

# **Bonding in Organic Compunds**

Ability of carbon to form 4 covalent bonds leads to an infinite number of possible compounds

- Chains of carbon atoms bonded to each other
- Can incorporate O, N, CI, S and other atoms

Functional groups – the reactions of organic compounds will be focused at key parts of a molecule

- A *functional group* is a specific grouping of atoms (e.g. carbon- carbon double bonds are in the family of alkenes)
- Makes properties and reactions predictable



# Alkanes = saturated hydrocarbonsMethane is first in a series of saturated hydrocarbonsAlkanes contain only C and H and no multiple bondsEthane $C_2H_6$ $CH_3$ - $CH_3$ Alkanes are combustible, but otherwise resistant to most<br/>reactions









### Molecular Orbital Theory explains benzene even better

Continuous overlap of p orbitals over the entire ring

- All carbons in benzene are sp<sup>2</sup> hybridized
  → Each carbon also has a p orbital
- Each p orbital overlaps with p orbitals on either side to give a continuous bonding molecular orbital that encompasses all 6 carbons
- All 6 π electrons are therefore *delocalized* over the entire ring, producing equivalency of all carbon-carbon bonds





All of the following representations are used for benzene. When the benzene ring is attached to other groups, it is called a phenyl group.

Substituted benzenes and other compounds with benzene-like stability is called aromatic

### Polar Covalent Bonds

- When a covalent bond is formed between two atoms of differing electronegativities, it will be polar
  - The more electronegative atom draws electron density closer to itself
  - The more electronegative atom develops a partial negative charge (δ-) and the less electronegative atom develops a partial positive charge (δ+)
  - A bond which is polarized is a dipole and has a dipole moment
  - The direction of the dipole can be indicated by a dipole arrow

(positive end) 
$$\stackrel{\delta^+}{\longleftrightarrow} \stackrel{\delta^-}{\longleftrightarrow}$$
 (negative end)















### Functional Groups

Certain arrangements of atoms are called a *functional group* because this is the site of most chemical reactivity of a molecule

 The functional group is also responsible for many of the physical properties of a molecule

Alkanes do not have a functional groups

Alkenes have the C=C as a functional group

Alkynes have a triple bond as a functional group













































				Family			
	Alkane	Alkene	Alkyne	Aromatic	Haloalkane	Alcohol	Ether
Functional group	C—H and C—C bonds	><	-C≡C-	Aromatic ring	$-\overset{l}{\overset{l}{\overset{}{\overset{}}}}-\overset{\ddot{}}{\overset{\ddot{}}{\overset{}{\overset{}}}}$	-с–ён	-ç-ğ-ç-
General formula	RH	$\begin{array}{l} \text{RCH}{=}\text{CH}_2\\ \text{RCH}{=}\text{CHR}\\ \text{R}_2\text{C}{=}\text{CHR}\\ \text{R}_2\text{C}{=}\text{CR}_2 \end{array}$	RC≡CH RC≡CR	ArH	RX	ROH	ROR
Specific example	CH <sub>3</sub> CH <sub>3</sub>	CH2=CH2	HC≡CH	$\bigcirc$	CH <sub>3</sub> CH <sub>2</sub> Cl	CH3CH2OH	CH3OCH3
IUPAC name	Ethane	Ethene	Ethyne	Benzene	Chloroethane	Ethanol	Methoxymethan
Common nameª	Ethane	Ethylene	Acetylene	Benzene	Ethyl chloride	Ethyl alcohol	Dimethyl ether





- What makes atoms and molecules stick to one another?
- Intermolecular Attractive Forces
- If there were no intermolecular attractive forces, everything would be a gas!
  - Helium a gas down to 4° K
- In order to exist as solids or liquids, molecules must have some attractive forces, which are overcome in melting, boiling, and solubility
- Higher melting points and boiling points will be a measure of the strength of the intermolecular attractive forces
- Intermolecular attractive forces are based on electrostatic attractions, either permanent or temporarily-induced

### Greatest intermolecular forces are between ions

- Ions of opposite charge attract each other strongly
- They forms a solid consisting of ions held together in a crystalline lattice
- Ionically bonded compounds are usually well ordered crystals with high melting points





















# van der Waals Forces are small, but...

• Molecules which rely only on van der Waals forces generally have low melting points and boiling points

A Gecko can hang from 1 pad, with no known stickum









	Summary of attra	active forces	
Electric Force	Relative Strength	Туре	Example
Cation–anion (in a crystal)	Very strong	• -	Sodium chloride crystal lattice
Covalent bonds	Strong (140–523 kJ mol <sup>-1</sup> )	Shared electron pairs	H—H (436 kJ mol <sup>-1</sup> ) CH <sub>3</sub> —CH <sub>3</sub> (378 kJ mol <sup>-1</sup> ) I—I (151 kJ mol <sup>-1</sup> )
lon-dipole	Moderate ő	6- 5- 5- 5- 5- 5- €- 5+ 5+	Na <sup>+</sup> in water (see Fig. 2.9)
Hydrogen bonds	Moderate to weak (4–38 kJ mol <sup>-1</sup> )	$-\!\!\!\!\stackrel{\delta^-}{Z}\!\!:\!\cdots\!\stackrel{\delta^+}{H}\!-\!\!\!\!$	R :0:H #+H
Dipole-dipole	Weak	$\delta + \cdots \delta -$	н ас н ас
van der Waals	Variable	Transient dipole	Interactions between methane molecules