

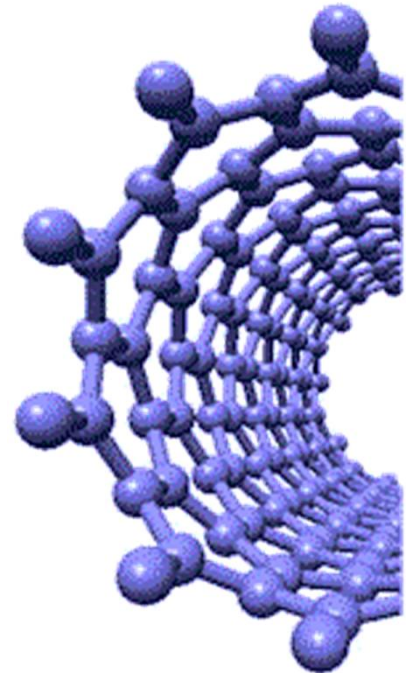


INVESTMENTS IN EDUCATION DEVELOPMENT

# Innovation and Development of Study Field Nanomaterials at the Technical University of Liberec

[nano.tul.cz](http://nano.tul.cz)

These materials have been developed within the ESF project: Innovation and development of study field Nanomaterials at the Technical University of Liberec



TECHNICAL UNIVERSITY OF LIBEREC  
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## **Introduction, to carbon containing molecules.**

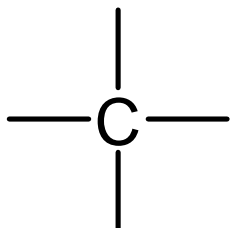
- bonding in organic compounds,**
- writing organic structures,**
- formulae,**
- nomenclature.**



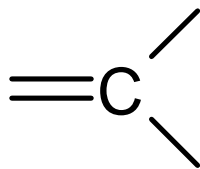
## Organic Chemistry – chemistry of „C“ compounds

- Three types of bonding between carbon atoms
- All four single bonds of Carbon are equal
- Carbon atoms can form chains of „unlimited“ length and shape
- Many heteroatoms can be incorporated into these chains

a)



b)



c)



d)

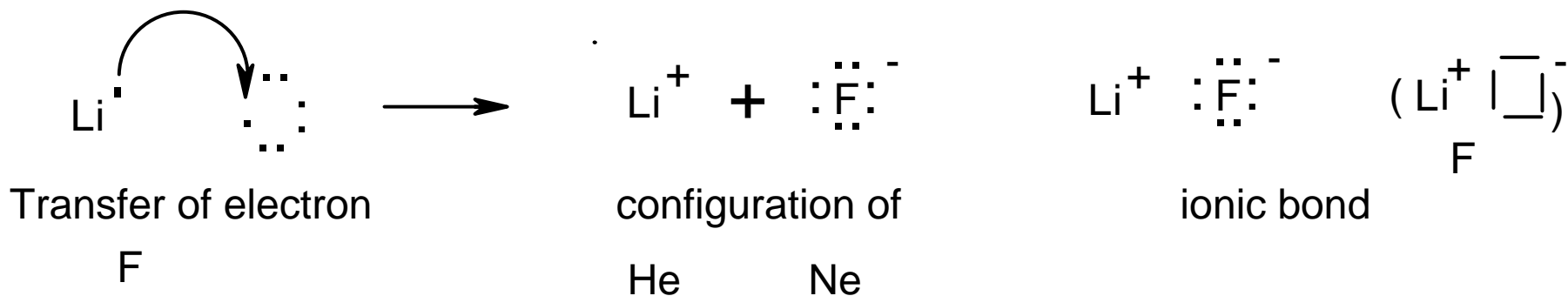




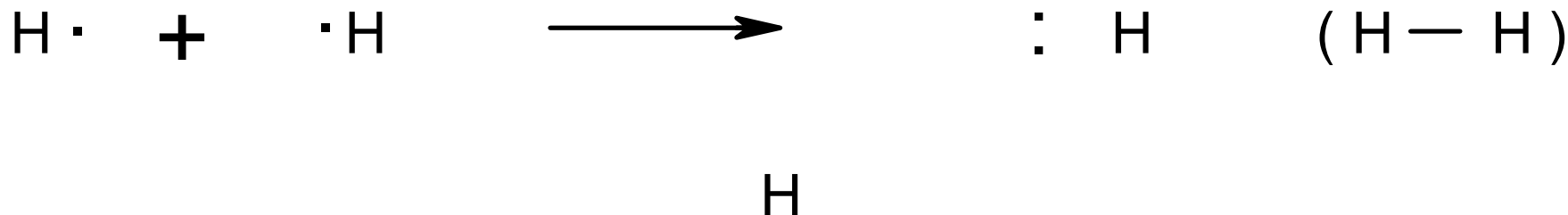
# Organic Chemistry – molecular (carbon) scaffold



## Ionic bond



## Covalent bond

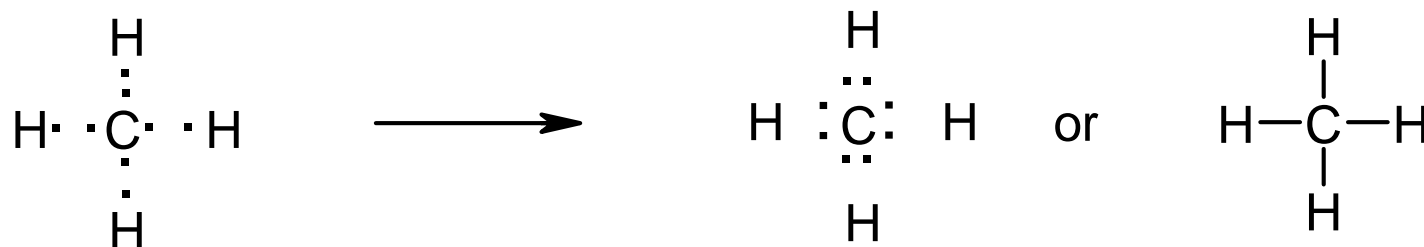




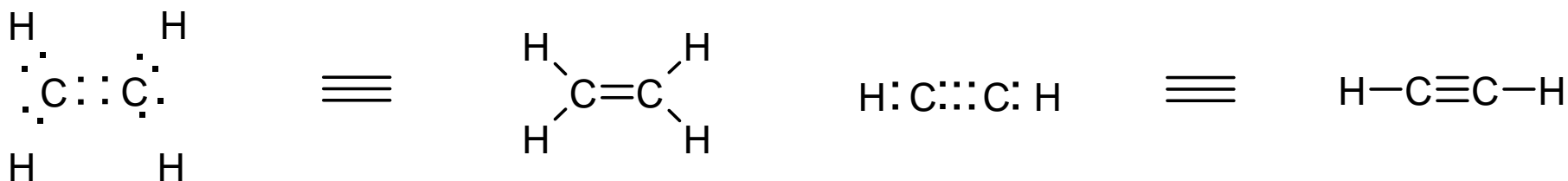
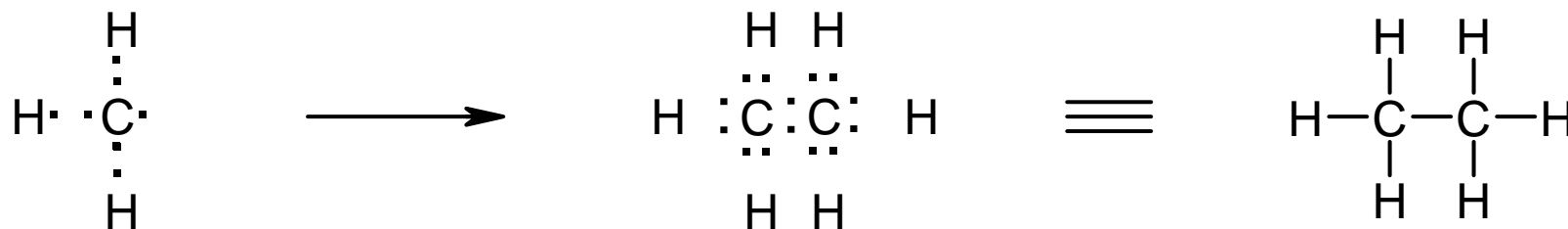
# Organic Chemistry – molecular (carbon) scaffold



## Covalent bond



methane



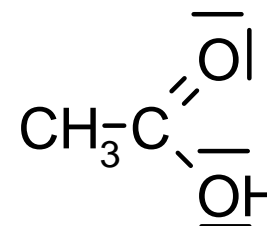
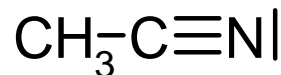
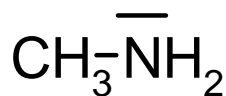
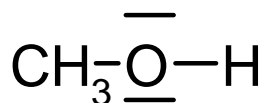
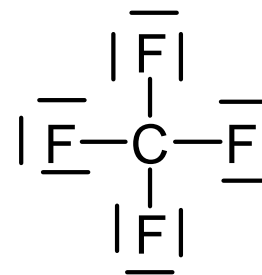
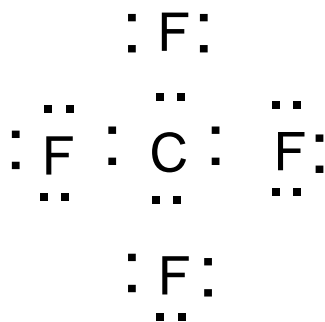
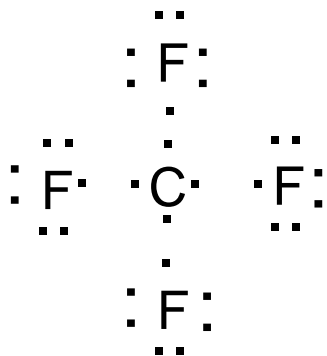


# Organic Chemistry – molecular (carbon) scaffold



## Covalent structures – **non-bonding electrons**

To understand organic chemistry – you should keep them in mind

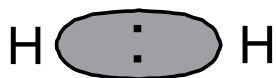




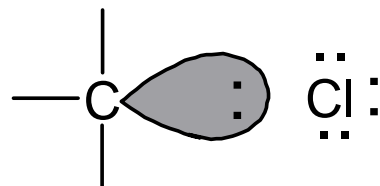
# Organic Chemistry – molecular (carbon) scaffold



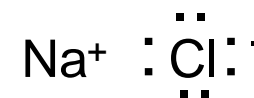
## Polar covalent bond - electronegativity



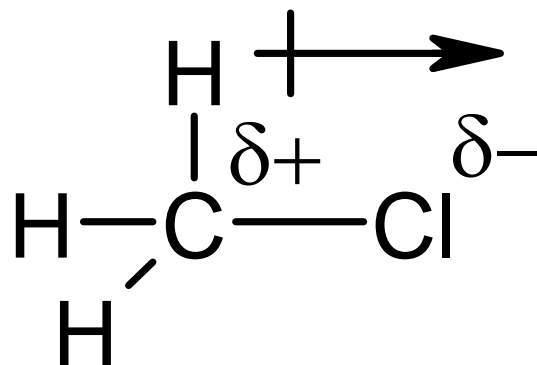
nonpolar  
covalent bond



polar  
covalent bond



ionic bond





# Organic Chemistry – molecular (carbon) scaffold



## Polar covalent bond – dipole moment

|             |             |             |             |            |             |
|-------------|-------------|-------------|-------------|------------|-------------|
| <b>H-C</b>  | <b>0,3</b>  | <b>H-N</b>  | <b>1,31</b> | <b>H-S</b> | <b>0,68</b> |
| <b>N-C</b>  | <b>0,40</b> | <b>H-O</b>  | <b>1,58</b> | <b>C=N</b> | <b>0,90</b> |
| <b>O-C</b>  | <b>0,86</b> | <b>H-Cl</b> | <b>1,03</b> | <b>C≡N</b> | <b>3,60</b> |
| <b>Cl-C</b> | <b>1,56</b> | <b>H-Br</b> | <b>0,78</b> | <b>C=O</b> | <b>2,40</b> |
| <b>Br-C</b> | <b>1,48</b> | <b>H-J</b>  | <b>0,38</b> | <b>C-S</b> | <b>0,95</b> |
| <b>I-C</b>  | <b>1,29</b> | <b>H-F</b>  | <b>1,98</b> | <b>C=S</b> | <b>2,80</b> |
| <b>F-C</b>  | <b>1,51</b> |             |             | <b>N-O</b> | <b>0,30</b> |
|             |             |             |             | <b>N=O</b> | <b>2,0</b>  |





# Organic Chemistry – molecular (carbon) scaffold



## Polar covalent bond - electronegativity

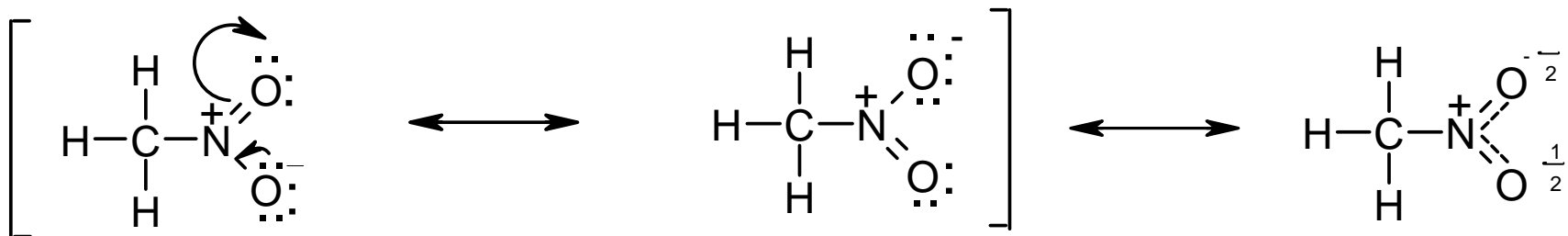
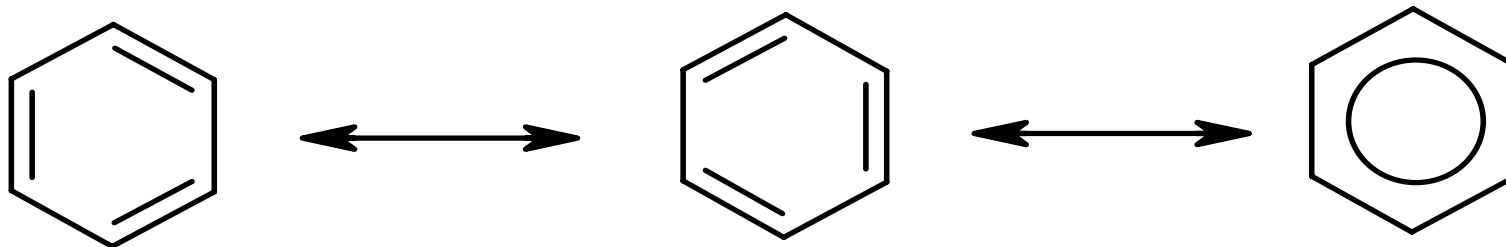
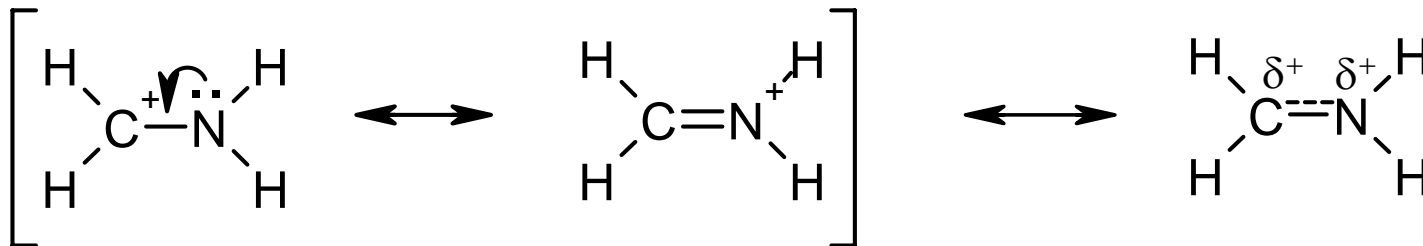
|                  |                  |                  |                  |                 |                 |                  |
|------------------|------------------|------------------|------------------|-----------------|-----------------|------------------|
| <b>H</b><br>2,2  |                  |                  |                  |                 |                 |                  |
| <b>Li</b><br>1,0 | <b>Be</b><br>1,6 | <b>B</b><br>1,8  | <b>C</b><br>2,5  | <b>N</b><br>3,0 | <b>O</b><br>3,4 | <b>F</b><br>4,0  |
| <b>Na</b><br>0,9 | <b>Mg</b><br>1,3 | <b>Al</b><br>1,6 | <b>Si</b><br>1,9 | <b>P</b><br>2,2 | <b>S</b><br>2,6 | <b>Cl</b><br>3,2 |
| <b>K</b><br>0,8  |                  |                  |                  |                 |                 | <b>Br</b><br>3,0 |
|                  |                  |                  |                  |                 |                 | <b>I</b><br>2,7  |



# Organic Chemistry – molecular (carbon) scaffold



## Covalent bond - resonance

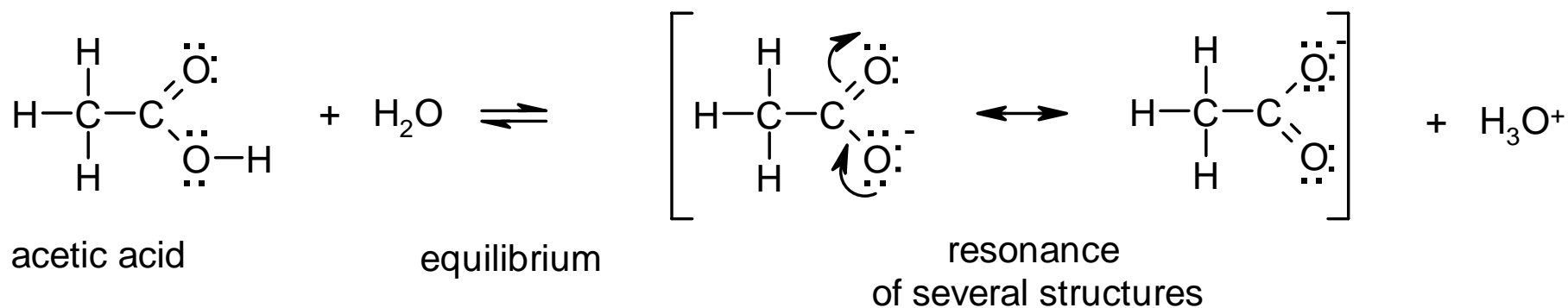




# Organic Chemistry – molecular (carbon) scaffold



## Covalent bond – equilibrium x resonance



**Only electrons are moving between (among) resonance structures (forms).**

carboxylic acid x carboxylate anion.



**!!! IMPORTANT !!!**

It is necessary to **master** writing (drawing) of chemical formulae, structures and equations.

**Nobody can learn organic chemistry by reading only !!!**

**You are expected to write when reading.**

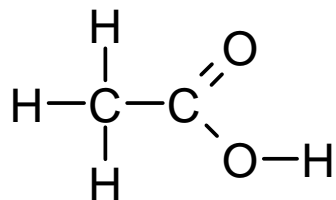
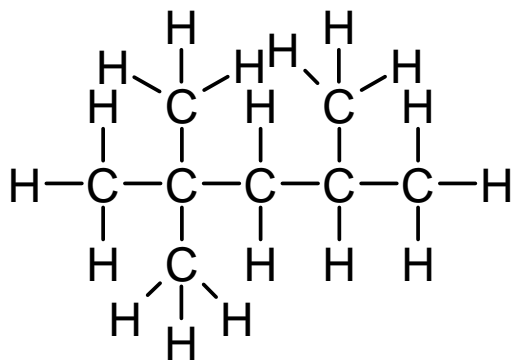


# Organic Chemistry – molecular (carbon) scaffold

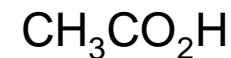
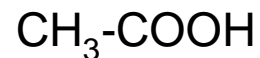
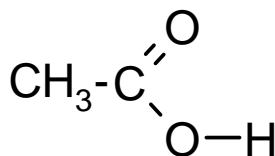
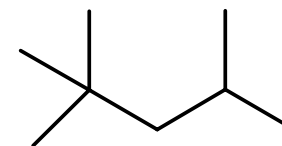
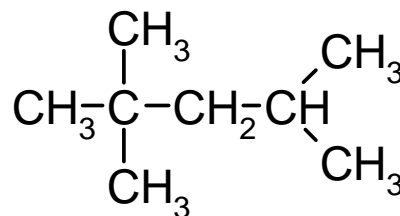
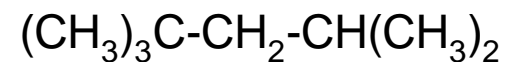


## Formulae used in organic chemistry

full



rational



Lewis formulae, structures – all non-bonding electrons are shown.



# Organic Chemistry – molecular (carbon) scaffold

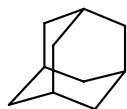


## Formulae

|                                  |               |                    |
|----------------------------------|---------------|--------------------|
| $\text{CH}_3\text{-}$            | Me-           | methyl             |
| $\text{CH}_3\text{CH}_2\text{-}$ | Et-           | ethyl              |
| $(\text{CH}_3)_2\text{CH-}$      | i-Pr-         | isopropyl          |
| $(\text{CH}_3)_3\text{C-}$       | <i>t</i> -Bu- | <i>tert</i> -butyl |
| $\text{C}_6\text{H}_5\text{-}$   | Ph-           | phenyl             |



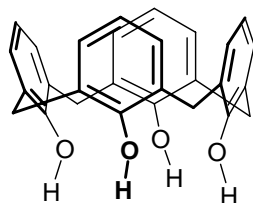
## Formulae – trivial names



adamantane      tricyklo[3.3.1.1<sup>3,7</sup>]dekane



cubane      pentacyclo[4.2.0.0<sup>2,5</sup>.0<sup>3,8</sup>.0<sup>4,7</sup>]  
octane



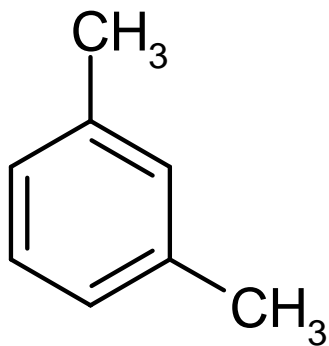
calix[4]arene      pentacyclo[19.3.1.1<sup>3,7</sup>.1<sup>9,13</sup>.1<sup>15,19</sup>]  
octacosan-  
1(25),3,5,7(28),9,11,13(27),1  
5,17,19(26),21,23-dodecaen-  
25,26,27,28-tetraol



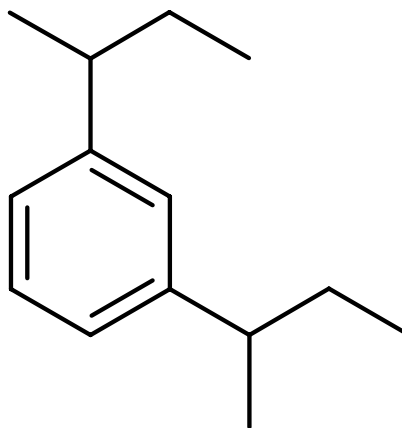




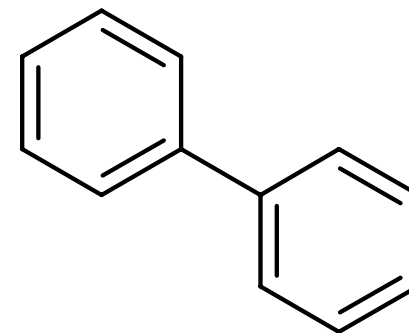
Nomenclature – locants



1,3-**di**methylbenzene



1,3-**bis**(1-methylpropyl)benzene



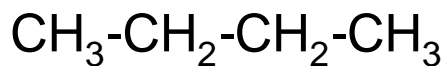
**bi**phenyle



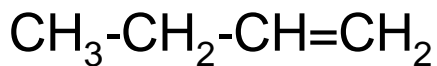
# Organic Chemistry – molecular (carbon) scaffold



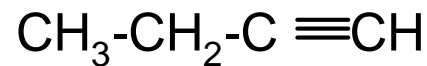
## Nomenclature – locants



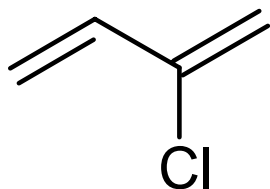
butane



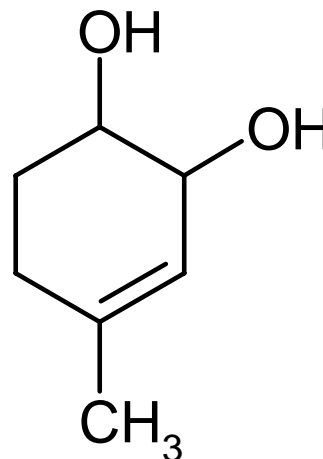
but-1-ene



but-1-yne



**2-chlorobuta-1,3-diene**



**4-methylcyclohex-3-ene-1,2-diol**



# Organic Chemistry – molecular (carbon) scaffold



## Functional group priorities (descending)

| Characteristic groups | formule  | prefix          | suffix   |
|-----------------------|--|-----------------|--|
| Cations               | (+)  | -onio-          | -onium<br>-ium   |
| Carboxylic acid       | -COOH<br>-(C)OOH   | carboxy-        | -carboxylic acid<br>-oic acid                                      |
| Sulfonic acid         | -SO <sub>2</sub> -OH, -SO <sub>3</sub> H                               | sulfo-          | -sulfonic acid   |
| Anhydrides            | -CO-O-CO-<br>-(C)O-O-(C)O-   |                 | -carboxanhydride<br>-anhydride<br>(anhydride ...oic acid)          |
| Salts                 | -COO <sup>-</sup> M <sup>+</sup><br>-(C)OO <sup>-</sup> M <sup>+</sup> |                 | (cation)-...-carboxylate<br>(cation)-...-oate                      |
| Esters                | -COOR<br>-(C)OOR   | R-oxycarbonyl-  | R-...-carboxylate<br>R-...-oate<br>(R-ester ...-oic acid)          |
| Acylhalogenides       | -CO-X<br>-(C)O-X   | halogencarbonyl | -carbonylhalogenide<br>-oylhalogenide<br>(halogenide ...-oic acid) |



# Organic Chemistry – molecular (carbon) scaffold



Functional group priorities (descending)

| Characteristic groups | formule                                      | prefix          | suffix  |
|-----------------------|--|-----------------|---|
| Amides                | -CO-NH <sub>2</sub><br>-(C)O-NH <sub>2</sub> | carbamoyl-      | -carboxamide<br>-amide<br>(amide of ...-oic acid) |
| Nitriles              |  | cyano-          | -carbonyle<br>-nitril, -onitril                   |
| Aldehydes             | -CHO<br>-(C)HO                               | formyl-<br>oxo- | -carbaldehyde<br>-al                              |
| Ketones               |  | oxo-            | -on   |



# Organic Chemistry – molecular (carbon) scaffold



Functional group priorities (descending)

| Characteristic groups | formule          | prefix      | suffix |
|-----------------------|------------------|-------------|--------|
| Alcohols              | -OH              | hydroxy-    | -ol    |
| Phenols               | -OH              | hydroxy-    | -ol    |
| Thiols                | -SH              | sulfanyl-   | -thiol |
| Amines                | -NH <sub>2</sub> | amino-      | -amine |
| Ethers                | -OR              | R-oxy-      |        |
| Sulfides              | -SR              | R-sulfanyl- |        |
| Halogenderivatives    | -X               | halogen-    |        |
| Nitrocompounds        | -NO <sub>2</sub> | nitro-      |        |

