BOOKS

1) Organic Chemistry Structure and Function, K. Peter C. Vollhardt, Neil Schore, 6th Edition

2) Organic Chemistry, T. W. Graham Solomons, Craig B. Fryhle

3) Organic Chemistry: A Short Course, H. Hart, L. E. Craine, D. J. Hart, C. M. Hadad,

4) Organic Chemistry: A Brief Course, R. C. Atkins, F.A. Carey

1. CHEMICAL BONDS

1.1 Introduction to Organic Chemistry

Before 1828, it was thought to be organic compounds were very complex and only obtained from living sources like animal urine. In 1828, Friedrich Wohler synthesized an organic compound (urea) from inorganic compounds (lead cyanate and ammonium hydroxide).

$$\mathrm{Pb(OCN)_2 + 2\,H_2O + 2\,NH_3 \longrightarrow 2\,\underset{\text{urea}}{H_2N\text{-}\overset{\overset{O}{\|}}{C}\text{-}NH_2} + Pb(OH)_2}$$

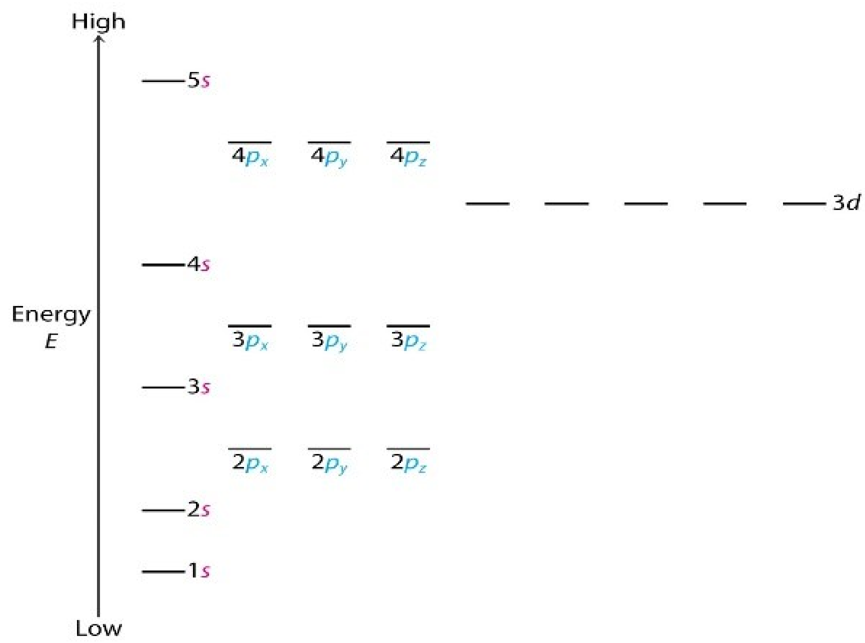
Organic Chemistry is chemistry of carbon compounds and carbon forms a variety of strong covalent bonds to itself and other atoms. Carbon can bond to itself and other atoms: in a straight chain or a branched or cyclic manner.

Importance of Carbon:

- It has **4 valence** electrons. $\cdot\dot{\underset{\cdot}{C}}\cdot + 4H\cdot \longrightarrow CH_4$
- It makes **4 covalent** bonds.
- It can bond with any element, but priorities to bond with other carbon atoms and make long chains.

1.2 Atoms, Electrons and Orbitals

In a neutral atom, the number of protons and electrons are always equal to each other and the charge is 0. Electrons exist in energy levels that surround the nucleus of the atom. The energy levels are called shells, and within these shells are other energy levels, called subshells or orbitals, that contain up to two electrons.



The below Table indicates the basic sequence of the atomic configuration of the known elements.

Electronegativity is a measure of the tendency of an atom to attract a bonding pair of electrons. If atoms bonded together have the same electronegativity, the shared electrons will be equally shared. *The Pauling scale* is the most commonly used.

Element	Atomic Number	Electron Configuration
Hydrogen (H)	1	$1s^1$ (First shell, one electron)
Helium (He)	2	$1s^2$
Lithium (Li)	3	$1s^2$, $2s^1$
Beryllium (Be)	4	$1s^2$, $2s^2$
Boron (B)	5	$1s^2$, $2s^2$, $2p^1$
Carbon (C)	6	$1s^2$, $2s^2$, $2p^2$
Nitrogen (N)	7	$1s^2$, $2s^2$, $2p^3$
Oxygen (O)	8	$1s^2$, $2s^2$, $2p^4$
Fluorine (F)	9	$1s^2$, $2s^2$, $2p^5$
Neon	10	$1s^2$, $2s^2$, $2p^6$ (Inert, completely filled)

1.3 Bonds

1.3.1 Ionic Bond

Ionic bonding is important between atoms of different electronegativity. The bond results from one atom giving up an electron while another atom accepts the electron. Both atoms attain a stable nobel gas configuration.

$$Na^{11} \xrightarrow{-1e} [Na^{10}]^+$$

$$F^{9} \xrightarrow{+1e} [F^{10}]^-$$

$$2\ Na + F_2 \longrightarrow 2\ Na^+ F^-$$

1.3.2 Covalent Bond

A covalent bond is formed by a sharing of two electrons by two atoms.

Hydrogen molecule: H•• H, H-H, H_2

1.3.3 Polar Covalent Bond

Polar covalent bonds are a particular type of covalent bond. Perfectly-ionic and perfectly-covalent bonds are the two extremes of bonding. A polar covalent bond is an unequally sharing of electrons between two atoms with different

$$H^{\delta+}:\ddot{\underset{\cdot\cdot}{Cl}}:^{\delta-}$$

1.4 Formal Charges

To assign formal charge, use the formula below

Formal charge = Group number -(electrons in lone pairs + the number of bonds**)**

Group number = # of valence electrons

For example, CH_4

The number of valence electrons' carbon is 4.

The number of non-bonded electrons is zero.

The number of bonds around carbon is 4.

So formal charge = 4 – (0 + 4) = 4 – 4 = 0

The formal charge of C in CH_4 is 0

What about the hydrogens:

Formal charge = 1 – (0 + 1) = 1 – 1 =0

1.5 Lewis Structures of Organic Molecules

Writing Lewis structures:

(i) Draw molecular skeleton

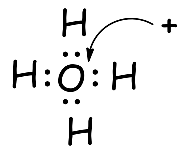
$CO_2 \longrightarrow$ O C O

(ii) Count total number of valence electrons. If there is a negative ion, add the absolute value of total charge to count of valence electrons; if a positive ion, subtract.

(iii) Octet (Duet) Rule: Provide octets (duets for H) around all atoms. Assign 2 bonding electrons to each bond.

H:H

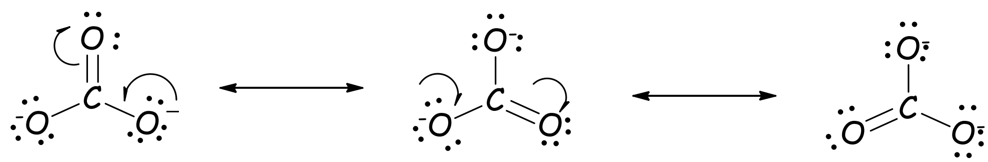
(iv) Take care of charges, if any. Charges occur when the formal "effective" electron count around the nucleus differs from valence electron count.



H_3O^+

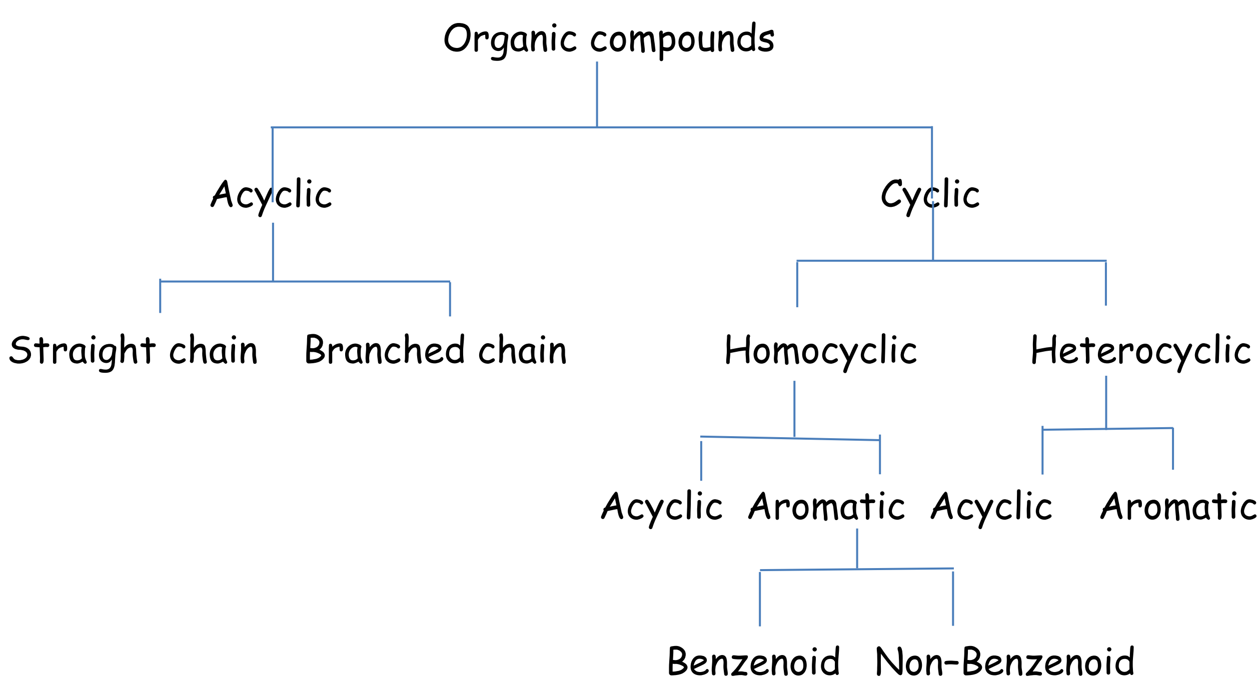
1.6 Resonance

The following structures, called resonance structures, are not real or detectable, but they are a useful conceptual tool for understanding the reactivity of molecules.



Carbonate, CO_3^{2-}. All forms are equivalent

1.7 Classification of Organic Compounds



1.8 Representation of the Organic Molecules

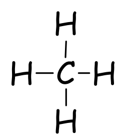
The structural formulas of the organic molecules can be shown in differ ent ways.

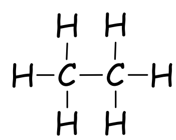
Chemical Formula CH_4 C_2H_6 C_3H_8

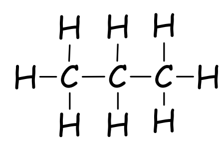
Condensed CH_4 CH_3CH_3 $CH_3CH_2CH_3$

Structural Formula

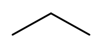
Lewis Structural Formula

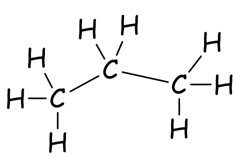


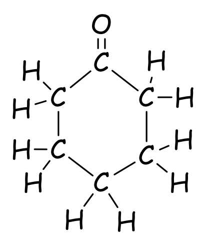


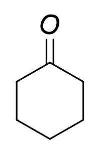


Line-Angle Formula





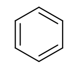
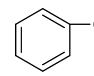
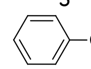
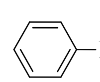




1.10. Naming of the Organic Compounds

In order to clearly identify compound, a systematic method of naming has been developed and is known as the IUPAC (International Union of Pure and Applied Chemistry) system of nomenclature. We can name them systematically (IUPAC).

Organic Functional Group List and IUPAC Names

Functional Group	Compound	Prefix/Suffix	Example	IUPAC Name (Common Name)
		Hydrocarbons		
R-H	Alkane	-ane	CH_3CH_3	ethane
C=C	Alkene	-ene	$H_2C=CH_2$	ethene (ethylene)
C≡C	Alkyne	-yne	HC≡CH	ethyne (acetylene)
Ar-H	Arenes	-ene		benzene
		Halogen-Containing Compounds		
R-X	Halo alkane	halo-	CH_3Cl	chloromethane
Ar-X	Aryl halides	halo-		chlorobenzene
		Oxygen-Containing Compounds		
R-OH	Alcohol	-ol (hydroxy-)	CH_3OH	methanol
ArOH	Phenols	-ol		phenol
R-O-R	Ether	ether (alkoxy-)	CH_3OCH_3	dimethyl ether
RCOH	Aldehyde	-al	CH_3CHO	ethanal (acetaldehyde)
RCOR	Ketone	-one	CH_3COCH_3	propanone (acetone)
RCOOH	Carboxylic acid	-oic acid	CH_3COOH	ethanoic acid (acetic acid)
		Carboxylic Acid Derivatives		
RCOOR	Ester	-oate	CH_3COOCH	methyl ethanoate (methyl acetate)
RCOOX	Acyl halides	-acyl	CH_3COOCl	Acetyl chloride
$RCONH_2$	Amide	-amide	CH_3CONH_2	ethanamide (acetamide)
RCOOCOR	Anhydride	-anhydride	$CH_3COOOCH_3$	Acetic anhydride
		Nitrogen-Containing Acid Derivatives		
$R-NH_2$	Amine	-amine (amino-)	$CH_3CH_2NH_2$	ethylamine aminoethane
RC≡N	Nitriles	-nitrile (cyano)	$CH_3C≡N$	acetonitrile
$ArNO_2$	Nitro compounds	-nitro		nitrobenzene

R = alkyl group, an unfunctionalized saturated chain; Ar= an aryl group; X = halogen