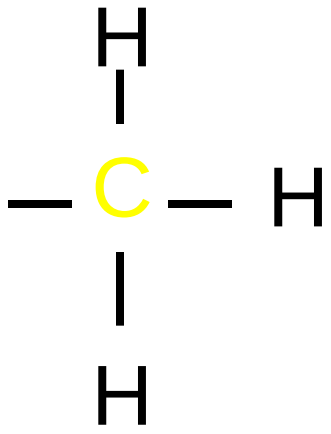
Prefix	Number of Carbon Atoms
meth-	1
eth-	2
prop-	3
but-	4
pent-	5
hex-	6
hept-	7
oct-	8
non-	9
dec-	10

- C_2H_2 = Ethyne
- C_3H_4 = Propyne
- C_4H_6 = Butyne
- C_5H_8 = Pentyne

Alkyl Groups – have one less hydrogen than the corresponding alkane.

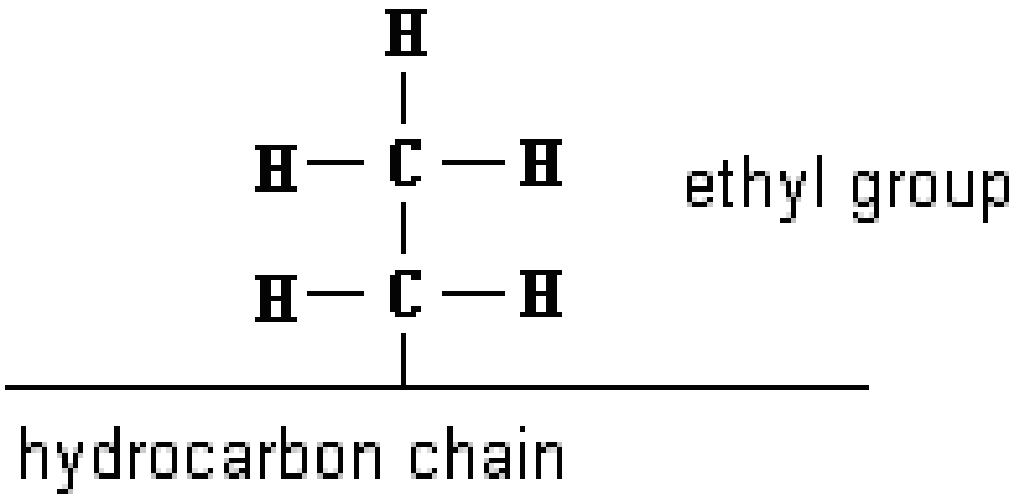
- CH_3 is methyl – one less H than methane, CH_4





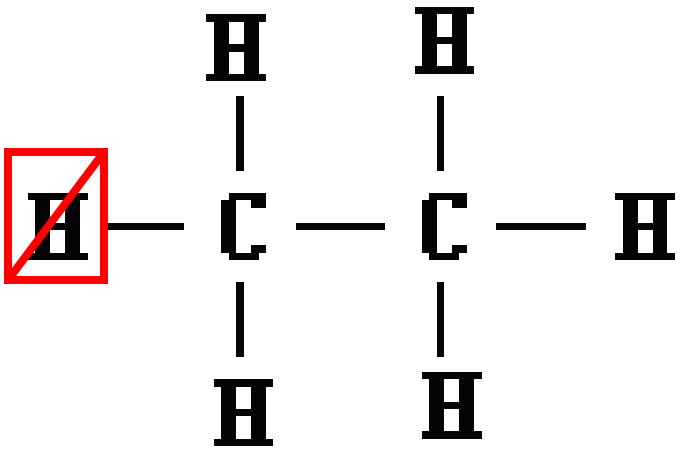
Draw methyl

- C_2H_5 is **ethyl** – one less H than ethane C_2H_6



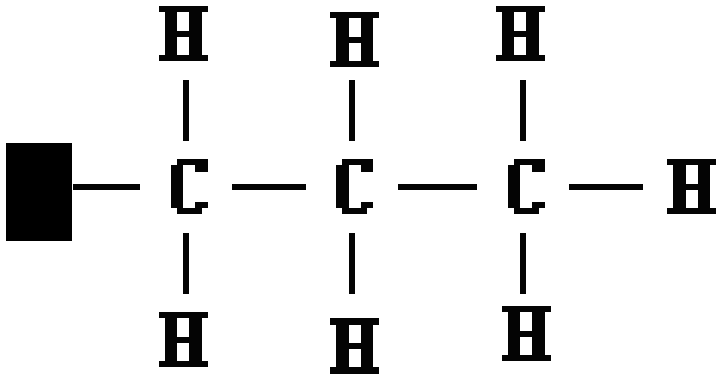
Condensed Formula:

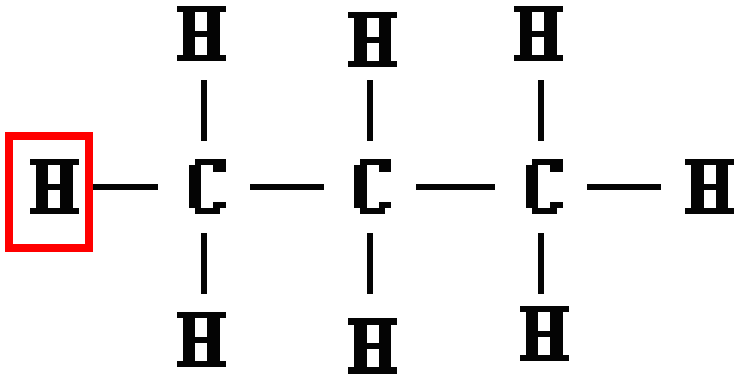
CH_2CH_3



Ethane

- C_3H_7 is **propyl** – one less H than propane C_3H_8



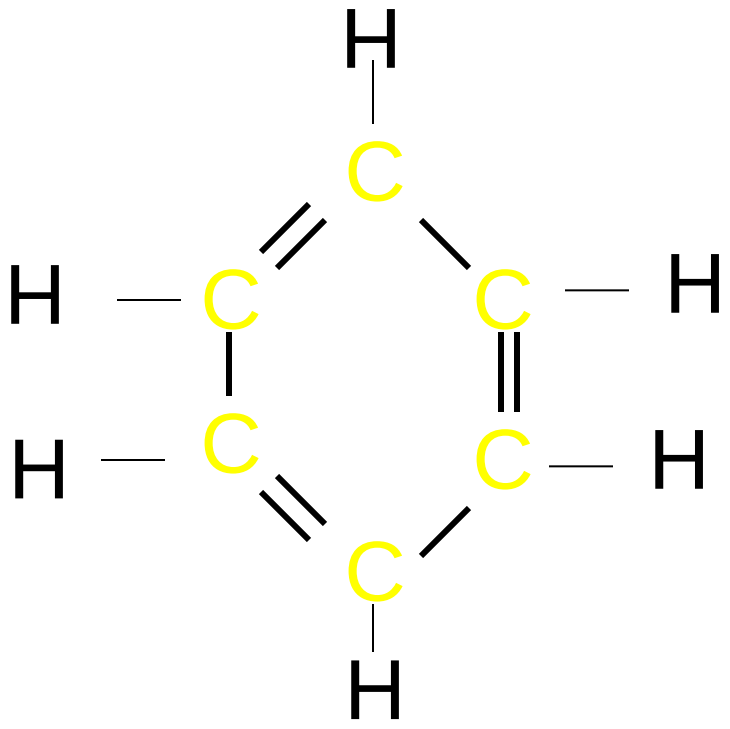


propane

Benzene – a series of cyclic unsaturated hydrocarbons.

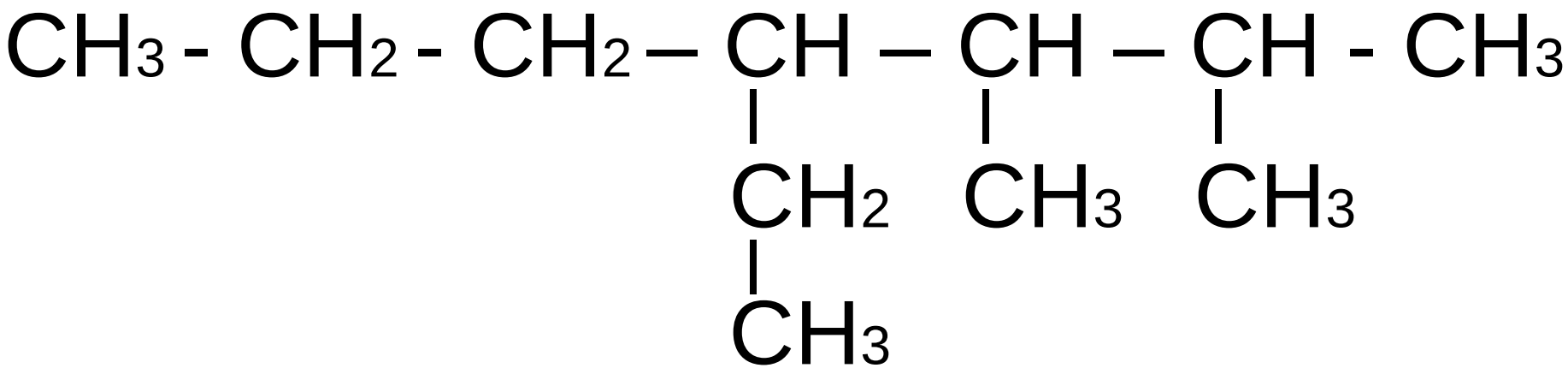
- General formula C_nH_{2n-6}

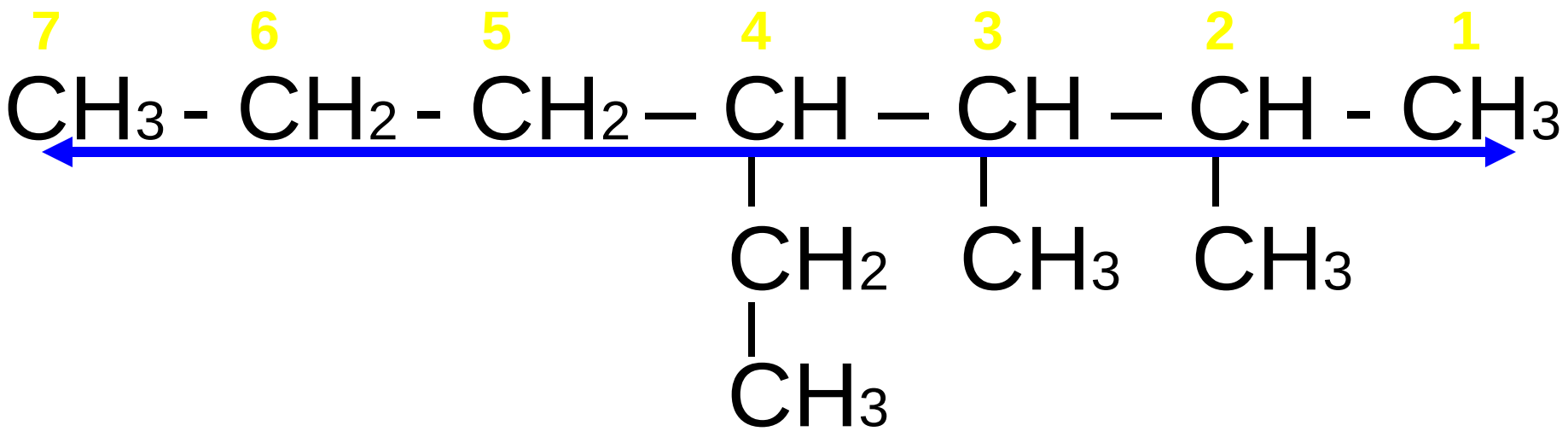
Benzene – C_6H_6 the simplest in the family



IUPAC Naming Branched Hydrocarbon Chains

Sometimes the hydrocarbon chains are not straight and sometimes they have other elements attached to them. Here is how they are named:

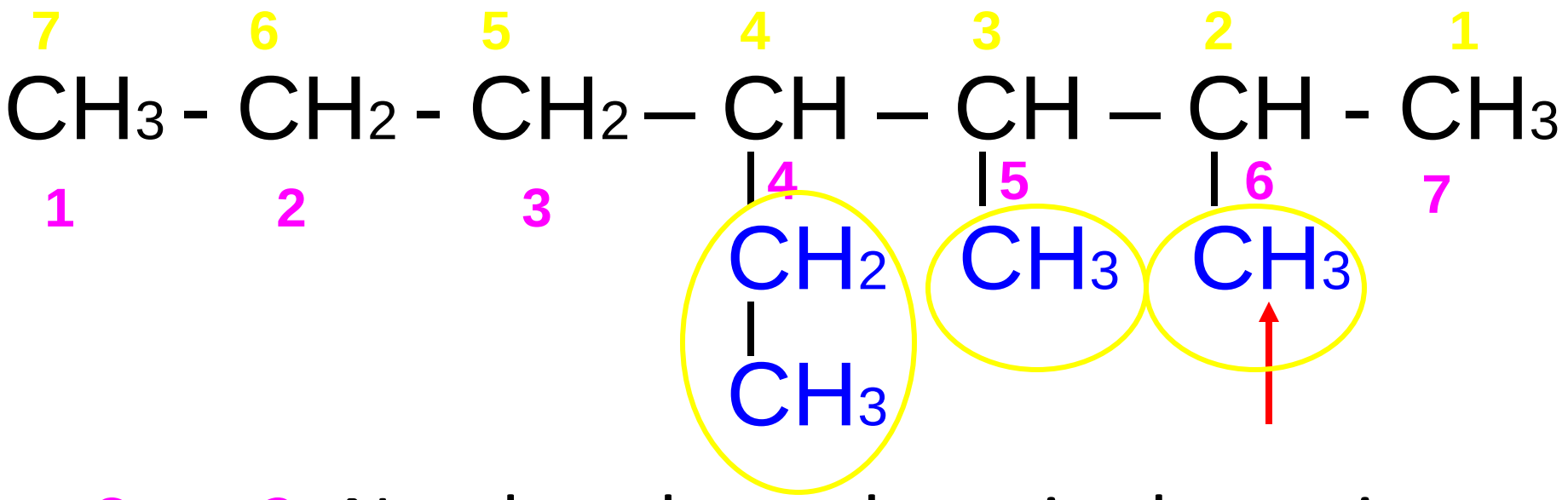




- Step 1: Find the longest continuous chain of carbons.

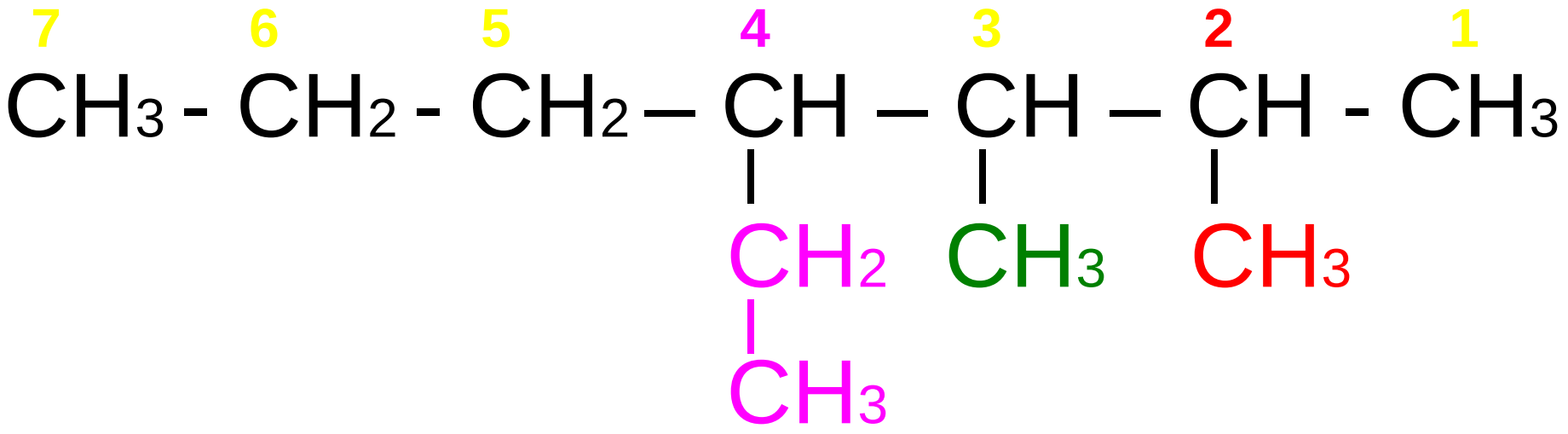
All bonds in the chain of carbons are single bonds so ending is…ane.

There are 7 continuous carbons, so the parent chain is heptane.



- Step 2: Number the carbons in the main sequence starting with the end that will give the attached groups the smallest #.

- This chain is numbered from right to left because there is a substituent closest to the right.



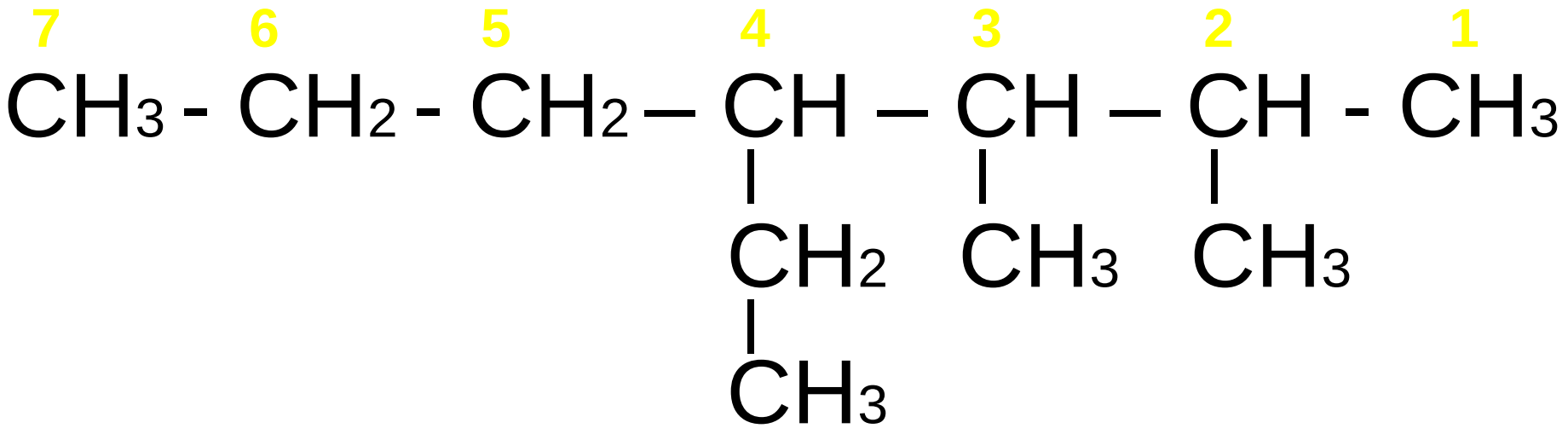
- Step 3 : Add numbers to the names of the groups to identify their positions on the chain.

- these numbers become prefixes to the parent chain.

In this ex. the positions are:

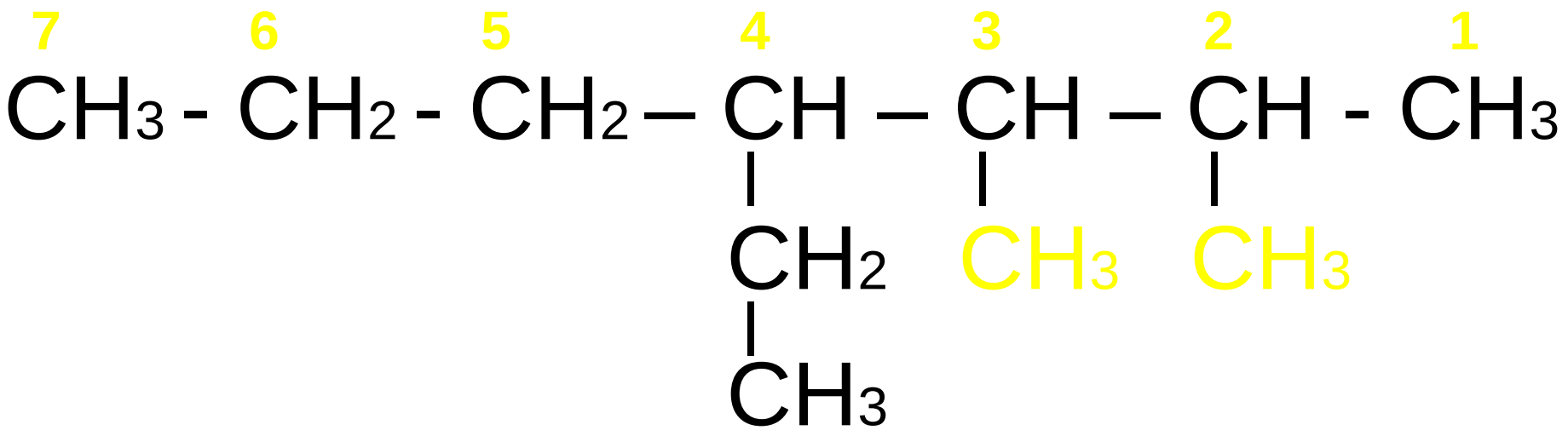
yl
ethane
C_2H_5

2- methyl, 3- methyl, 4- ethyl



- Step 4: Use prefixes to indicate the appearance of a group more than once in the structure.

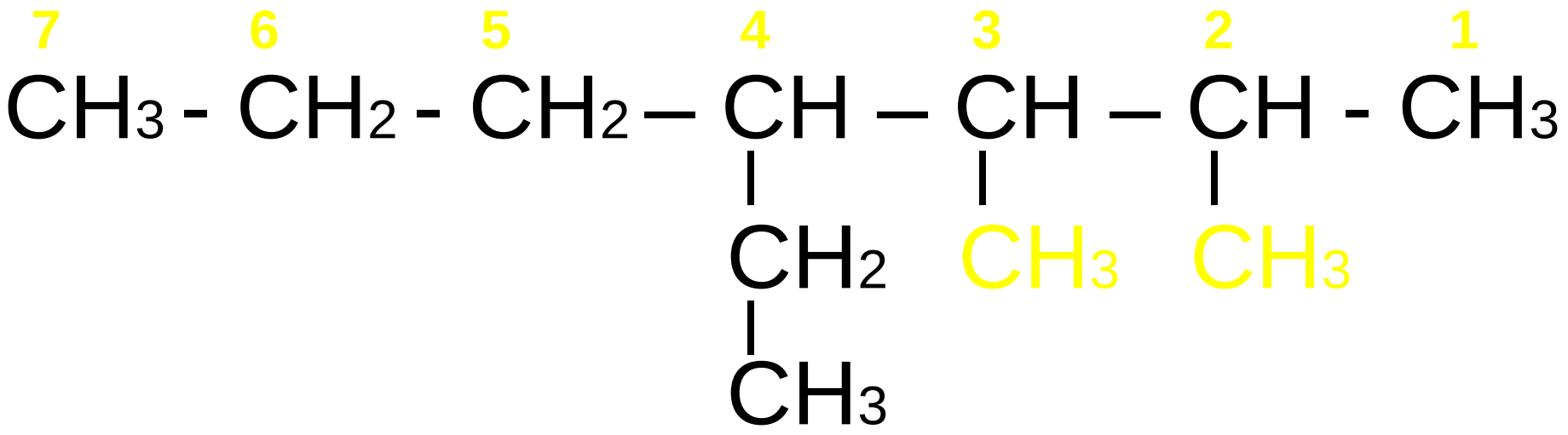
Di	=	twice
Tri	=	three times
Tetra	=	four times
Penta	=	five times



- This chain has 2 methyl groups so dimethyl is used.

Step 5: List the alkyl groups in alphabetical order.

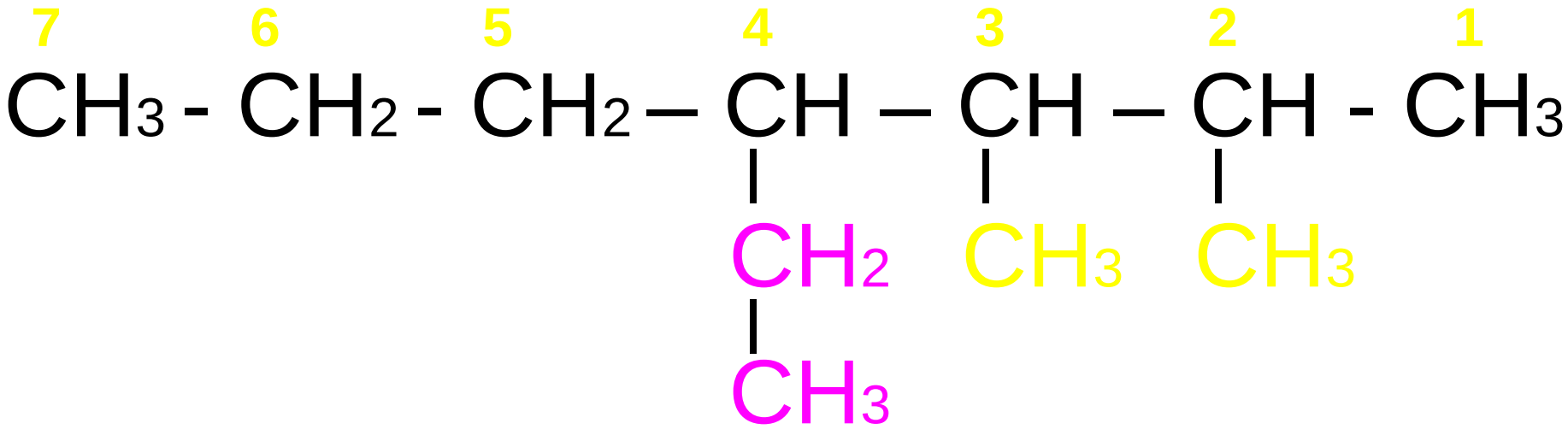
In this ex. dimethyl is listed before the ethyl.



Step 6: Use punctuation

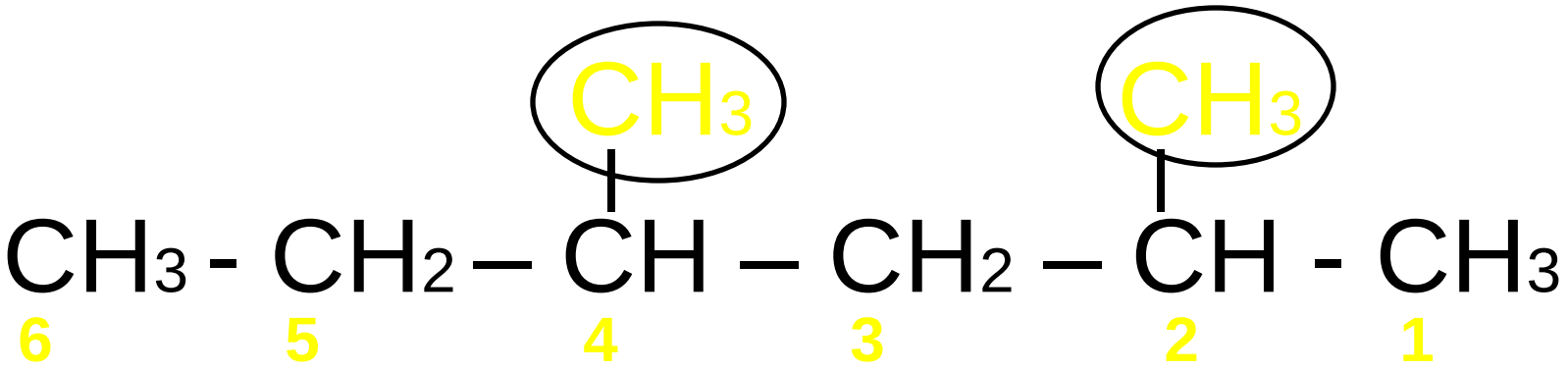
- use commas to separate numbers

-hyphens to separate numbers with words.



- The name of this compound is:

2,3-dimethyl – 4-ethyl heptane



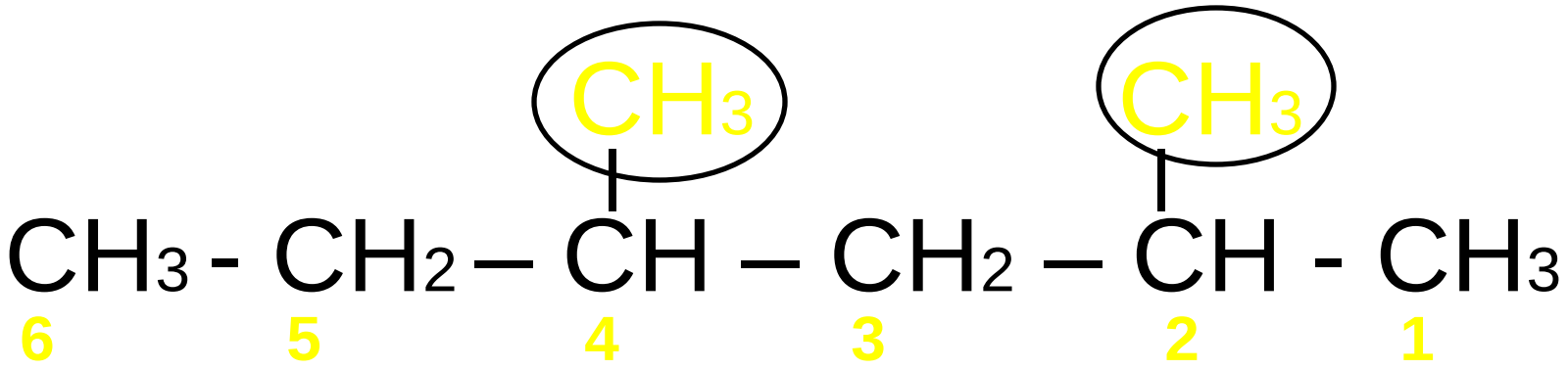
Step 1: 6 carbons = hex

All single bonds = ends in ane

So parent chain is hexane

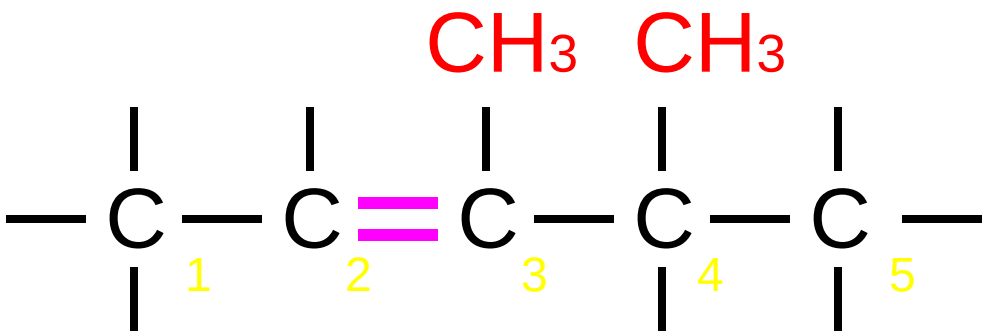
Step 2: start numbering from right to left

Step 3: 2 -methyl and 4-methyl



2,4 dimethyl hexane

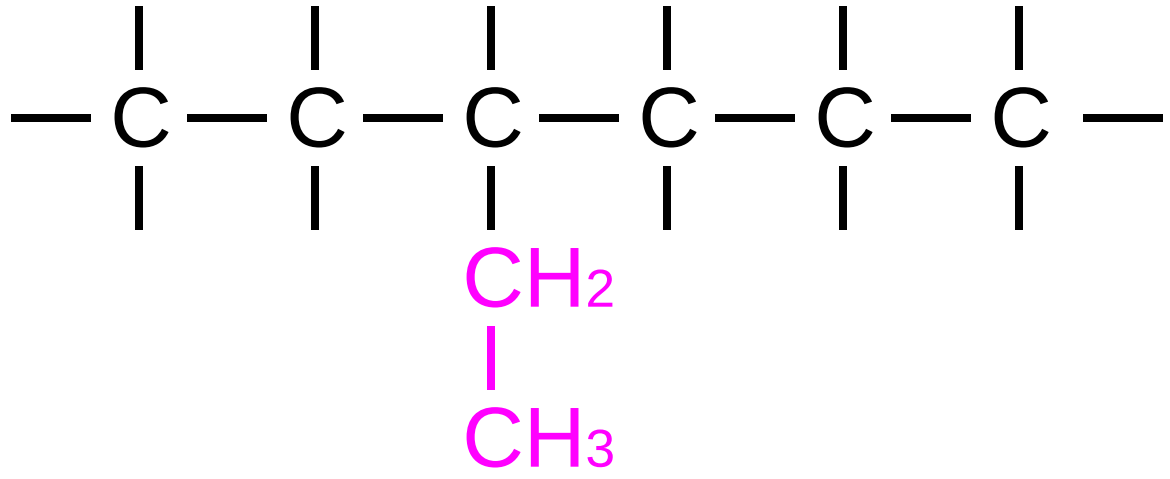
When naming with a double/triple bond- start # carbons closest to the bond.



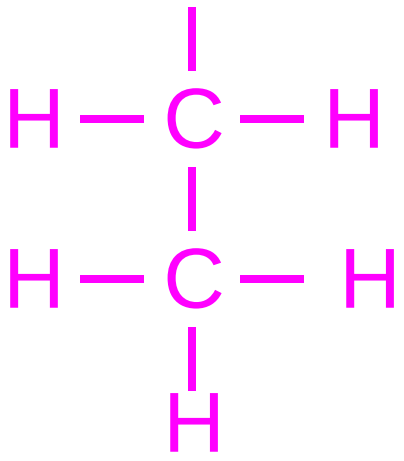
3,4 dimethyl, 2-pentene

Now start with name and draw the structure.

- 3-ethylhexane

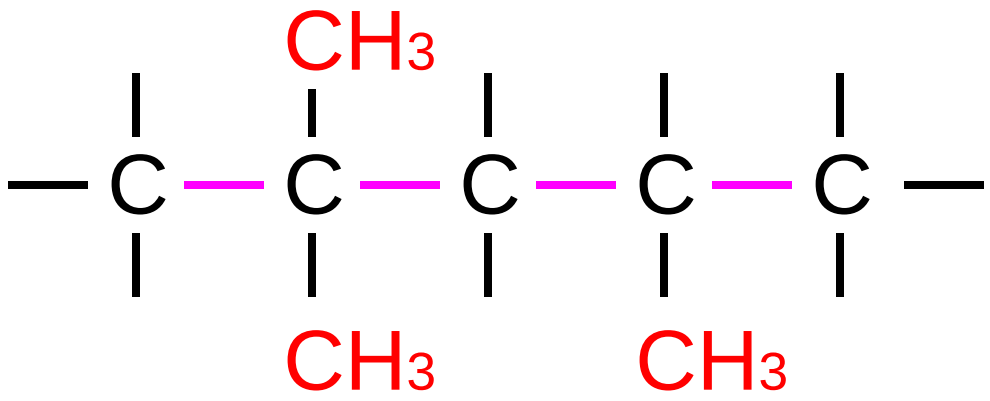


You can place H's all around or just leave as is.



yl
ethane
C_2H_5

- 2,2,4-trimethylpentane



Other Organic Compounds

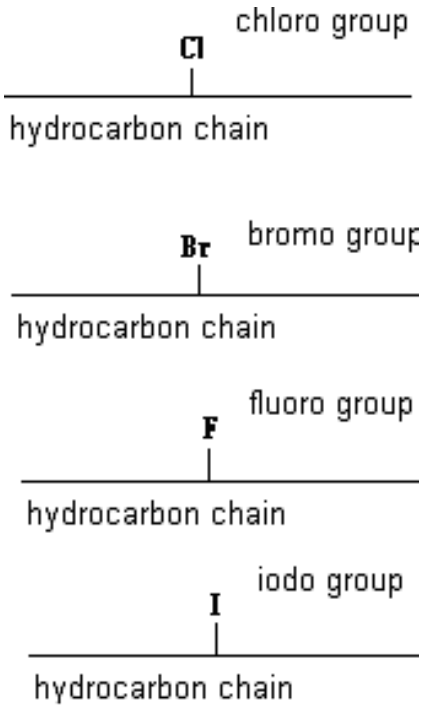
Functional Groups – specific groupings of atoms that give characteristic properties to organic compounds.

➡ halides F (fluoro-)

Cl (chloro-)

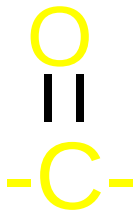
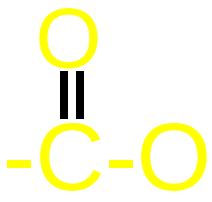
Br (bromo-)

I (iodo-)



What group do these belong to?

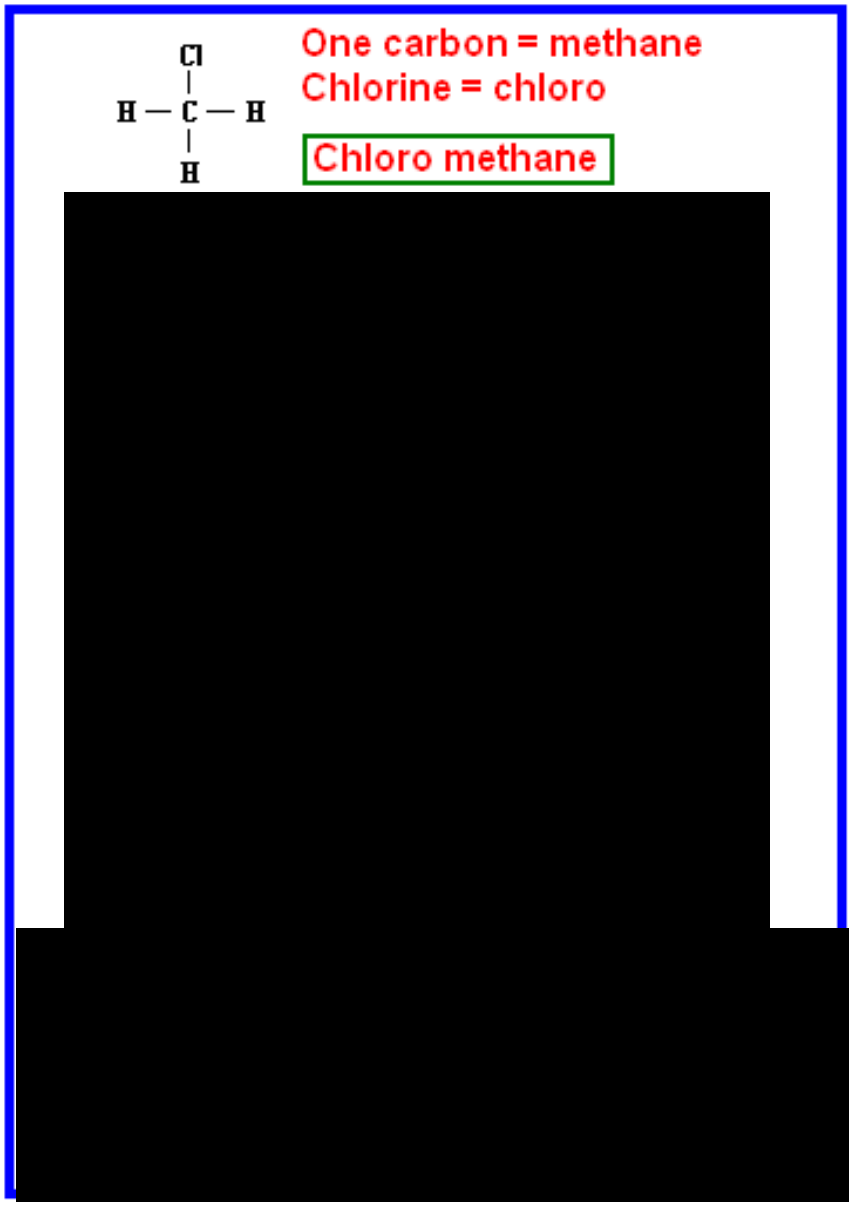
Halogens

- Alcohols -OH hydroxyl
- Organic acids -COOH carboxyl
- Aldehydes -CHO carbonyl
- Ketones 
- Ethers -O-
- Esters 
- Amines
- Amides

Halides

Cmpds that are formed when any halogen (F,Cl,Br,I) replaces an H atom in an alkane.

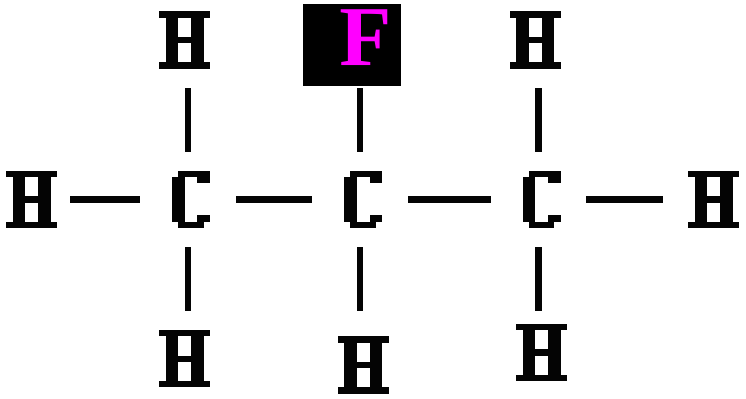
The functional group is the halide (F,Cl,Br,I)



Halides

- They are named by citing the location of the halogen attached to the chain

Drop the “ine” and add “o”



2- fluoropropane

Alcohols

- Are organic cmpds in which one or more of the hydrogens is replaced with an – OH group.

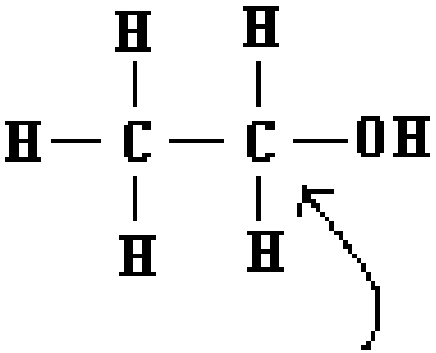
- OH group is called the hydroxyl group

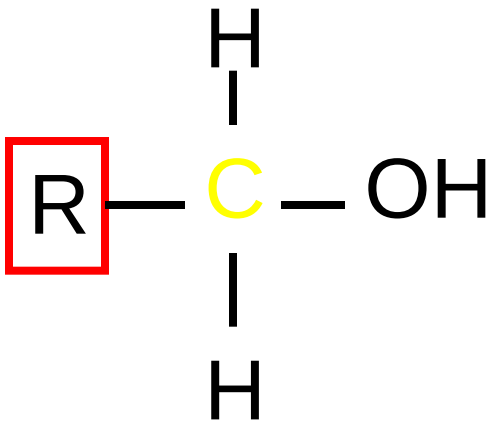
Table R
Organic Functional Groups

Class of Compound	Functional Group	General Formula	Example
alcohol	—OH	R—OH	$CH_3CH_2CH_2OH$ 1-propanol

Monohydroxyl Alcohols

-have one –OH group





Shortcut way to represent a primary alcohol

R-OH

R stands for REST of the molecule

IUPAC naming of alcohols

- Replace the final "e" with "-ol"
  - methane → methanol → CH_3OH
  - ethane → ethanol → C_2H_5OH
  - propane → propanol → C_3H_7OH
  - butane → butanol → C_4H_9OH
  - pentane → pentanol → $C_5H_{11}OH$

Example

C – C – C – C – O – H

Base contains 4 carbon

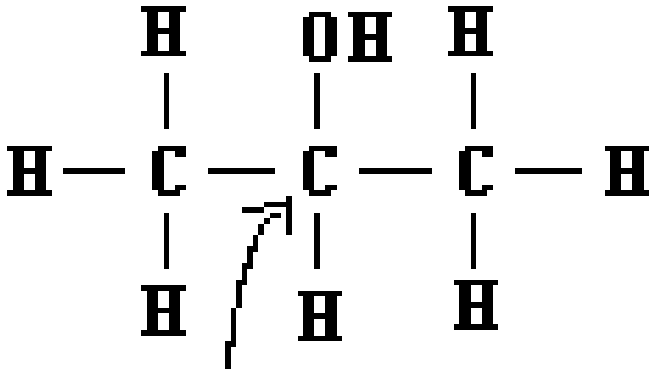
alkane name is butane

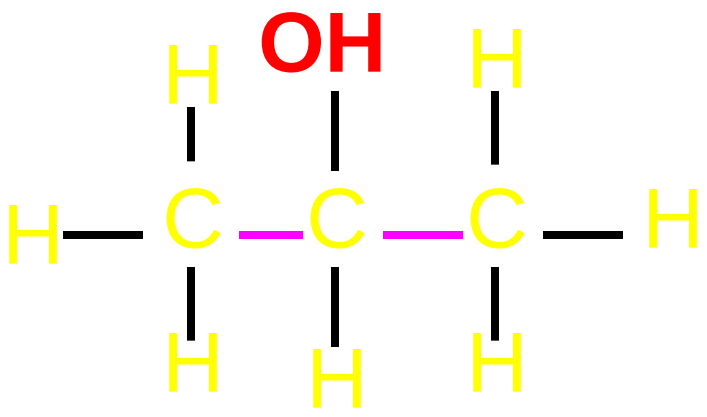
remove –e and add –ol

alcohol name – butanol

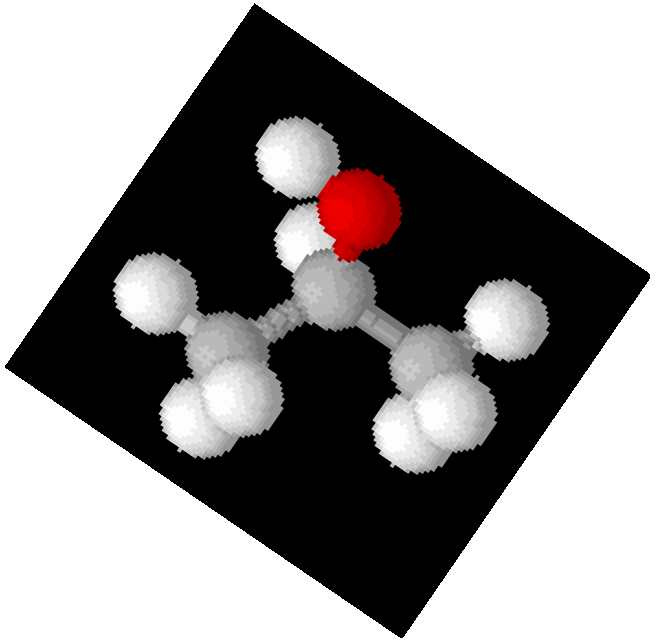
OH is on the first carbon so – 1–butanol

Ex. 2-propanol





1 2 3



Organic acids – have the functional group -COOH

- R-COOH

Carboxyl group

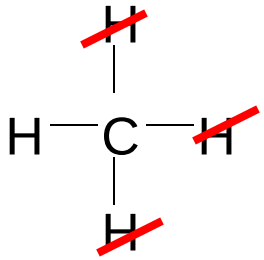
Table R
Organic Functional Groups

Class of Compound	Functional Group	General Formula	Example
organic acid	$-\overset{\overset{O}{\|\|}}{C}-OH$	$R-\overset{\overset{O}{\|\|}}{C}-OH$	$CH_3CH_2\overset{\overset{O}{\|\|}}{C}-OH$ propanoic acid

IUPAC naming of Organic Acids

- Replace the final “e” with “-oic ”acid

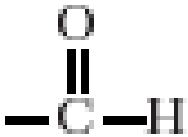
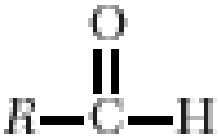
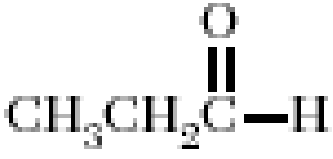
Methanoic acid - HCOOH



Aldehydes- contain the functional group -CHO

R-CHO

Table R
Organic Functional Groups

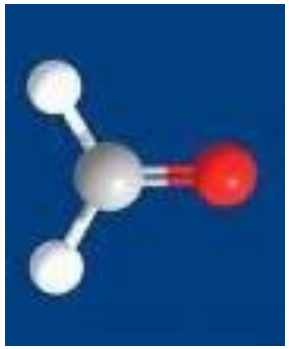
Class of Compound	Functional Group	General Formula	Example
aldehyde			 propanal

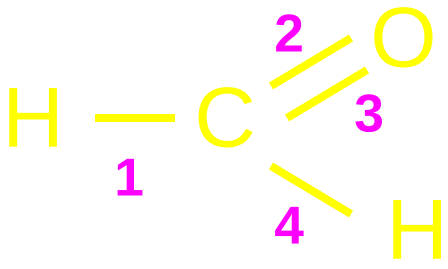
IUPAC naming of Aldehydes-

- Replace the final “e” the the ending “al”

First member of the aldehyde family is methanal

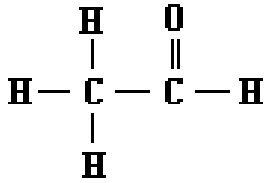
-its common name is formaldehyde





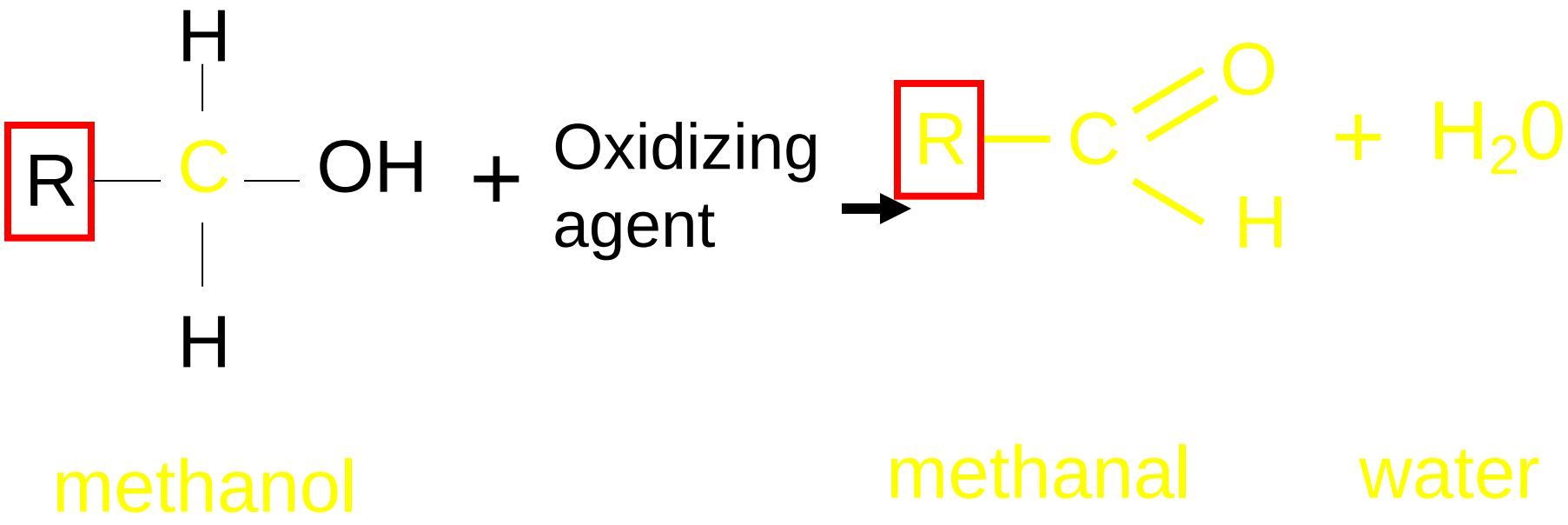
Used to preserve biological samples

Methanal (formaldehyde): a one-carbon aldehyde. Used to preserve biological specimens and as a glue to hold the layers of plywood and oriented strand board together.

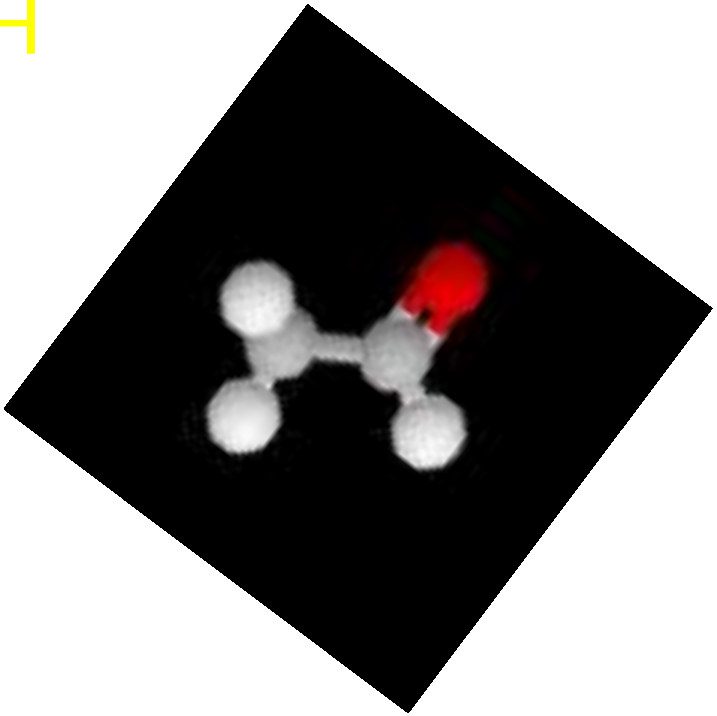


Ethanal (acetaldehyde): a two-carbon aldehyde.

- Alcohols can be oxidized to aldehydes



Draw ethanal

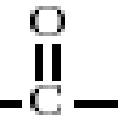
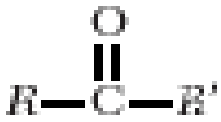


Ketones – contain the functional group

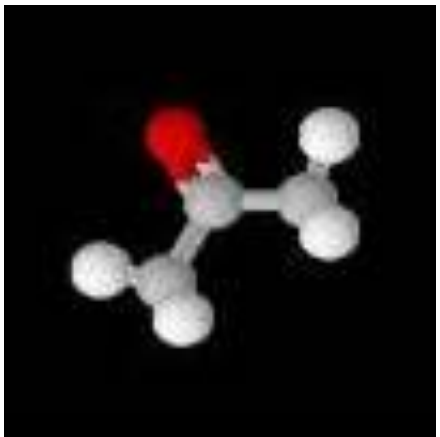
R-CO-R

- Replace the final "e" with "-one".

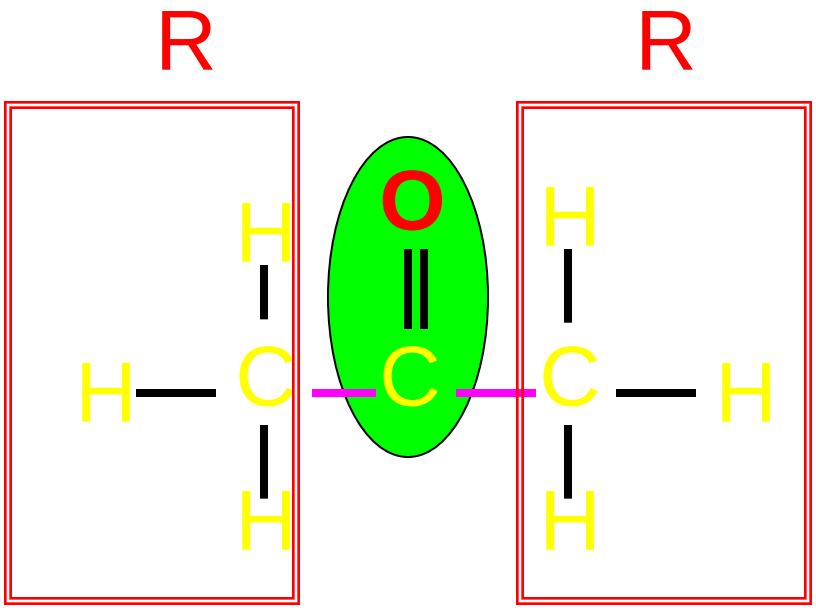
Table R
Organic Functional Groups

Class of Compound	Functional Group	General Formula	Example
ketone			 2-pentanone

- The simplest member of the ketone family is propanone.



- IUPAC name is propanone but its common name is acetone, it is an important industrial solvent.



Ethers -

- when two primary alcohols are treated with dehydrating agent, water is removed and the 2 alcohols are joined together by an oxygen "bridge".

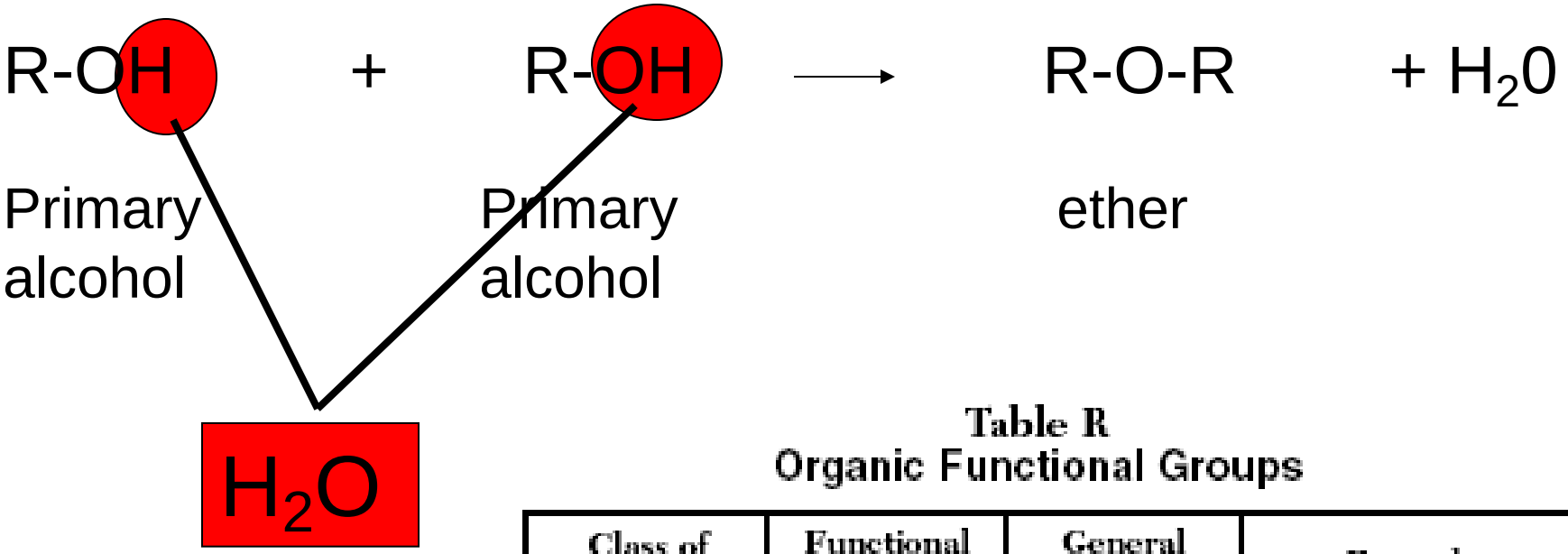
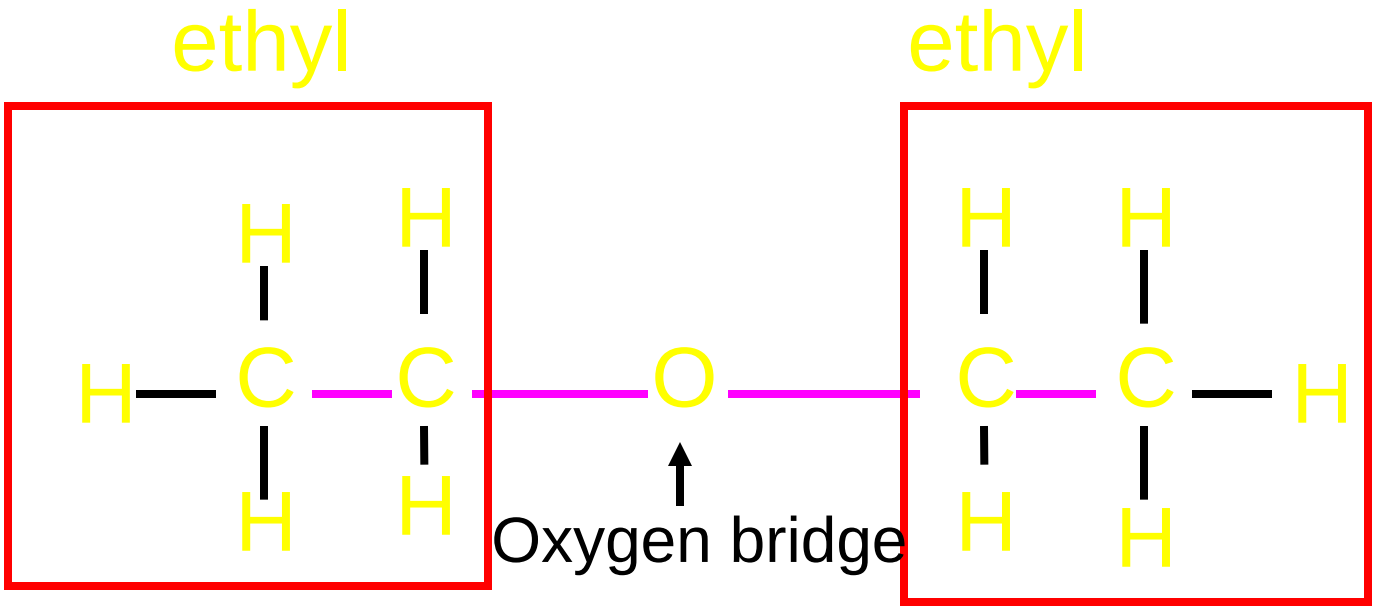


Table R
Organic Functional Groups

Class of Compound	Functional Group	General Formula	Example
ether	—O—	$R—O—R'$	$CH_3OCH_2CH_3$ methyl ethyl ether

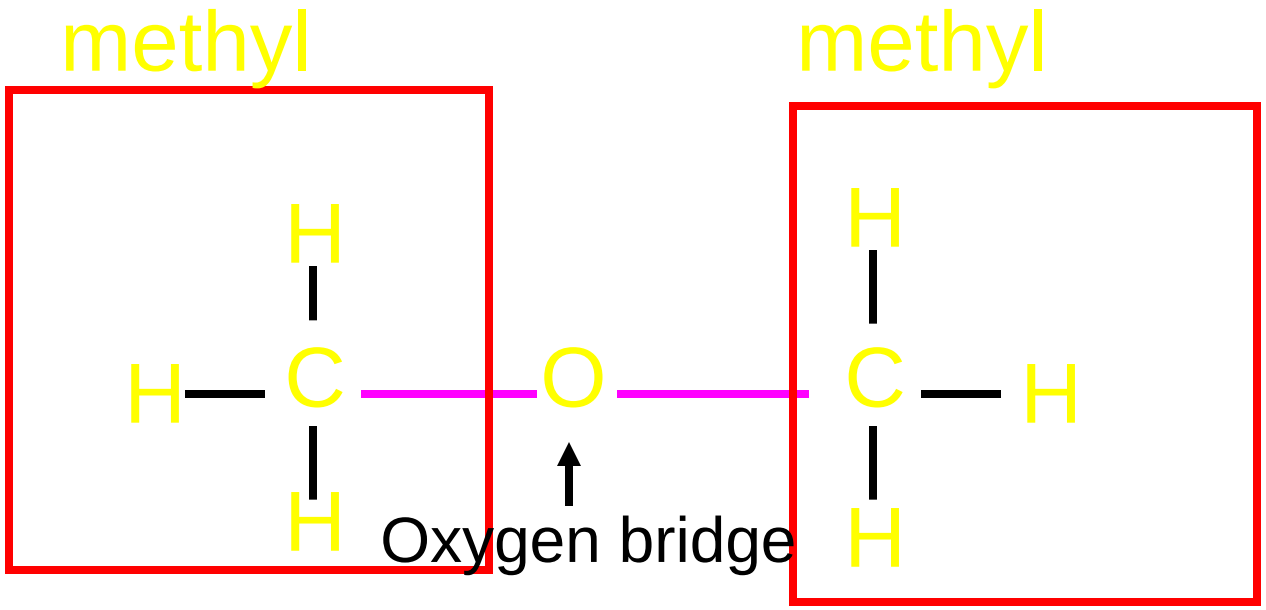
Diethyl ether- used as a general anesthetic



Condensed formula

$CH_3\ CH_2\text{-}O\text{-}\ CH_2CH_3$

Dimethyl ether-



Condensed formula

CH_3-O- CH_3

Name These:

Condensed formula

CH_3-O- CH_2CH_3

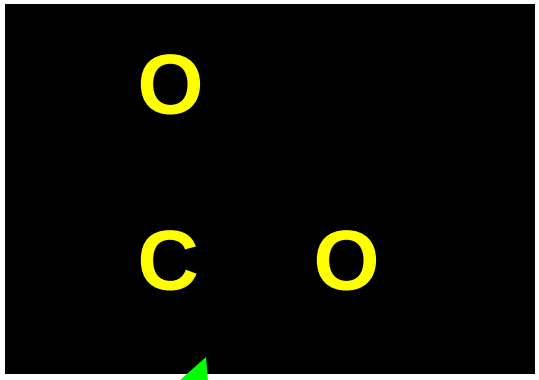
Methyl ethyl ether

CH_3CH_2-O- $CH_2CH_2CH_3$

Ethyl propyl ether

Esters – are organic cmpds with the general formula *R*-CO-O-*R*

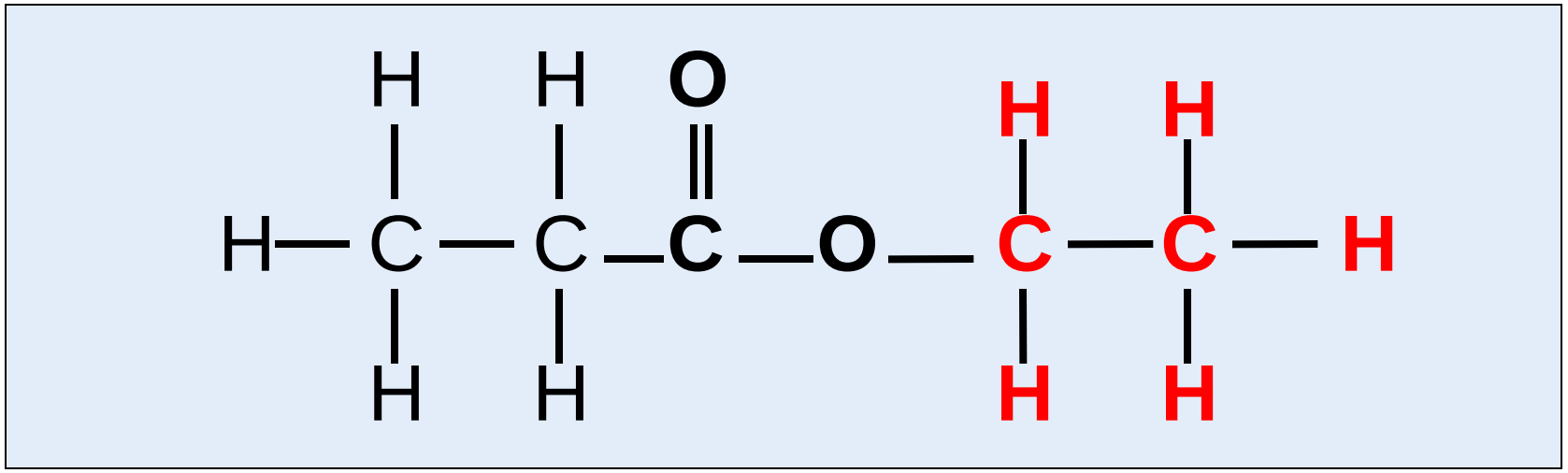
They are formed in a rxn between an organic acid and an alcohol.



Draw this:

Esters have strong fragrant aromas and are what make pineapples, bananas, wintergreen & oranges so YummY!

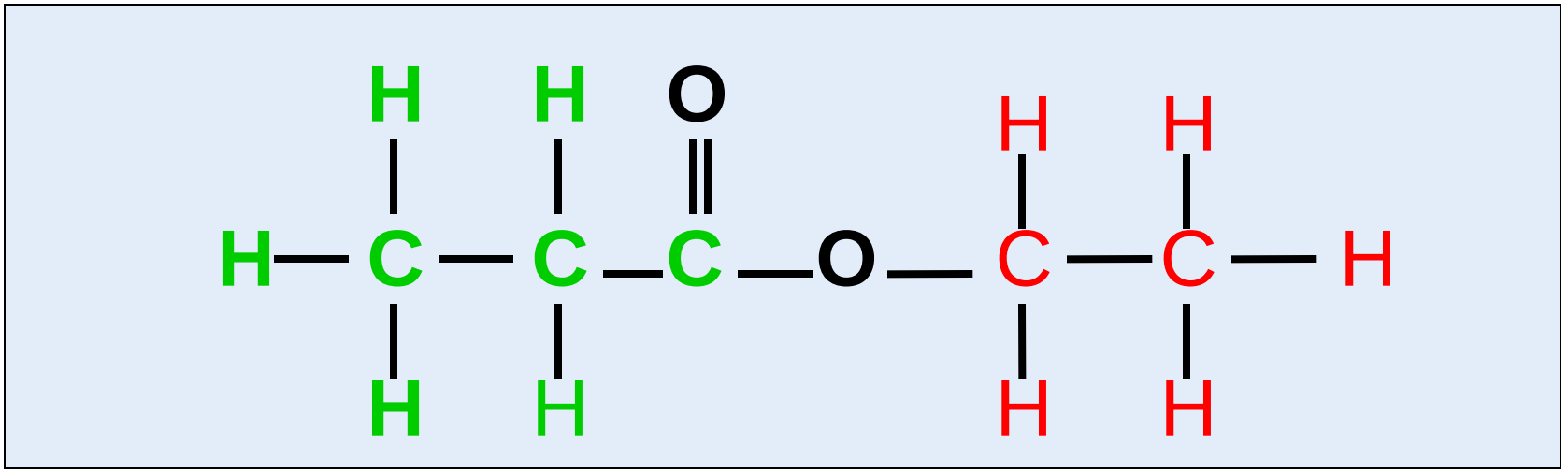
IUPAC naming of Esters:



1. Look at chain after the –C-O- write its prefix

Ex.(meth,eth, etc.) and add –yl to the end of prefix

In this ex. : eth + yl = ethyl



Condensed formula

$CH_3\,CH_2\,COO\,CH_2CH_3$

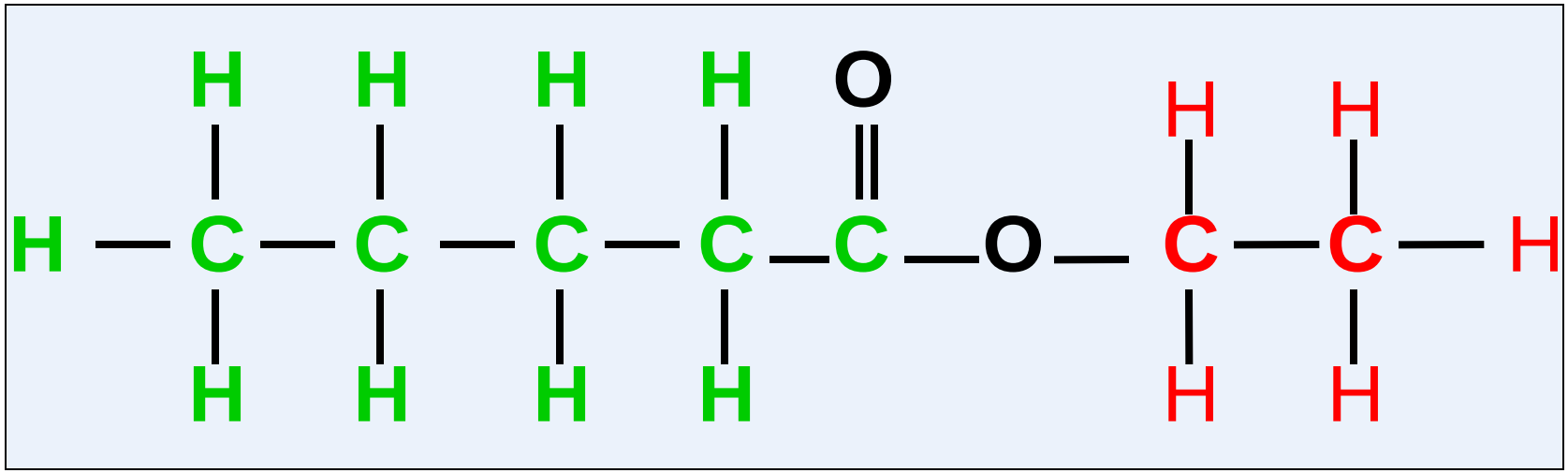
2. Give the name of the carbon chain that includes the C=O, leave off the last letter and add –oate.

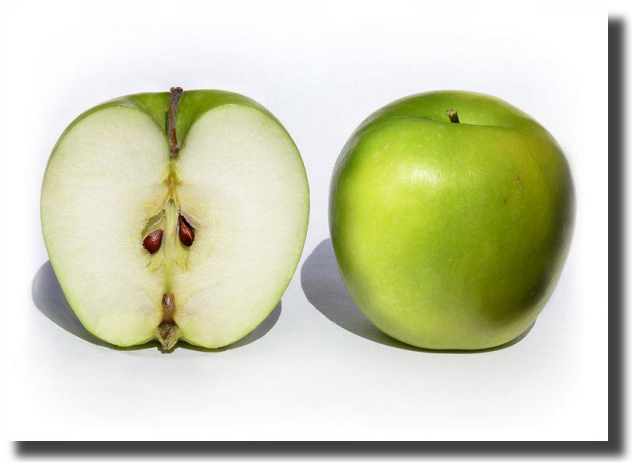
Propane

propane + oate = propanoate

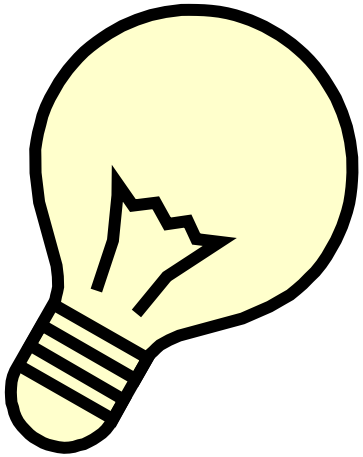
Ethyl propanoate

Ex.) Draw ethyl pentanoate





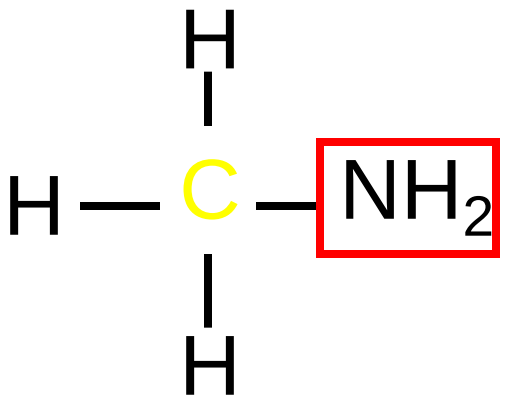
Now you've got it!



Amines – contain the functional group **-N-**

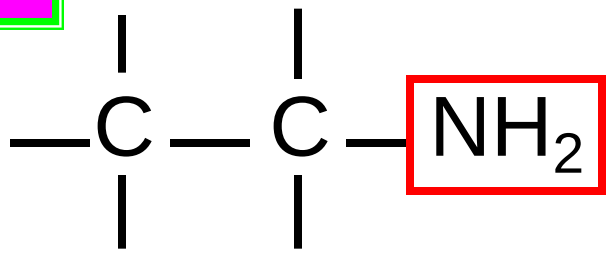
- It is a derivative of ammonia – NH_3
- IUPAC naming of amines –

  - replace the final –e with "-amine"



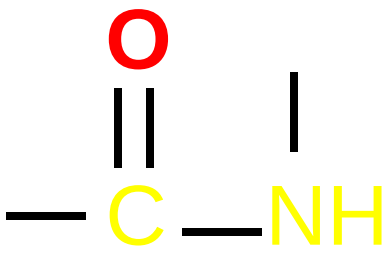
methanamine

Draw:



ethanamine

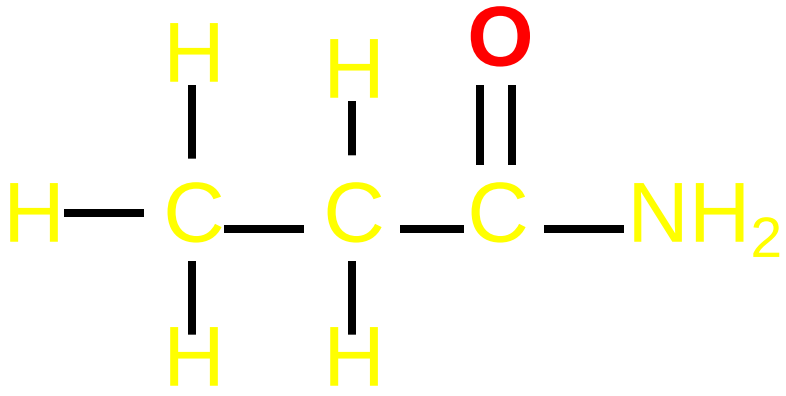
Amides – contain the functional group:



Found at the end of a carbon chain

- IUPAC naming of amides:

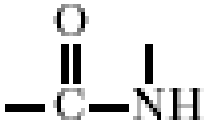
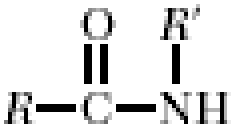
  -drop the final –e and add "amide"

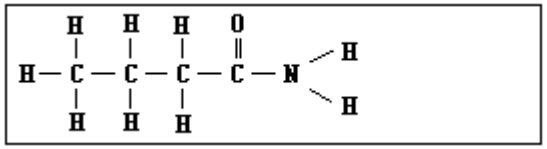


propanamide

Amide

Table R
Organic Functional Groups

Class of Compound	Functional Group	General Formula	Example
amide			 propanamide



butanamide

Synthetic Polyamides: nylon, kevlar

Natural Polyamide: silk!


Thank You.