# Organic Chemistry (Naming & Drawing)

## A. Introduction

**Organic Chemistry**: the chemistry of **CARBON compounds** except **Oxides & ionic compounds**.

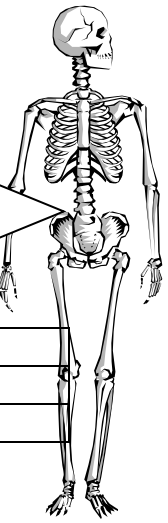
*carbon compound = organic compound(O.C.)*

Why OCs are so important in chemistry:

- we are **made of them**
- there are so **many**
- they are very **useful** to us

Common OCs: **glucose**($C_6H_{12}O_6$), **nicotine** ($C_{10}H_{14}N_2$), **Teflon** ($[C_2F_4]_x$) ,

Carbon is called the "**backbone**" of organic



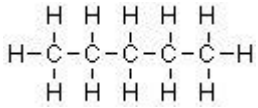
***The Abundance of OCs***

| Compounds containing: | Abundance: |
|---|---|
| only C and H *(called **hydrocarbons**)* | **hundreds of thousands** |
| C, H, and other atoms (i.e. O, N, Cl, etc.) | **over 8 million** |

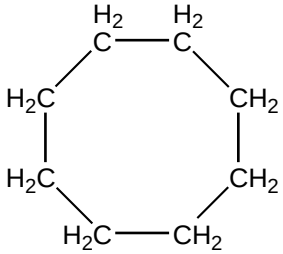
Why so many types of hydrocarbons.....2 reasons:

1. Carbon compounds are chains of carbon linked in:

- **straight lines**(linear):

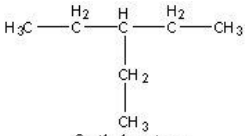


- **circular** pattern(cyclic):



cyclooctane

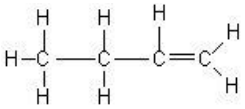
- **substituted** (branched):



3-ethylpentane

2. Carbon atoms may form **single, double**, or **triple** bonds, each having **different properties**.

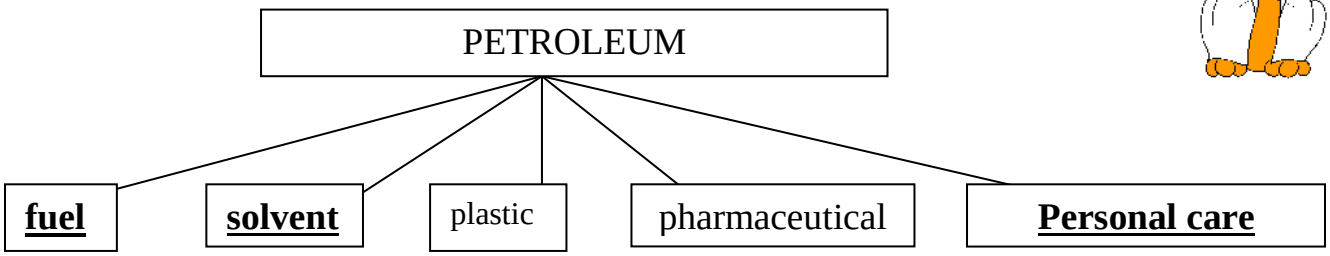
eg) this molecule has single and double C-C bonds:



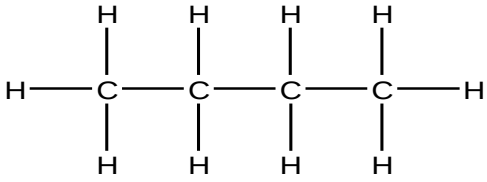
***The Uses of OCs***

**Petroleum**: "a **fossil fuel**" plant and animal remains trapped underground for hundreds of millions of years.

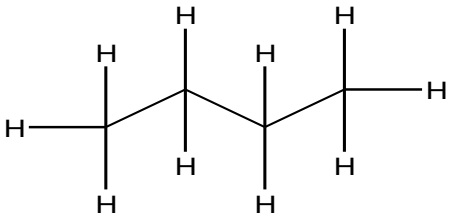
Using organic chemistry, many useful substances are derived from petroleum.



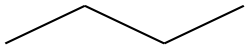

**5 Ways to represent butane**



Full structure



Half skeleton structure



Skeleton structure

$CH_3$-$CH_2$-$CH_2$-$CH_3$ or $CH_3CH_2CH_2CH_3$

Condensed structure

$C_4H_{10}$

Molecular formula

## B. Hydrocarbons ( only C and H )

3 main groups of hydrocarbons: alkanes, alkenes, alkynes.

**Type 1. ALKANES**

- contain only single C-C bonds (also called **saturated** hydrocarbons)
- are divided into: **linear**, **substituted**, and **cyclic** alkanes types.

Definition: If an atom is ***saturated***, it is bonded to the maximum number of other atoms (for C this is 4 other atoms, since the valence of C = 4)

### *a) NAMING LINEAR ALKANES*

| # of C in chain | Prefix | Suffix | Name | Molecular formula | Mnemonic |
|---|---|---|---|---|---|
| 1 | meth- | ane | *methane* | **$CH_4$** | **Mark** |
| 2 | eth- | ane | *ethane* | **$C_2H_6$** | **Eats** |
| 3 | prop- | ane | *propane* | **$C_3H_8$** | **Pizza** |
| 4 | but- | ane | *butane* | **$C_4H_{12}$** | **But** |
| 5 | pent- | ane | *pentane* | **$C_5H_{12}$** | **Penny** |
| 6 | hex- | ane | *hexane* | **$C_6H_{14}$** | **Hates** |
| 7 | hept- | ane | *heptane* | **$C_7H_{16}$** | **His** |
| 8 | oct- | ane | *octane* | **$C_8H_{18}$** | **Onion-breath** |
| 9 | non- | ane | *nonane* | **$C_9H_{20}$** | **Next** |
| 10 | dec- | ane | *decane* | **$C_{10}H_{22}$** | **day** |
| etc… | | | | | |

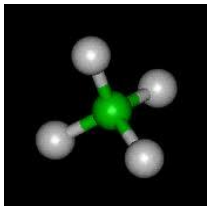
(**notice**; **General formula** = $C_nH_{2n+2}$)

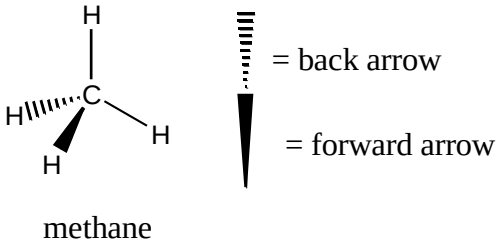
### *ii) GEOMTERY:*

On paper, bonds on carbon atoms are all at **right angles** BUT bond angles are actually = **109.5 °.**

The bonds are actually arranged in the shape of a 4 cornered pyramid. (*tetra* hedron) (**4 sides**)

eg) $CH_4$






methane

### *b) SUBSTITUTED ALKANES*

These are alkanes with **branches**, and the branches are **hydrocarbons** themselves.

To make a branch (alkyl group):

**alkyl group**

| Alkane | | Branch form |
|---|---|---|
| $C_2H_6$ | Remove a Hydrogen → | - $C_2H_5$ |
| ethane | | ethyl |

***i) NAMING AND DRAWING:***

| original alkane | alkane name | branch form | branch name |
|---|---|---|---|
| $CH_4$ | methane | $–CH_3$ | **methyl** |
| $CH_3CH_3$ | ethane | $–CH_2CH_3$ | **ethyl** |
| $CH_3CH_2CH_3$ | propane | $–CH_2CH_2CH_3$ | **propyl** |
| $CH_3CH_2CH_2CH_3$ | butane | $–CH_2CH_2CH_2CH_3$ | **butyl** |

*Molecule name:*

Steps

1. Find the **longest continuous** carbon chain.
2. **number** the carbons in the chain, starting at end **nearest** to the **branch**/substitution and find the number where substitution is.
3. name the branch
4. put together the name as follows: (# of the substituted C) – (branch name) (name of longest chain)

always dashes between #'s and words

eg) $CH_3–CH(CH_2–CH_2–CH_2–CH_2–CH_3)–CH_2–CH_2–CH_3$

1. longest chain has __**(9)** carbons ∴ chain name = **(nonane**)

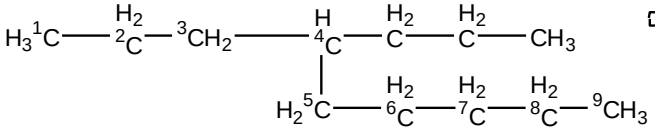
2. substitution is at Carbon # **(4)**

3. Branch name = **(methyl)**

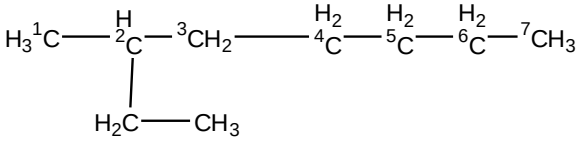
4. Name = (# of the substituted C) – (branch name) – (name of longest chain)

**4-methylnonane**

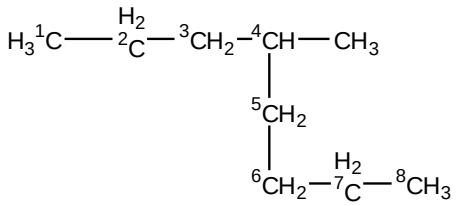
**Practice**




⇒ 4-propylnonane




⇒ 2-ethylheptane



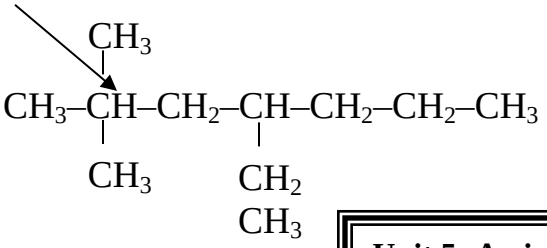

⇒ 4-methyloctane

Ex.2 is incorrectly numbered and named. It should be numbered from the bottom. ****3-Methyloctane

***Notes:***

- If a molecule has **multiple** **branches**, list them in **alphabetical** order
- If an alkyl group is **repeated**:
  *- list each carbon number where the **repeated** group is attached separated by **commas** and…*
  *- prefix the repeated group name with di, tri, tetra, etc.. to show how many are attached.*

***Carbon can have only four bonds. Therefore this hydrogen cannot be part of this structure.***



**4-ethyl-2,2-dimethylheptane**

**Unit 5: Assignment 1**

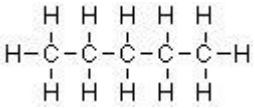
- P.361 #1, 4
- P.370 #7(a,b,f,g,h), 8, 9, 10(c,d), 11

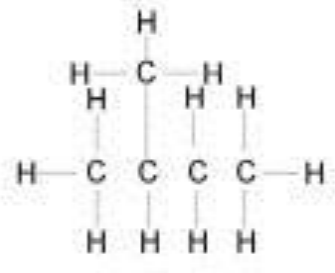
- **ALWAYS** include both name & drawing

***ii) STUCTURAL ISOMERS:***

Compounds which have the **same molecular formula** but a **different** arrangement of atoms.

eg1) **linear** & **branched** $C_5H_{12}$

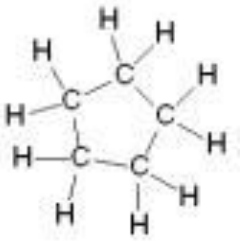




***c) Type 2 . CYCLOALKANES***

These are hydrocarbon chains which connect "head-to-tail" (in a **circle**)

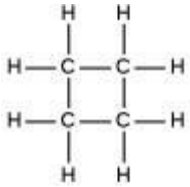
eg)



### *i) NAMING CYCLOALKANES*

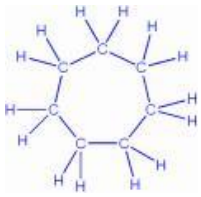
Simply add the word "**cylco**" before the name of the **alkane**.

eg1)



4 carbons = **butane** ∴ **cyclobutane**

eg2)



7 carbons = **heptane** ∴ **cycloheptane**

**Unit 5: Assignment 2**
P.372 #5(a,d,e), 6, 7, 8, 10
- **ALWAYS** include both name & drawing

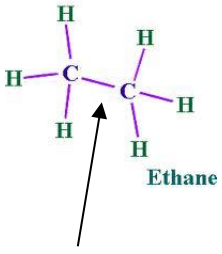
## Type 3. ALKENES

- contain C=C double bonds
- ∴ are **unsaturated**

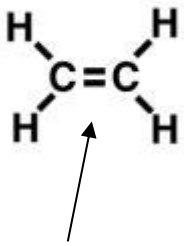
### *i) NAMING*

Alkane name ending is changed from "ane" to "**ene**"

eg) ethane becomes **ethene**



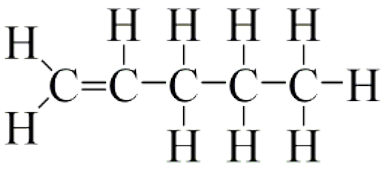

bond CAN rotate



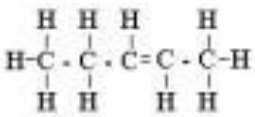
bond CANNOT rotate

a) Always locate the double-bond (db).

eg) **pent-1-ene**:



eg) **pent-2-ene**:

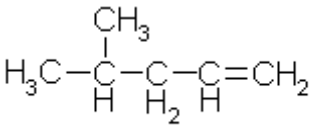


b) if alkene also has substitutions

- numbering starts **nearest** the db & identify db (db is more important)
- must count across db
- write locations and **branch names** first

eg) **4-methyl-pent-1-ene**

branch first



***Practice:*** Draw 3,4-diethyl-cyclopentene

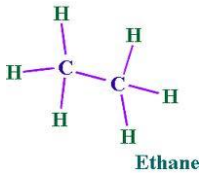
## Type 4. ALKYNES

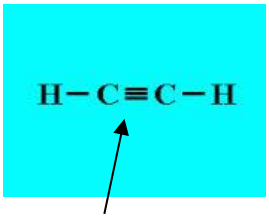
- contain C≡C triple bonds
- ∴ are un**saturated**

### i) NAMING

Alkane name ending is changed from "ane" to "**yne**"

eg) **ethane** becomes **ethyne**



bond CANNOT **Rotate**

**Unit 5: Assignment 3**

- P.377 #1-7
- P.380 #1, 4, 6- 9, 11

- **ALWAYS** include both name & drawing

## ALKYL HALIDES

these are hydrocarbons with halogen(s) attached.

| Branch | Name |
|---|---|
| –F | Fluoro |
| –Cl | Chloro |
| –Br | Bromo |
| –I | Iodo |

eg) chloromethane : **$CH_3Cl$**

eg) **1-bromopropane**: $CH_3CH_2CH_2Br$

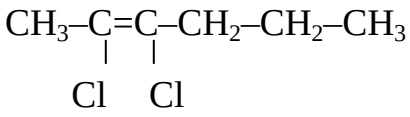
**General formula**: R–F, R–Cl, R–Br, R–I

**the "R"** represents any **carbon compound**
∴ R–OH represents any carbon compound with an OH group attached
∴ R–Cl " " " " " a Cl attached

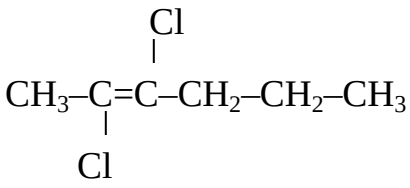
eg. $CH_3Br$ , $CH_3CH_2$ Br, and $CH_3CH_2CH_2$ Br can all be represented by the general formula: R– Br

You **do not** need the cis or trans in these examples.

eg) **cis-2,3-diclhoro-hex-2-ene**



eg) **trans-2,3-diclhoro-2-hex-2-ene**



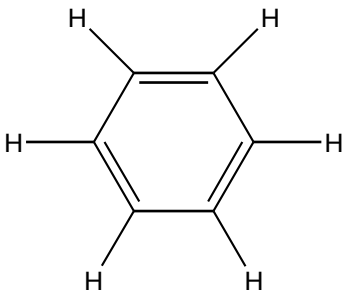
**Unit 5: Assignment 4**

- P. 418 #1-3, 4(c,d), 5(b,d)
- P. 422 # 7, 9, 11
- P.424 # 2-4

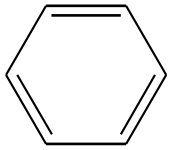
- **ALWAYS** include both name & drawing

## 4. AROMATIC COMPOUNDS

**Benzene** ($C_6H_6$):

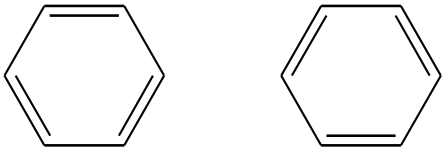



or simply

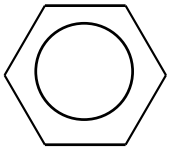


Two **resonance** structures exist

- Due to electrons **moving** freely within the ring.

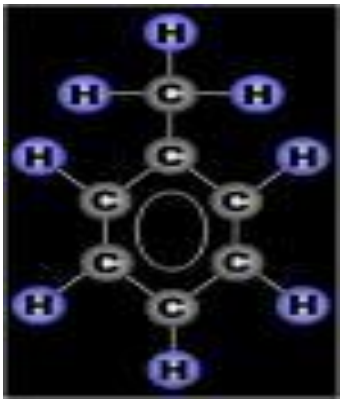


Benzene is a mixture of the two & is sometimes represented like this

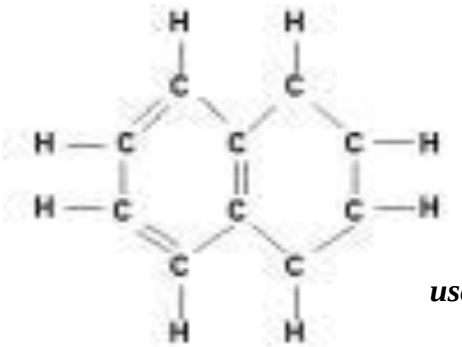


**Aromatic compound**: contains one or more **benzene rings**

eg1) methylbenzene



eg2) naphthalene ($C_{10}H_8$)



***used in moth-balls***

## 5. FUNCTIONAL GROUPS

**Functional group: a specific group of atoms which exists in a molecule and gives the molecule an ability to react in a specific manner or gives it special properties.**

**Types of *functional groups (*Not needed in Chem 30)*:**

- **A. alcohols** ( R–OH )
- **aldehydes** ( R–CHO )
- **ketones** ( R–CO–R )
- **ethers** ( R–O–R )
- **amines** ( $R–NH_2$ )
- **amides** ( $R–CONH_2$ )
- **B. carboxylic acids** ( R–COOH )
- **C. esters** ( R–COO–R )

**Note**: for the groups we cover, be able to identify these different structures from a diagram or a name.

### A. Alcohols (R–OH)

An alcohols is an organic compound that contains an **OH group**

*i) Naming Alcohols*

- Number the hydrocarbon chain so that OH group attached to lowest # C
- Place number immediately before the hydrocarbon name, separated by a dash
- Alkyl groups placed before the # for OH
- Change ending of hydrocarbon name to "ol"

eg) $CH_3CH_2CH_2–OH$ **propanol**

propane ol

eg) $CH_3–CH_2–CH_2–CH_2–CH_2–OH$ **pentanol**

eg) $CH_3CH(OH)CH_2CH_3$ **butan-2-ol**

eg) $CH_3–CH_2–CH(OH)–CH_2–CH(CH_2CH_3)–CH_3$ **5-ethyl-butan-3-ol**

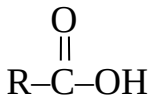
**Unit 5 Assignment 5**
- # P. 430 #5-9, 11, 13, 14
- P. 432 #19
- P. 435 # 2. 4. 6. 8

*ii) Properties of Alcohols*

- The OH group is **polar**, which tends to make alcohols **soluble** in water
- Hydrocarbon chains are **non-polar**, tending to make alcohols **insoluble** in water.
- ∴ The **larger** the hydrocarbon chain, the **less soluble** the alcohol.
- Alcohols are **poison**

## B. Carboxylic acids

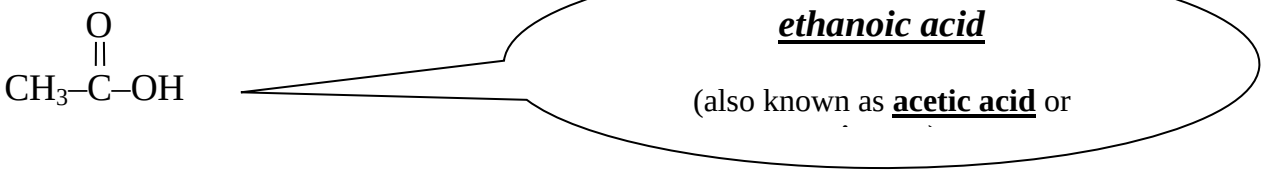
A carboxylic acid is an organic compound that contains a COOH group.



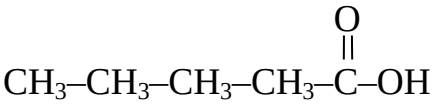
( written as R–COOH )

*Naming:* Change the end of the hydrocarbon name from "e" to "oic acid"

eg)



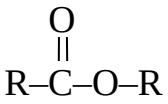

eg)



**pentanoic acid**

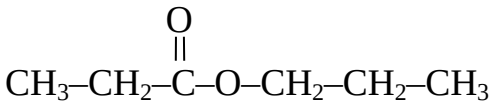
*Organic acids have a "sharp" and "biting" odor.*

## C. Esters



*(written as R–COO–R )*

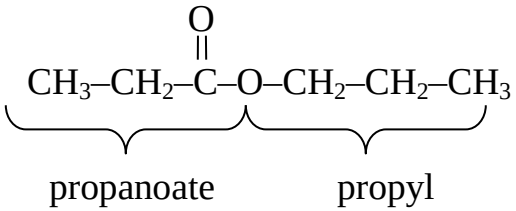
An ester is a compound in which a COO group joins two hydrocarbons.

eg)  **propyl propanoate**

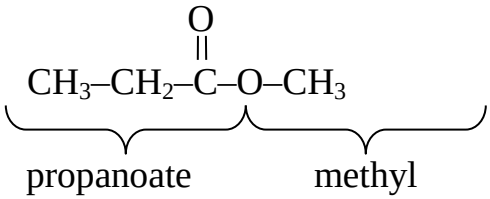
*Naming Esters*

- They hydrocarbon chain attached directly to the carbon side of the COO group has its ending "e" changed to "oate"
- The COO group is part of the hydrocarbon chain
- The other hydrocarbon chain is attached to the oxygen side of the COO and is named as an alkyl group
- The alkyl name is used as a separate, initial word.

eg)




*propyl* **propyl propanoate**




**methyl propanoate**

**Unit 5 Assignment 6**

- **#** P. 438 #1 & 2
- P. 441 # 3-5
- P. 444 # 6-8

# Making Esters

Esters are prepared by **reacting** an **alcohol** with a **carboxylic acid**.

eg) $CH_3 – CH2 – C(=O) - OH + HO- CH_2 – CH2 - CH_3$

$H_2O$

$CH_3 – CH2 – C(=O) - O- CH_2 – CH2 - CH_3$

**OR ALSO DRAWN LIKE THIS**

$CH_3\text{-}CH_2\text{-}COOH + CH_3\text{-}CH_2\text{-}CH_2\text{-}OH \rightarrow CH_3\text{-}CH_2\text{-}C\text{-}O\text{-}CH_2\text{-}CH_2\text{-}CH_3 + H_2O$

**Carboxylic acid** + **alcohol** → **ester** + **water**

*Generally, esters have a pleasant smell*

eg) the odour in bananas is **pentyl ethanoate**

" " "pineapples is **methyl butanoate**

**Unit 5 Assignment 7**

- **#** P. 448 # 1-5
- P. 451 # 10
- P. 452 # 12,13
- P. 455 # 15, 17